TECHNICAL SPECIFICATIONS

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1. CARRIAGE

1.1 CARRIAGE OF MATERIALS

1.1.1 SCOPE

The carriage and stacking of materials shall be done as provided in the Contract Agreement. All tools and plants and means of transport shall be arranged by the Contractor. The carriage of materials includes loading unloading and stacking unless specifically provided otherwise in the Contract Agreement.

1.1.2 RESPONSIBILITY FOR LOSS OR DAMAGE

The Contractor undertaking carriage of material shall be responsible for its safe loading, carriage, unloading, and delivery to the specified site within the specified time and stacking.

1.1.3 MODE OF CARRIAGE

Depending upon the feasibility and economy, the Contractor shall propose the mode of carriage viz. whether by mechanical or animal transport and shall be as approved by the Engineer-in-Charge in accordance with corresponding CSR item as provided in Contract Agreement.

1.1.4 LEAD

All distances shall be measured over the shortest practical route and not necessarily the route actually taken. Route other than shortest practical route may be considered in cases of unavoidable circumstances and as approved by Engineer-in-Charge along with reasons in writing. Carriage by animal and mechanical transport shall be reckoned in one km unit. Distances of 0.25 km or more shall be taken as 0.50 km and distance of less than 0.25 km shall be ignored.

Carriage by mechanical transport shall be reckoned in one km unit. Distances of 0.5 km or more shall be taken as 1 km and distance of less than 0.5 km shall be ignored. However, when the total lead is less than 0.5 km, it will not be ignored but paid for separately in successive stages of 30 metres subject to the condition that the rate worked on this basis does not exceed the rate for initial lead of 1 km by mechanical.

1.1.5 MEASUREMENT AND PAYMENT

The rates are applicable to carriage of materials in plain areas on Pacca road only. For Kacha roads an allowance of 20% extra shall be allowed for 2nd and subsequent distance covered in Km. Rates. Rate upto 1st km. is however common to both Kacha and Pacca roads. For Hilly areas 25% above the rates in plain areas shall be allowed for total distance covered in Kms. Similarly, for desert road 15% above the rates in plain areas shall be allowed for total distance covered in Kms and 25% above the rates in Hard Area. The rates for carriage by boat or streamer shall be the same as by any other mechanical means on land.

The Measurement and payment for the carriage of materials including loading unloading and stacking shall be made corresponding to CSR items as provided in Contract Agreement and shall constitute full compensation for performance and completion of work in all respects as specified and approved by the Engineer-in-Charge. No additional payment shall be made to Contractor for charges like demurrage, wharf age, toll tax, zila tax etc.

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2. LOADING, UNLOADING AND STACKING

2.1.1 SCOPE

Scope of work shall include the loading into trucks from specified sites or stockpiles (or unloading as the case may be) as provided in the Contract Agreement and approved by the Engineer-in-Charge.

2.1.2 REQUIREMENTS

a) The Contractor shall furnish, install, operate and maintain all necessary facilities for loading/unloading trucks.

b) The Contractor shall perform all loading/unloading operations in a systematic manner without breakages or segregation as determined by the Engineer-in-Charge and that the cement bags and such other materials do not catch moisture and will not be contaminated with soil or other foreign material. Contractor shall load trucks in which materials are to be transported in such a manner as to avoid loss in transit and shall be responsible for and make good any loss of materials lost in transit due to improper loading of mobile trucks and other handing operations. The materials carted shall be properly stacked as specified or directed by the Engineer-in-Charge.

2.1.3 STACKING AND STORAGE OF MATERIALS

2.1.3.1 Cement

a) Cement shall be stored at the work site in a building or a shed which is dry, leakproof and as moisture proof as possible. The building or shed for storage should have minimum number of windows and close fitting doors and these should be kept closed as far as possible.

Cement shall be stored and stacked in bags and shall be kept free from the possibility of any dampness or moisture coming in contact with them. Cement bags shall be stacked off the floor on wooden planks in such a way as to keep about 150 mm to 200 mm clear above the floor. The floor may comprise of lean cement concrete or two layers of dry bricks laid on well consolidated earth. A space of 600 mm minimum shall be left all around between the exterior walls and the stacks.

In the stacks the cement bags shall be kept close together to reduce circulation of air as much as possible. Owing to pressure on the bottom layer of bags sometimes 'warehouse pack' is developed in these bags. This can be removed easily by rolling the bags when the cement is taken out for use. Lumbed bags, if any should be removed and disposed off.

b) The height of stack shall not be more than 10 bags to prevent the possibility of lumping up under pressure. The width of the stack shall be not more than four bags length or 3 metres. In stacks more than 8 bags high, the cement bags shall be arranged alternately length-wise and cross-wise so as to tie the stacks together and minimize the danger of topping over. Cement bags shall be stacked in a manner to facilitate their removal and use in the order in which they are received; a label showing date of receipt of cement shall be put on each stack to know the age of cement.

c) Extra safety shall be exercised in coastal areas, or when it is expected to store for an unusually long period, the stack shall be completely enclosed by a water proofing membrane such as polyethylene, which shall close on the top of the stack. Care shall be taken to see that the waterproofing membrane is not damaged any time during use.

2.1.4 BRICKS

Bricks shall be stacked in regular tiers as and when they are unloaded to minimize breakage and defacement. These shall not be dumped at site.

Bricks stacks shall be placed close to the site of work so that least effort is required to unload and transport the bricks again by loading on pallets or in barrows. Building bricks shall be loaded or unloaded a pair at a time unless palletized. Unloading of building bricks or handling in any other way likely to damage the corners or edges or other parts of bricks shall not be permitted.

Bricks shall be stacked on dry firm ground. For proper inspection of quality and ease in counting the stacks shall be 50 bricks long, 10 bricks high and not more than 4 bricks in width, the bricks being placed on edge, two at a time along the width of the stack. Clear distance between adjacent stacks shall not be less than 0.8 m. Bricks of each truck load shall be put in one stack.

2.1.5 BLOCKS

Blocks shall be unloaded one at a time and stacked in regular tiers to minimize breakage and defacement. These shall not be dumped at site. The height of the stack shall not be more than 1.2 m. The length of the stack shall not be more than 3.0 m, as far as possible and the width shall be of two or three blocks.

Normally blocks cured for 28 days only should be received at site. In case blocks cured for less than 28 days are received, these shall be stacked separately. All blocks should be water cured for 10 to 14 days and air cured for another 15 days; thus no blocks with less than 28 days curing shall be used in building construction. The date of manufacture of the blocks shall be suitably marked on the stacks of blocks manufactured at factory or site.

2.1.6 FLOOR, WALL AND ROOF TILES

Floor and wall roof tiles of different types, such as, cement concrete tiles (plain, coloured and terrazzo),ceramic tiles (glazed and unglazed) and Porcelain tiles shall be stacked on regular platform as far as possible under cover in proper layers and in tiers and they shall not be dumped in heaps. In the stack, the tiles shall be so placed that the mould surface of one faces that of another. Height of the stack shall not be more than one metre. During unloading, these shall be handled carefully so as to avoid breakage.

Tiles of different quality, size and thickness shall be stacked separately to facilitate easy removal for use in work. Ceramic tiles and clay roof tiles are generally supplied in cartons which shall be handled with care. It is preferable to transport these at the site on platform trolleys.

2.1.7 AGGREGATES

Aggregates shall be stored at site on a hard dry and level patch of ground. If such a surface is not available, a platform of old corrugated iron sheets, or a floor of bricks, or a thin layer of lean concrete shall be made so as to prevent contamination with clay, dust, vegetable and other foreign matter Stacks of fine and coarse aggregates shall be kept in separate stock piles it sufficient distance from each other to prevent the material at the edges of the piles from getting intermixed. On a large job, it is desirable to construct dividing walls to give each type of aggregates its own compartment. Fine aggregates shall be stacked in a place where loss due to the effect of wind is minimum.

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2.1.8 STEEL

For each classification of steel, separate areas shall be earmarked. It is desirable that ends of bars and sections of each class be painted in distinct separate colours. Steel reinforcement shall ordinarily be stored in such a way as to avoid distortion and to prevent deterioration and corrosion. It is desirable to coat reinforcement with cement wash before stacking to prevent scaling and rusting. Bars of different classification, sizes and lengths shall be stored separately to facilitate issues in such sizes and lengths so as to minimize wastage in cutting from standard lengths. In case of long storage, reinforcement bars shall be stacked above ground level by atleast 150 mm. Moreover, in coastal areas or in case of long storage a coat of cement wash shall be given to prevent scaling and rusting.

Structural steel of different classification, sizes and lengths shall be stored separately. It shall be stored above ground level by at least 150 mm upon platforms, suitable supports to avoid distortion of sections. In coastal areas or in case of long storage suitable protective coating of primer paint shall be given to prevent scaling and rusting.

2.1.9 ALUMINIUM SECTIONS

Aluminium sections of different classification, sizes and lengths shall be stored separately, on a level platform under cover. The aluminium sections shall not be pulled or pushed from the stack nor shall be slided over each other, to protect the anodizing layer.

2.1.10 DOORS, WINDOWS AND VENTILATORS

While unloading, shifting handling and stacking timber material, metal and plastic door and window frames and shutters, care shall be taken that the material is not dragged one over the other as it may cause damage to the surface of the material. The material should be lifted and carried preferably flat avoiding damage of corners or sides. Metal and plastic doors, windows and ventilators shall be stacked upright (on their sills) on level ground preferably on wooden battens and shall not come in contact with dirt and ashes.

Metal and plastic frames of doors, windows and ventilators shall be stacked upside down. These shall not be allowed to stand for long in this manner before being fixed so as to avoid the door frames getting out of shape and hinges being strained and shutters drooping.

During the period of storage all metal doors, windows and ventilators shall be protected from loose cement and mortar by suitable covering such as tarpauline. The tarpauline shall be hung loosely on temporary framing to permit circulation of air to prevent condensation.

All timber based frames and shutters shall be stored in a dry and clean covered space away from any infestation and dampness. The storage shall preferably be in well ventilated dry rooms. The frames shall be stacked one over the other in vertical stacks with cross battens at regular distances to keep the stack vertical and straight. These cross battens should be of uniform thickness and placed vertically one above the other. The door shutters shall be stacked in the form of clean vertical stacks over the other and at least 80 mm above ground on pallets or suitable beams or rafters. The top of the stack shall be covered by a protecting cover and weighted down by means of scantlings or other suitable weights. The shutter stack shall rest on hard and level ground.

If any timber based frame or shutter becomes wet during transit, it shall be kept separate from the undamaged material. The wet material may be dried by stacking in shade with battens in between adjacent boards with free access of dry air generally. Separate stacks shall be built up for each size and type of material. When materials of different sizes and types are to be stacked in one stack due to shortage of space, the bigger size shall be stacked in the lower portion of the stacks. Suitable pallets or separating battens shall be kept in between the two types of material.

2.1.11 ROOFING SHEETS

Plastic sheets and Fibre glass sheets shall be stacked under a shed to a height of not more than 0.5 m on a firm and level ground with timber or other packing beneath them.

2.1.12 GYPSUM BOARDS, PLYWOOD, FIBREBOARD, PARTICLE BOARD, BLOCK BOARD.

These boards shall be stored flat in a covered clean and dry place. Different sizes and types of each of these boards shall be stacked separately. The board shall be stacked on a flat platform on which a wooden frame shall be constructed with 50 mm x 25 mm battens in such a way that it will give support to all four edges and corners of the boards with intermediate battens placed at suitable intervals to avoid warping. Boards shall be stacked in a solid block in a clear vertical alignment. The top sheet of each stack shall be suitably weighed down to prevent warping wherever necessary. The boards shall be unloaded and stacked with utmost care avoiding damage to the corners and surface. In case of decorative plywood and decorative boards, the surfaces of which are likely to get damaged by dragging one sheet over another it is advisable that these are lifted as far as possible in pairs facing each other.

2.1.13 GLASS SHEETS

It is important that all glass sheets whether stored in crates or not shall be kept dry. Suitable covered storage space shall be provided for the safe storage of the glass sheets. In removing glass sheets from crates, great care shall be taken to avoid damages. The glass sheets shall be lifted and stored on its long edges against a vertical wall or other support with the first sheet so placed that its bottom edge is 25 mm from the vertical support. The stacks shall be of not more than 25 panes and shall be supported at two points by fillets of wood at 300 mm from each end. The whole stack shall be as close and as upright as possible.

The glass sheets of different sizes, thickness and type shall be stacked separately. The distance between any two stacks shall be of the order of 400 mm.

2.1.14 CAST IRON, GALVANIZED IRON AND NON -ASBESTOS FIBRE CEMENT PIPES AND FITTINGS

The pipes shall be unloaded where they are required when the trenches are ready to receive them. Storage shall be done on firm, level and clear ground and wedges shall be provided at the bottom layer to keep the stack stable.

The stack shall be in pyramid shape or the pipes length-wise and cross-wise in alternate layers. The pyramid stack is advisable in smaller diameter pipes for conserving space in storing them.

The height of the stack shall not exceed 1.5 m. Each stack shall contain only pipes of same class and size, with consignment or batch number marked on it with particulars of suppliers wherever possible.

Cast iron detachable joints and fittings shall be stacked under cover separately from the asbestos cement pipes and fittings

2.1.15 UNPLASTICIZED PVC PIPES

The pipe should be given adequate support at all times. Pipes should be stored on a reasonably flat surface free from stones and sharp projections so that the pipe is supported throughout its length. In storage, pipe racks should be avoided. Pipe should not be stacked in large piles, especially under warm temperature conditions as the bottom pipes may distort, thus giving rise to difficulty in jointing. Socket and spigot pipes should be stacked in layers with sockets placed at alternate ends of the stacks to avoid lopsided stacks.

It is recommended not to store pipe inside another pipe. Pipe should not be stored in a stressed or bent condition or near the sources of heat. Pipes should not be stacked more than 1.5 m high. Pipes of different sizes and classes should be stacked separately.

The ends of pipe should be protected from abrasion particularly those specially prepared for jointing either spigot or socket solvent welded joints or shouldered for use with couplings.

In Dry and Hot conditions, pipes should be stored in shade. In very cold weather, the impact strength of PVC is reduced making it brittle and more care in handling shall be exercised in wintry condition. If due to unsatisfactory storage of handling a pipe becomes kinked, the damaged portion should be cut out completely. Kinking is likely to occur only on very thin walled pipes.

2.1.16 BITUMEN, ROAD TAR, ASPHALT, ETC.

All types of bitumen, road tar, asphalt, etc, in drums or containers shall be stacked vertically on their bottoms in upto 3 tiers. Leaky drums shall be segregated. Empty drums shall be stored in pyramidal stacks neatly in rows.

2.1.17 WATER

Wherever water is to be stored for construction purposes this shall be done in proper storage tanks to prevent any organic impurities getting mixed up with it.

2.1.18 OIL PAINTS

All containers of paints, thinners and allied materials shall preferably be stored in a separate room on floors with sand cushions. The room shall be well-ventilated and free from excessive heat, sparks of flame and direct rays of sun. The containers of paint shall be kept covered or properly fitted with lid and shall not be kept open except while using. The containers of paints have expiry date marked by the manufacturers, which should be highlighted so as to facilitate use of paint within due period.

2.1.19 SANITARY APPLIANCES

All sanitary appliances shall be carefully stored under cover to prevent damage. When accepting and storing appliances, advance planning shall be made regarding the sequence of removal from the store to the assembly positions. Supporting brackets shall be so stored as to be readily accessible for use with the appliances.

2.1.20 OTHER MATERIALS

Small articles like nails, screws, nuts and bolts, door and window fittings, polishing stones, protective clothing, spare parts of machinery, linings, packing, water supply and sanitary fittings, electrical fittings, insulation board, etc, shall be kept in suitable and properly protected store rooms. Valuable small material such as, copper pipes and fittings shall be kept under lock and key.

2.2 MEASUREMENT AND PAYMENT

The Employer will not be responsible for possible damage of any material, equipment or system during loading, unloading or transportation of goods to the site of works.
The Contractor shall replace any damage goods at his own expense without additional cost to the Employer.
Measurement and payment for loading/unloading into trucks and stacking shall be made corresponding to CSR item as provided in the Contract Agreement and shall constitute full compensation for performance and completion of work in all respect as specified and approved by the Engineer-in-Charge.

Length, breadth and height of stacks shall be measured correct to a cm. The quantity shall be worked out in cubic metre correct to two place of decimal. The volume of stacks shall be reduced by percentages as shown against each for looseness in stacking to arrive at the net quantity for payment. No reduction shall be made in respect of articles or materials for which mode of payment is by length or weight or number.

2.2.1 EARTH

a) In loose stacks such as cart loads, lorry loads, etc. – 20%
b) In fills consolidated by light mechanical machinery – 10%
c) In fills consolidated by heavy mechanical machinery but not under OMC (Optimum Moisture Content) – 5%
d) In fills consolidated by heavy mechanical machinery at OMC – Nil
e) Consolidated fills in confined situation such as under floors. etc. – Nil

2.2.2 OTHER MATERIALS

a) Manure or sludge – 8%
b) Moorum, building rubbish Lime and sand – Nil
c) Stone metal, 40 mm nominal size and above – 7.5%
d) Coarse aggregate/ stone metal below 40 mm nominal size – Nil
e) Soling stone/ Boulder 100 mm and above – 15%
f) Excavated rocks – 50%

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3. EARTHWORK

3. EARTHWORK

3.0. SCOPE

Earth work shall include furnishing of all labour, material, tools, plants, equipment, instruments and services for;

a) Excavation and formation of embankment in all types of soils. It also covers lifting and transporting excavated material. Suitable material intended for use as backfill shall be placed in temporary stockpiles. All other excavated material shall be placed in spoil banks. These works shall be performed and executed by the Contractor in accordance with stipulations and requirements set forth herein which shall apply except when they are specifically modified in writing by the Engineer-in-Charge for any particular item. The method of carrying out earthwork shall be subject to approval of the Engineer-in-Charge in writing.

b) Fill and backfill using selected excavated material or imported material obtained from approved sources or by blending the excavated and imported materials.

c) Before commencement and during the execution of works, the Contractor shall be responsible for surveys, layout and their maintenance for execution of works according to contract and as approved by the Engineer-in-Charge-

d) Compaction of fill and backfill.

3.1. CODES AND STANDARDS

The following Codes and Standards shall be followed wherever relevant and as directed by the Engineer-in-Charge.

ASTM D-1556-74 Test for density of soil in place by the sand cone method.

ASTM D-1557-78 Test for moisture-density relations of soils and soil aggregate moisture using 4.5 Kg rammer and 457 mm drop.

B.S 1377-75 Methods of tests for soils for civil engineering purposes.

3.2. CLASSIFICATION OF SOILS

The earthwork shall be classified under the following categories and measured separately for each category:

3.2.1 SOFT SOIL

It shall include all cutting in sand, silt and those soils which offer no resistance to excavation and sometime requires shoring when foundation of exact dimensions are required to be excavated having small angle of repose. Ordinary kassi, shovels or spade can be used for excavation in such type of soils.

3.2.2 ORDINARY SOIL

It includes cutting in earth which in general can be ploughed, irrespective of the fact whether picks or “pkawrahs” have been used in actual excavation.

Generally, the ordinary soils comprise of:

- Spoil or rubbish of every description.
- Earth and sandy loam
- Any other formation into which a shovel can be entered with foot pressure and can be easily excavated by the application of Kassi, pick or showel.

3.2.3 MURUM AND HARD SOILS

There are the following two types of hard soils:

It includes a stiff and heavy clay soil having specific gravity of 1.5 and above, which can be dug with repeated blows of kassi or pick axe.
Soil having small percentage, say up to 15, of kankar or boulders which can be dug and removed along with the soil.
It includes hard murum with high percentage of kankar (More than 15%) or (Less than 20%) which can be individually lifted by hand.

3.2.4 SHINGLE AND GRAVEL/GRAVELLY SOIL

This Includes;

(I) Gravel Formation
(II) Large Boulders Above 20 Percent Which Can Be Individually Lifted By Hand
(III) Soils which contain more than 50% of larger than 1-2'' size particles of gravel and kankar etc., and is such as can be removed with a spade i.e. is in a semi compact state and requires more labour to excavate than the soft or hard soil will be classed as gravelly soil, stretches where gravel may be found in a loose state which can be picked up by spade or can be easily removed with pick axe as hard soil will not be classed as gravelly soil but as soil or hard soil as the case may be.

3.2.5 WET SOIL

Wet soil or slush when so composed that it cannot support weight of labourer working in to the pit and excavated material sticks to the implements used for digging shall be identified and paid for separately.

3.3. ANTIQUITIES AND USEFUL MATERIALS

Any as ancient carvings, relics of antiquity, coins, fossils or other articles of archaeological value discovered or excavated during progress of work shall be delivered to the Engineer-in-Charge and shall be the property of the Government.
In case of archaeological monuments are found within the area, the contractor shall take such measures such as fencing etc. to secure these items as directed by the Engineer-in-Charge and protect the same properly during execution of works. Payment for providing fencing etc. shall be made separately.

3.4. PROTECTIONS

The Contractor shall so control his operations as to prevent damage to shrubs, which are to be preserved. Protections may include fence and boards latched to shrubs, to prevent damage from machine operations. Any damage as a result of Contractor's operations shall immediately be rectified by the Contractor at his own expense.
Excavation where directed by the Engineer-in-Charge shall be securely barricaded and provided with proper caution signs, conspicuously displayed during the day and properly illuminated with red lights and/or written using fluorescent reflective paint during the night to avoid accident. The Contractor shall take adequate protective measures to see

that the excavation operations do not damage the adjoining structures or dislocate the services. Water supply pipes, sluice valve chambers, sewerage pipes, manholes, drainage pipes and chambers, communication cables, power supply cables etc. met within the course of excavation shall be properly supported and adequately protected, so that these services remain functional. However, if any service is damaged during excavation shall be restored in reasonable time by the Contractor with approval of Engineer-in-Charge.

Excavation shall not be carried out below the foundation level of the adjacent buildings until underpinning, shoring etc. is done as per the directions of the Engineer-in-Charge. Any damages done by the contractor to any existing work shall be made good by him at his own cost. Existing drains, pipes, culverts, overhead wires, water supply lines and similar services encountered during the course of execution shall be protected against damage by the tools and/ or equipment used during the excavation. The contractor shall not store material or otherwise occupy any part of the site in manner likely to hinder the operations of such services.

3.5. SETTING OUT AND SITE PREPARATION

The Contractor shall set out the Works and shall be responsible for true and perfect setting out of the same and for correctness of the positions, levels, dimensions and alignments of all parts thereof. If at any time any error in this respect shall appear the Contractor shall at his own expense rectify such error, to the satisfaction of the Engineer-in-Charge.

The bench marks or datum for setting out the Works will be provided by the Engineer-in-Charge. The Contractor shall however maintain accurate bench marks and survey monuments so that the lines and levels can be easily checked by the Engineer-in-Charge.

The Contractor shall perform a joint survey with the Engineer-in-Charge, of the area where earthwork is required, plot the ground levels on the Drawings and obtain approval from the Engineer-in-Charge before starting the earthwork.

Before the earthwork is started, the area coming under cutting and filling shall be cleared of shrubs, rank vegetation, grass, brushwood, trees saplings and removed directed by Engineer-in-Charge. The roots of trees and saplings shall be removed to a depth of 60 cm below ground level or 30 cm below formation level or 15 cm below sub grade level, whichever is lower, and the holes or hollows filled up with the suitable material as specified by the Engineer-in-Charge, rammed and levelled.

3.6. SUBMITTALS

a) Records of Excavation

Ground elevation shall be taken at specified intervals duly witnessed by the Engineer-in-Charge immediately after the Contractor has completed the under listed jobs.

Clearing, grubbing including removal of 150 mm top surface soil, cutting and removal of unwanted trees, stumps and roots of trees complete as per instructions of the Engineer-in-Charge.

The layout and levels will constitute the basis for measurements and shall be submitted for necessary approval to the Engineer-in-Charge prior to commencement of Work. Prior to cleaning and grubbing natural ground levels should be taken and submitted to Engineer-in-Charge for the record.

b) Records of Fill

The Contractor shall submit to the Engineer-in-Charge within 7 days of the completion of the respective survey work:
Contractor's record of foundation layout and levels taken prior to placement of fill duly witnessed and signed by the Engineer-in-Charge.
Drawings showing layout plan and sections showing elevations before and after the fill.

c) Records of Tests

The Contractor shall submit the following to the Engineer-in-Charge for his review and approval.
Laboratory test results as specified by the Engineer-in-Charge.
Field density test result for compaction, max dry density and relative density.

d) Methodology

The Contractor shall submit the following to the Engineer-in-Charge for his review and approval before starting Earthwork. Proposed sources of fill material and samples of proposed fill. Details of plant, equipment and method of excavation, fill and compaction.
Proposal for dewatering the areas of excavation.

3.7. EXCAVATION IN ALL KINDS OF SOILS

3.7.1 EXCAVATION OPERATIONS

All excavation operations manually or by mechanical means shall include excavation and disposal of the excavated material for canals, drains foundations, buildings foundations, trenches, basements, water tanks sewers and manholes; including excavation in hard soils and under water etc. The work shall include of depositing the excavated materials as specified. The disposal of the excavated material beyond free lead shall be either stated as a separate item or included with the items of excavation stating lead. During the excavation the natural drainage of the area shall be maintained. Excavation shall be done from top to bottom. Undermining or undercutting shall not be done.

In firm soils, the sides of the excavations shall be kept vertical up to a depth of 2 meters from the bottom. For greater depths, the excavation profiles shall be widened by allowing steps of 50 cms on either side after every 2 metres from the bottom. Alternatively, the excavation can be done so as to give slope of 1:4 (1 horz.: 4 vert.). Where the soil is soft, lose or slushy, the width of steps shall be suitably increased or sides sloped or the soil shored up as directed by the Engineer-in-Charge-. It shall be the responsibility of the contractor to prepare proposals for the stepping, sloping or shoring as required for excavation for various depths, moreover in case of deep foundation the proposal shall contain all safety arrangements which will be bear by the contractor at his own cost. The work shall be executed only after the proposal is approved by the Engineer-in-Charge.

The excavation shall be done true to levels, slope, shape and pattern as per drawings and directed by the Engineer-in-Charge. Only the excavation shown on the drawings or as approved by the Engineer-in-Charge- shall be measured for payment. No separate measurement and payment shall be made for excavation, centring, shuttering and for contractor's convenience.

For excavation in foundation in trenches and other like areas, the bed of excavations shall be to the correct level or slope and consolidated by watering and ramming and other means when necessary. If the excavation is done to a depth greater than that shown in the drawings unless it is required by the Engineer-in-Charge-, the excess depth shall be made good by the contractor at his own cost with the concrete of the mix used for levelling/ bed concrete for foundations. Soft/defective spots at the bed of the foundations shall be dug out and filled with concrete (to be paid separately) as directed by the Engineer-in-Charge.

While carrying out the excavation for drain work care shall be taken to cut the side and bottom to the required shape, slope and gradient. The surface shall then be properly dressed. If the excavation is done to a depth greater than that shown on the drawing or as required by the Engineer-in-Charge, the excess depth shall be made good by the contractor at his own cost with stiff clay puddle at places where the drains are required to be pitched and with ordinary earth, properly watered and rammed, where the drains are not required to be pitched. In case the drain is required to be pitched, the back filling with clay puddle, if required, shall be done simultaneously as the pitching work proceeds. The brick pitched storm water drains should be avoided as far as possible in filled-up areas and loose soils.

In all other cases where the excavation is taken deeper by the contractor, it shall be brought to the required level by the contractor at his own cost by filling in with earth duly watered, consolidated and rammed. In case the excavation is done wider than that shown on the drawings or as required by the Engineer-in-Charge, additional filling wherever required on that account shall be done by the contractor at his own cost.
The excavation shall be done manually or by mechanical means as proposed by the contractor and approved by Engineer-in-Charge considering feasibility, urgency of work, availability of labour/mechanical equipment's construction completion programme and other factors involved. Contractor shall ensure the safety measures for the workers fully complying with recognised procedures and state laws.

3.7.2 DISPOSAL OF EXCAVATED MATERIALS

The free lead for disposal of excavated materials where stated in the "Schedule of Quantities" against various items is the average lead for the disposal of excavated earth within the site of work. The subsequent disposal of the excavated material where required shall be either stated as a separate item or included with the item of excavation stating lead. The actual lead for the disposal of earth beyond free lead shall be measured for payment appropriately. The excavated earth shall be disposed of at the locations proposed by the Contactor and approved by the Engineer-in-Charge-. The contractor has to take written permission about place of disposal of earth before the earth is disposed of, from Engineer-in-Charge.

3.8. EXCAVATION IN ORDINARY / HARD ROCK

3.8.1 GENERAL

All excavation operations shall include excavation and disposal of the excavated material as shown on drawings and approved by the Engineer-in-Charge-. In case of excavation for trenches, basements, water tanks etc. the excavation shall include disposal of the excavated materials within free lead as specified. The disposal of the excavated material beyond free lead shall be stated as a separate item unless it is included with the item of excavation. During excavation, the natural drainage of the area shall be maintained; Excavation shall be done from top to bottom. Undermining or under cutting shall not be done.

3.8.2 ORDINARY / SOFT ROCK

The ordinary rock excavation shall be carried out by crowbars, pick axes or pneumatic drills and blasting operation shall not be generally adopted. Where blasting operations are not prohibited and it is practicable to resort to blasting for excavation in ordinary rock, contractor may do so with the permission of the Engineer-in-Charge in writing but nothing extra shall be paid for this blasting. Blasting shall be done as specified hereof.

If the required excavation is done to a depth greater than that shown in the drawings or as required by the Engineer-in-Charge, the excess depth shall be made good by the contractor at his own cost with the concrete of the mix used for levelling/ bed concrete for foundations. Soft/ defective spots at the bed of foundations shall be dug out and filled with concrete (to be paid separately) as directed by the Engineer-in-Charge.

In case the excavation is done wider than that shown on the drawings or as required by the Engineer-in-Charge, filling wherever required on this account shall be done by the contractor at his own cost. Only the excavation shown on the drawings or as required by the Engineer-in-Charge shall be measured and recorded for payment except in case of hard rock, where blasting operations have been resorted to, excavation shall be measured to the actual levels, provided the Engineer-in-Charge is satisfied that the contractor has not gone deeper than what was unavoidable.

3.8.3 HARD ROCK

a) General

Where hard rock is met with and blasting operations are considered necessary, the contractor shall obtain the approval of the Engineer-in-Charge in writing for resorting to the blasting operations. Blasting operations shall be done as specified and chiselling and/ or drilling holes shall be done to obtain correct levels, slopes, shape and pattern of excavation as per the drawings or as required by the Engineer-in-Charge and nothing extra shall be payable for chiselling.

The Contractor shall submit in advance a complete plan of the area requiring blasting, estimated quantity of rock to be blasted, nature of rock, blasting charge required with complete calculations, sequence of blasting for overall area and for daily operations, safety measures and qualification and experience of contractor's staff deputed for the work

.

The Contractor shall be fully responsible for all operations and ensure safety of the works, personnel and adjoining structures/ public property.

Any approval of the Engineer-in-Charge shall not relieve the Contractor of his responsibilities mentioned herein.

b) Blasting

Blasting operations shall be carried out under the supervision of a responsible licensed blasting authorized agent of the contractor (referred as agent), during specified hours as approved in writing by the Engineer-in-Charge. The agent shall be conversant with the rules of blasting notified by Government from time to time. All blasting operations shall be carried out with due regard to safety regulations in force.

Where explosives are used the Contractor shall provide suitable buildings or warehouse in approved positions for the storage of explosives, which shall be stored in the manner and quantity approved by the Engineer-in-Charge or as per relative laws of government. Such storage place shall be accessible only to authorized personnel. They shall be properly marked, all doors or accesses thereto shall be constructed of materials as directed by the Engineer-in-Charge and provided with secure locks and all necessary means for preventing access by unauthorized persons.

The contractor shall be responsible for prevention of any unauthorized issued or improper use of any explosives. The handling of explosives shall be entrusted only to experienced and responsible men, to the satisfaction of the Engineer-in-Charge and in conformity with the statutory regulations.

All procedures and safety precautions for the use of explosives drilling and loading of explosives drilling and loading of explosives before and after shot firing and disposal of explosives shall be taken by the contractor in accordance with safety code for blasting and related drilling operation.

For blasting with dynamite or any other high explosive, the position of all the bore holes to be drilled shall be marked in circles with white paint. These shall be inspected by the contractor’s agent. Bore holes shall be of a size that the cartridge can easily pass down. After the drilling operation, the agent shall inspect the holes to ensure that drilling has been done only at the marked locations and no extra hole has been drilled. The agent shall then prepare the necessary charge separately for each bore hole. The bore holes shall be thoroughly cleaned before a cartridge is inserted. Only cylindrical wooden tamping rods shall be used for tamping. Metal rods or rods having pointed ends shall never be used for tamping. One cartridge shall be placed in the bore hole and gently pressed but not rammed down. Other cartridges shall then be added as may be required to make up the necessary charge for the bore hole. The top most cartridge shall be connected to the detonator which shall in turn be connected to the safety fuses of required length. All fuses shall be cut to the length required before being inserted into the holes. Joints in fuses shall be avoided. Where joints are unavoidable a semi-circular nitch shall be cut in one piece of fuse about 2 cm deep from the end and the end of another piece inserted into the nitch. The two pieces shall then be wrapped together with string. All joints exposed to dampness shall be wrapped with rubber tape.

The maximum of eight bore holes shall be loaded and fired at one occasion. The charges shall be fired successively and not simultaneously. Immediately before firing, warning shall be given and the agent shall see that all persons have retired to a place of safety. The safety fuses of the charged holes shall be ignited in the presence of the agent, who shall see that all the fuses are properly ignited.

Careful count shall be kept by the agent and others of each blast as it explodes. In case all the charged bore holes have exploded, the agent shall inspect the site soon after the blast but in case of misfire the agent shall inspect the site after half an hour and mark red crosses (X) over the holes which have not exploded. During this interval of half an hour, nobody shall approach the misfired holes. No driller shall work near such bore until either of the following operations has been done by the agent for the misfired boreholes.

The contractor’s agent shall very carefully (when the tamping is of damp clay) extract the tamping with a wooden scraper and withdraw the fuse, primer and detonator. After this a fresh detonator, primer and fuse shall be placed in the misfired holes and fired, or the holes shall be cleaned for 30 cm of tamping and its direction ascertained by placing a stick in the hole. Another hole shall then be drilled 15 cm. away and parallel to it. This hole shall be charged and fired. The misfired holes shall also explode along with the new one.

Before leaving the site of work, the agent of one shift shall inform the another agent relieving him for the next shift, of any case of misfire and each such location shall be jointly inspected and the action to be taken in the matter shall be explained to the relieving agent. The Engineer-in-Charge shall also be informed by the agent of all cases of misfires, their causes and steps taken in that connection.

c) General Precautions

All drilling and blasting shall be done in such a manner as to bring the excavation as close as possible to the required cross-section and to disturb as little as possible the material to be left in place. Blasting by means of drill holes, tunnels, or any other method shall be performed at the entire risk and responsibility of the Contractor who shall have no claim to payment for extra work occasioned by breakage outside the approved cross-sections or dimensions.

The greatest care shall be taken by the Contractor during all blasting operations to ensure that no injury be done to persons or damage to property or to the finished work. Shots shall be properly loaded and capped and only a moderate charge shall be used in each hole. A record of all explosives used, showing locations and amounts, shall be kept by the Contractor for checking by the Engineer-in-Charge.

Where directed by the Engineer-in-Charge, the Contractor shall provide heavy mesh blasting mat for protection of persons, property and the work. If necessary, blasting shall be restricted to time prescribed by the Engineer-in-Charge.

For the safety of persons red flags shall be prominently displayed around the area where blasting operations are to be carried out. All the workers at site, except those who actually ignite the fuse, shall withdraw to a safe distance of at least 200 meters from the blasting site. Audio warning by blowing whistle shall be given before igniting the fuse.

Blasting work shall be done under careful supervision and trained personnel employed by the Contractor. Blasting shall not be done within 200 metres of an existing structure, unless specifically permitted by the Engineer-in-Charge in writing.

d) Precautions against misfire

The safety fuse shall be cut in an oblique direction with a knife. All saw dust shall be cleared from inside of the detonator. This can be done by blowing down the detonator and tapping the open end. No tools shall be inserted into the detonator for this purpose.
If there is water present or if the bore hole is damp, the junction of the fuse and detonator shall be made water tight by means of tough grease or any other suitable material.
The detonator shall be inserted into the cartridge so that about one third of the copper tube is left exposed outside the explosive. The safety fuse just above the detonator shall be securely tied in position in the cartridge. Water proof fuse only shall be used in the damp bore hole or when water is present in the bore hole.

If a misfire has been found to be due to defective fuse, detonator or dynamite, the entire consignment from which the fuse detonator or dynamite was taken shall be got inspected by the Engineer-in-Charge or his authorized representative before resuming the blasting or returning the consignment.

3.9. EXCAVATION & GRADING OF ROCKS

a) Excavation Methods for Rock

The Method relates to rock strength and fracture density.
Direct excavation: possible in fractured lock and in all soils; using face shovel, backhoe, clam shell grab or dragline.
Ripping: needed to break up slightly stronger rock, using tractor-mounted ripper, or breaking with boom-mounted hydraulic pick (pecker).
Blasting: generally required in stronger, less fractured rock. Rock is loosened in the ground by undercharged blasting in some quarries: on urban sites can be broken by hand-held pneumatic drill or by pecker. Massive rock of moderate or high strength needs to be fractured normally by blasting, where blasting is unacceptable, breaking by pecker or hydraulic breaker is very slow. shown in the Table given below, the excavation type and ranges with respect to UCS and Fracture spacing.

Excavation and Strength Properties of Rock

Grade	Material/Rock Type and name	U.C.S. (unconfined compressive strength) MPa	Dry Density t/m^3	Field Properties of Rocks	Work Type
I	Coal	2-100	1.4	Crumble under blows break with hammer and hand	Pick work/ Jumper work

	Gypsum	20-30	2.2	Dent by finger nail white in color	Jumper Work.
	Salt	5-20	2.1	Show cubical cleavage ductile deformation in stress	Jumper Work.
	Clay (Cretaceous)	1-4	1.8	Mold by finger, break by hammer if compacted.	Pick work.
II	Musdtone (Carboniferous)	10-50	2.3	Break by hammer crumble under pick blows. Break by hand.	Pick work/ Jumper work
	Shale (Carboniferous)	05-30	2.3		Pick work/ Jumper work
	Chalk (Carboniferous)	05-30	1.8		Jumper Work.
III	Limestone (carboniferous)	50-150	2.6	Moderately strong rock, break by hammer lime stone.	Jumper work / Blasting work.
	Dolomite	50-150	2.5		
IV	Gneiss	50-200	2.7	Strong break by hammer	Jumper work / Blasting work
	Marble	60-200	2.6	Moderately strong rock, break by hammer.	
	Schist	20-100	2.7		
	Slate	20-250	2.7	Ripping needs to break.	
V	Sandstone (Greywacke)	100-200	2.6	Blasting generally required.	Blasting work/ Chiseling
	Conglomerate	variable	variable	Ripping & blasting required if cemented conglomerate.	Jumper work / Blasting work.
	Weathered sandstone	5-40	1.9		
VI	Granite	50-350	2.7	Blasting, Chiseling and ripping required to break, very strong rocks. Mostly rocks are igneous and metamorphic.	Blasting work/ chiseling
	Basalt	100-350	2.9		
	Quartzite	100-350	2.7		Blasting Work.

b) Cut Slopes in Rock

Sound rock can be cut to vertical faces; normally raked back by 10° and benched at 10 m intervals to improve safety. Inclined fractures are main hazard, notably dipping 30-70° Dips> 50° normally required cutting face back to clean bedding or fracture. Shale beds may weather and undercut slopes in strong sandstone or limestone. Hillside excavations may undercut unstable weathered rock, old landslides or soliflucted head.

The Table given below shows tha ranges of stable cutting slopes in rock and soil.

Material	Cohesion	Critical Height, H	
		Un-fissured	Fissured
Soft Clay	25 KPa	5 m	3 m
Firm Clay	50 KPa	10 m	6 m
Stiff Clay	12 KPa	24 m	15 m

Values for typical fissure depth = z = 1.5 c/y

c) Cut Slopes in Clay

Drainage changes stability over time where face is cut into clay with initial water table near the surface. Excavation permits stress relief, pore water pressure (pwp) decreases. Pwp rises to regain equilibrium (drained state); strength and stability therefore decrease.
Slope ultimately drains (or is artificially drained) to new lower water table; reduced pwp then increases stability.

Premature failure occurs where stability is due to temporary pore water suction; failure maybe in minutes or hours so faces are battered back for longer safety. Clay, un-weathered, may cut to 65° slopes to 8 m high where small slips can be tolerated. Stiff glacial till may stand close to vertical for some months at less than critical height, so retaining walls can be built in front. Weep horizons on sand layers' cause instability. Lateral stress relief in slopes cut in over-consolidated clay may cause outward movement. Settlement adjacent to stable cut slope may be 1-2 % of excavation depth.

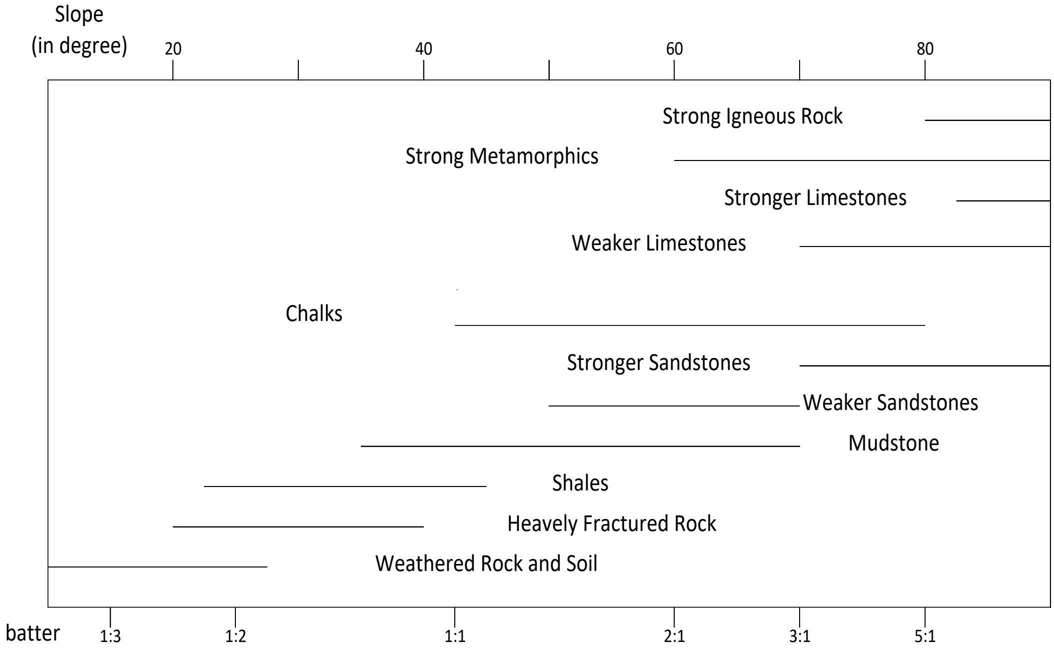


Fig 1:
Parameters for Stable Cutting Slopes in rocks and Soils

3.10. EXCAVATION IN OR UNDER WATER AND /OR LIQUID MUD

3.10.1 GENERAL

Excavation, where water is encountered shall fall in this category. Steady water level in the trial pits before the commencement of bailing or pumping operations shall be the sub-soil water level in that area. Planking and strutting or any other protection work done with the approval of the Engineer-in-Charge- to keep the trenches dry and/or to save the foundations against damage by corrosion of rise in water levels shall be measured and paid for separately. Bailing or pumping out water, accumulated in excavation, due to rains is included under respective items of earthwork and is not to be paid separately. In case item for dewatering is listed in the bid schedule, it will be paid as lump sum item and will constitute full compensation for all labour, equipment's, tools and all other items necessary and incidental to the completion of the work.

3.10.2 CARE OF WATER/ DEWATERING

All water that may accumulate in excavations during the progress of the work from springs, tidal or river seepage, broken water mains or drains (not due to the negligence of the contractor), and seepage from subsoil aquifer shall be bailed, pumped out or otherwise removed by the contractor. The contractor shall take adequate measures for bailing and/or pumping out water from excavations and/or pumping out water from excavations and construct diversion channels, bunds, sumps, coffer dams etc. as may b required. Pumping shall be done directly from the foundations or from a sump outside the excavation or any other appropriate method proposed by Contractor in advance of undertaking the work and approved by the Engineer-in-Charge- in such a manner as to preclude the possibility of movement of water through any fresh concrete or masonry and washing away parts of concrete or mortar. During laying of concrete or masonry and for a period of at least 24 hours thereafter, pumping shall be done from a suitable sump separated from concrete or masonry by effective means.
Capacity and number of pumps, location at which the pumps are to be installed, pumping hours etc. shall be proposed from time to time by the contractor and approved by the Engineer-in-Charge.

Pumping shall be done in such a way as not to cause damage to the work or adjoining property by subsidence etc. Disposal of water shall not cause inconvenience or nuisance in the area or cause damage to the property and structure nearby. To prevent slipping of sides, planking and strutting may also be done with the approval of the Engineer-in-Charge.

The approval by the Engineer-in-Charge of the Method Statement for pumping shall not relieve the contractor of his responsibility. The applicable extra unit rate for wet and underwater excavation of earthwork includes full compensation for performance of the work and no separate payment shall be allowed, in case item for dewatering in not listed in the bid separately.

3.10.3 MEASUREMENTS

The unit, namely, metre depth shall be the depth measured from the level of foul position/ sub- soil water level and upto the centre of gravity of the cross sectional area of excavation actually done in the conditions classified above. Metre depth shall be reckoned correct to 0.1 m, 0.05 m or more shall be taken as 0.1 m and less than 0.05 m ignored. The extra percentage rate is applicable in respect of each item but the measurements shall be limited only to the quantities of earth work actually executed in the conditions classified.

In case earth work in or under foul position is also in or under water and/or liquid mud, extra payment shall be admissible only for the earth work actually executed in or under foul position.

Pumping or bailing out water met within excavations from the sources specified in above where envisaged and specifically ordered in writing by the Engineer-in-Charge shall be measured separately and paid. Quantity of water shall be recorded in kilolitres correct to two places of decimal. This payment shall be in addition to the payment under respective items of earthwork and shall be admissible only when pumping or bailing out water has been specifically ordered by the Engineer-in-Charge in writing.

Planking and strutting or any other protection work done with the approval of the Engineer-in- Charge to keep the trenches dry and/or to save the foundations against damage by corrosion of rise in water levels shall be measured and paid for separately. Bailing or pumping out water, accumulated in excavation, due to rains is included under respective items of earthwork and is not to be paid separately.

3.11. FILLING

3.11.1. GENERAL

i. For fillings and embankment construction, the earth from excavation as far as practicable shall be directly used for filling and no payment for double handling of earth shall be admissible. All costs shall be deemed to be included in the unit rate for excavation.

ii. The earth used for filling and embankment construction shall be free from all roots, grass, shrubs, rank vegetation, brushwood, tress, sapling and rubbish. Filling with excavated earth shall be done in regular horizontal layers each not exceeding 20 cm in thickness unless otherwise specified or approved by the Engineer-in-Charge-. All lumps exceeding 8 cm in any direction shall be broken.

iii. Each layer shall be watered and consolidated with steel rammer or ½ tonne roller. Where specified, every third and top most layer shall also be consolidated with power roller of minimum 8 tonnes. Wherever depth of filling exceeds 1.5-meter vibratory power roller shall be used to consolidate the filing unless otherwise directed by Engineer-in-Charge. The top and sides of filling shall be neatly dressed. The contractor shall make good all subsidence and shrinkage in earth fillings, embankments, traverses etc. during execution and till the completion of work unless otherwise specified.

3.11.2. LARGE SCALE LEVELLING WORK

a) In case of large scale levelling work involving both cutting and filling, an accurate site plan shall be prepared before the work is commenced by contractor for approval of the Engineer-in-Charge. The portions requiring cutting and filling shall then be divided into squares and corresponding squares into filling, which are complementary to the squares in cutting giving the same number.

b) A table may be provided in the plan showing leads involved between the various complementary squares. This would form a lead chart for the work to be done.

c) Before the work of levelling is commenced, the lead chart shall be checked in the presence of the contractor or his authorized representative, and his signatures shall be obtained on the same. This should form an integral part of the contract and should be duly signed by both the integral parties before commencement of the work.

d) The payment for lead shall be based on lead chart prepared in the aforesaid manner.

3.11.3. BORROW SOIL

Materials required for fill and embankment construction not available from excavations be imported from pre-determined borrow areas approved by the Engineer-in-Charge- before the start of the work. Wherever feasible, the average lead should be worked out and stipulated in the tender.

The borrow area shall be stripped carefully of topsoil, sod and other matter unsuitable for fill. Surface of borrow areas shall be left after completion in a reasonable smooth and even condition approved by Engineer-in-Charge-.

The initial limits and levels of the area to be filled should be recorded and approved by Engineer-in-Charge-. The levels should be properly checked during the progress of work and on completion.

The borrow pits for canals & drains shall comply with the provisions of Clause 3.9.

AASHTO SOIL CLASSIFICATION SYSTEM.

AASHTO Soil Classification System table is as follows

ASSHTO SOIL Classification System											
General Classification	**Granular Materials 35% or less passing 200 Sieve (0.075 mm)**							**Silt-Clay Materials >35% passing 200 Sieve (0.075 mm)**			
Group Classification	**A-1**		**A-3**	**A-2**				**A-4**	**A-5**	**A-6**	**A-7**
	A-1-a	**A-1-b**		**A-2-4**	**A-2-5**	**A-2-6**	**A-2-7**				**A-7-5 A-7-6**
Sieve Analysis, % passing											
2.00 mm (No. 10)	50 max	–									
0.425 mm (No. 40)	30 max	50 max	51 max	–							
0.075 mm (No. 200)	15 max	25 max	10 max	35 max	35 max	35 max	35 max	36 min	36 min	36 min	36 min
Characteristics of friction passing 0.425 mm (No .40)											
Liquid Limit (LL)	–	–	40 max	41 min	40 max	41 min	41 min	40 max	41 min	40 max	41 min
Plasticity Index (PI)	6 max		N.P	10 max	10 max	11 min	11 min	10 max	10 max	11 min	11 min
Usual Types of significant constituent material	Stone fragments, gravel and		Fine sand	Silty or clayey gravel and sand				Silty soils		Clayey soils	

	sand				
General Rating as a sub-grade	Excellent to Good			Fair to poor	
PI of A-7-5 subgroup is equal to or less than LL-30			PI of A-7-6 subgroup is greater than LL-30		

Soil Classification as per ASTM D-2487-06 (Unified Soil Classification System based)

Criteria for Assigning Group Symbols and Group Names Using Lab Test [A]				**Soil Classification**	
				Group Symbol	**Group Name [B]**
Coarse-Grained Soils	Gravels	Cleans Gravels	Cu $ 4 and 1 # Cc #3[C]	GW	Well graded gravel [D]
More than 50 % Retained on No. 200 sieve	More than 50 % of coarse fraction retained on No. 4 sieve	Less than 5 % fines.[E]	Cu < 4 and/or 1 > Cc > 3 [C]	GP	Poorly graded gravel [D]
		Gravels with Fines	Fines classify as ML or MH	GM	Silty gravel [D,F,G]
		More than 12 % fines [E]	Fines classify as CL or CH	1>GC	Clayey gravel [D,F,G]
	Sands	Clean Sands	Cu $ 6 and 1 # Cc #3[C]	SW	Well graded sand [H]
	50 % or more of coarse	Less than 5 % fines [I]	Cu < 6 and/or 1 > Cc > 3 [C]	SP	Poorly graded sand[H]
	fraction passes No. 4 sieve	Sands with Fines	Fines classify as ML or MH	SM	Silty sand [F,G,H]
		More than 12 % Fines	Fines classify as CL or CH	SC	Clayey sand [F,G,H]
Fine Grained Soils	Silts and Clays	Inorganic	PI > 7 and plots on or above “A” line [J]	CL	Lean clay [K,L,M]
50 % or more passes No 200 Sieve	Liquid limit less than 50		PI < 4 or plots below “A” line [J]	ML	Silt [K,L,M]
		Organic	Liquid limit − oven Dried > < 0.75	OL	Organic clay [K,L,M,N]
			Liquid limit dried	OL	Organic silt [K,L,M,O]
	Silts & Clays	Inorganic	PI plots on or above “A” line	CH	Fat clay [K,L,M]
	Liquid limit 50 or more		PI plots below “A” line	MH	Elastic silt [K,L,M]
		Organic	Liquid limit − oven dried < 0.75	OH	Organic clay [K,L,M,P]
			Liquid limit- not dried		Organic silt [K,L,M,Q]
Highly Organic Soils	Primarily organic matter, dark in colour, and organic odour			PT	Peat

A Based on the material passing the 3-in. (75-mm) sieve.

B If field sample contained cobbles or boulders, or both, add “with cobbles or boulders, or both” to group name.

C Cu = D60/D10 Cc 5 ~D30^2/ (D10 x D60)

D If soil contains $15 % sand, add “with sand” to group name.

E Gravels with 5 to 12 % fines require dual symbols:

GW-GM well-graded gravel with silt
GW-GC well-graded gravel with clay
GP-GM poorly graded gravel with silt
GP-GC poorly graded gravel with clay

F If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

G If fines are organic, add “with organic fines” to group name.

H If soil contains $15 % gravel, add “with gravel” to group name.

I Sands with 5 to 12 % fines require dual symbols:

SW-SM well-graded sand with silt
SW-SC well-graded sand with clay
SP-SM poorly graded sand with silt
SP-SC poorly graded sand with clay

J If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.

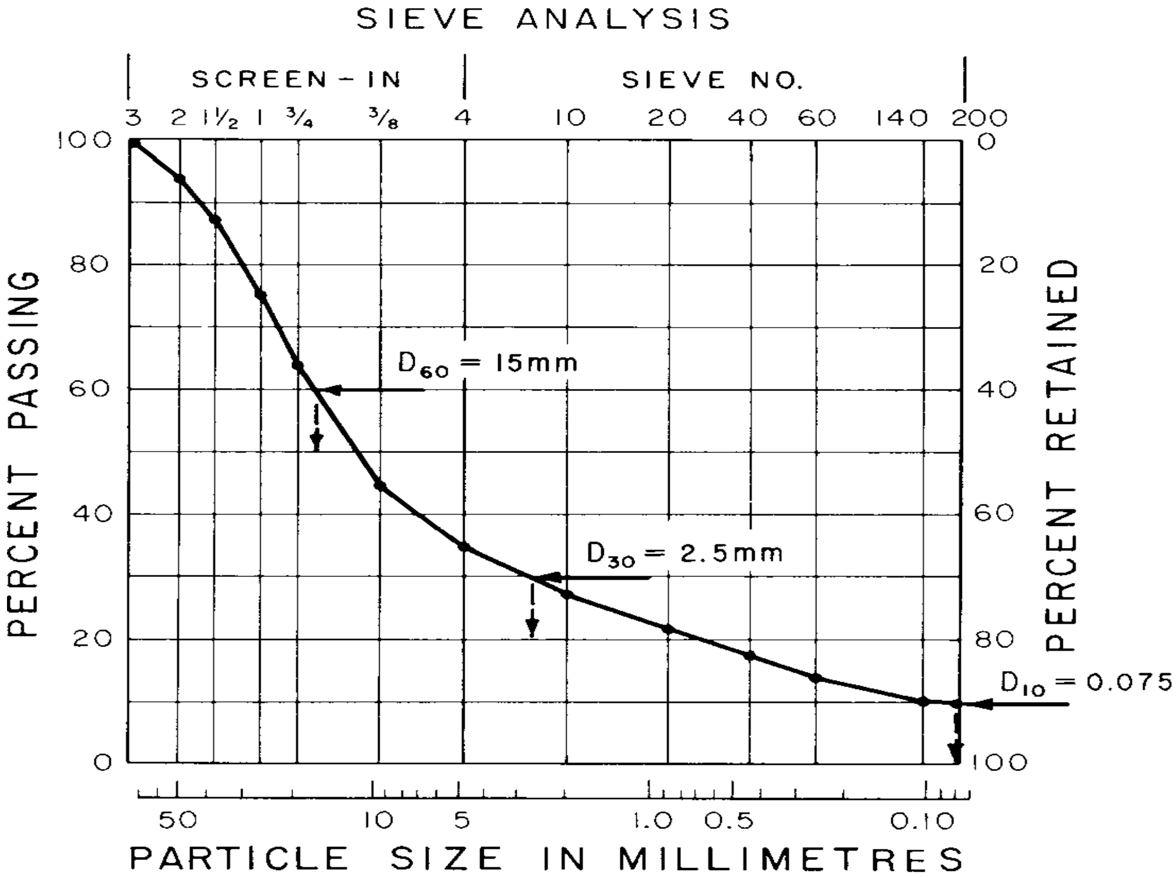
K If soil contains 15 to 29 % plus No. 200, add “with sand” or “with gravel,” whichever is predominant.

L If soil contains $30 % plus No. 200, predominantly sand, add “sand ” to group name.

M If soil contains $30 % plus No. 200, predominantly gravel, add “gravelly” to group name.

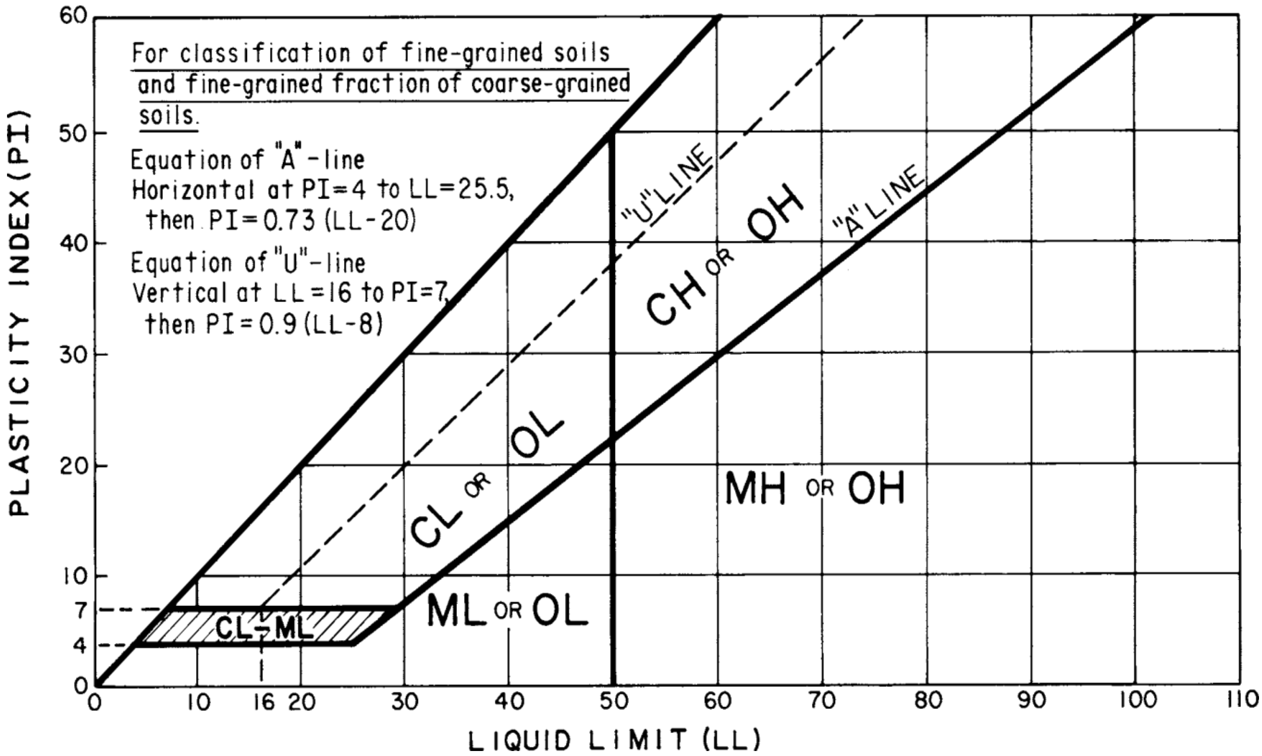
N PI $ 4 and plots on or above “A” line.

O PI < 4 or plots below“ A” line. P PI plots on or above “A” line. Q PI plots below “A” line.



$$Cu = \frac{D_{60}}{D_{10}} = \frac{15}{0.075} = 200 \qquad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}} = \frac{(2.5)^2}{0.075 \times 15} = 5.6$$

Cumulative Particle-Size Plot



Plasticity Chart

Some Important Terms as per Unified Soil Classification System Classification of Soil Table as per ASTM D2487-06

Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) U.S. standard sieve, and

Boulders—particles of rock that will not pass a 12-in. (300-mm) square opening.

Clay—soil passing a No. 200 (75-µm) U.S. standard sieve that can be made to exhibit plasticity (putty-like proper- ties) within a range of water contents and that exhibits considerable strength when air dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid limit falls on or above the “A” line.

Gravel—particles of rock that will pass a 3-in. (75- mm) sieve and be retained on a No. 4 (4.75-mm) U.S. standard sieve with the following subdivisions:

Coarse—passes 3-in. (75-mm) sieve and retained on 3⁄4-in. (19-mm) sieve.

Fine—passes 3⁄4-in. (19-mm) sieve and retained on No. 4 (4.75-mm) sieve.

Organic Clay—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

Organic Silt—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

Peat—a soil composed of vegetable tissue in various stages of decomposition usually with an organic odour, a dark-brown to black colour, a spongy consistency, and a texture ranging from fibrous to amorphous.

Sand—particles of rock that will pass a No. 4 (4.75- mm) sieve and be retained on a No. 200 (75-µm) U.S. standard sieve with the following subdivisions:

Coarse—passes No. 4 (4.75-mm) sieve and retained on No.10 (2.00-mm) sieve,

Medium—passes No. 10 (2.00-mm) sieve and retained on No. 40 (425-µm) sieve.

Fine—passes No. 40 (425-µm) sieve and retained on No.200 (75-µm) sieve.

Silt—soil passing a No. 200 (75-µm) U.S. standard sieve that is non-plastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4 or if the plot of plasticity index versus liquid limit falls below the “A” line.

Coefficient of Curvature, Cc—the ratio $(D30)^2/(D10 \times D60)$, where D60, D30, and D10 are the particle sizes corresponding to 60, 30, and 10 % finer on the cumulative particle-size distribution curve, respectively.

Coefficient of Uniformity, Cu—the ratio D60/D10, whereD60 and D10 are the particle diameters corresponding to 60 and10 % finer on the cumulative particle-size distribution curve, respectively.

3.11.4. MEASUREMENTS

The length and breadth of excavation or filling shall be measured with a steel tape correct to the nearest cm. The depth of cutting or height of filling shall be measured, correct to 5 mm, by recording levels before the start of the work and after the completion of the work. The cubical contents shall be worked out to the nearest two places of decimal in cubic metres.

In case of open footings up to the depth of 1.5 metres, around excavation of 30 cm. beyond the outer dimension of footing shall be measured for payment to make allowances for centering and shuttering. Any additional excavation beyond this limit shall be at the risk and cost of the contractor and shall not be measured for payment.

In case of open footings/Rafts at a depth of more than 1.5 metre, around excavation of 75 cm shall be measured for payment to make allowance for centering and shuttering. Additional excavation beyond this limit shall be at the risk and cost of the contractor and shall not be measured for payment.

In case the ground is fairly uniform and where the site is not required to be levelled, the Engineer-in-Charge may permit the measurements of depth of cutting or height of filling with steel tape, correct to the nearest cm. In case of borrow pits, diagonal ridges, cross ridges or dead-men, the position of which shall be fixed by the Engineer-in-Charge, shall be left by the contractor to permit accurate measurements being taken with steel tape on the completion of the work Deduction of such ridges and dead men shall be made from the measurements unless the same are required to be removed later on and the earth so removed is utilized in the work. In the latter case nothing extra will be paid for their removal as subsequent operation.

Where ordinary rock and hard rock is mixed. The measurement of the excavation shall be made as specified in above. The two kinds of rock shall be stacked separately and measured in stacks. The net quantity of the two kinds of rocks shall be arrived at by applying deduction of 50% to allow for voids in stacks. If the sum of net quantity of two kinds of rocks exceeds the total quantity of the excavated material, then the quantity for each type of rock shall be worked out from the total quantity in the ratio of net quantities in stack measurements of the two types of rocks. If in the opinion of the Engineering-in-charge stacking is not feasible, the quantity of ordinary and hard rock shall be worked out by means of cross-sectional measurements.

Where soil, ordinary rock and hard rock are mixed, the measurements for the entire excavation shall be made as specified above. Excavated materials comprising hard rock and ordinary rock shall be stacked separately, measured, and each reduced by 50% to allow for voids to arrive at the quantity payable under hard rock and ordinary rock. The difference between the entire excavation and the sum of the quantities payable under hard rock and ordinary rock shall be paid for as excavation in ordinary soil or hard soil as the case may be.

Where it is not possible or convenient to measure the depth of cutting by recording levels as specified above quantity of excavation shall be worked out from filling. The actual measurements of the fill shall be calculated by taking levels of the original ground before start of the work after site clearance and after compaction of the fill as specified and the quantity of earth work so computed shall be reduced by 10% in case of consolidated fills and by 5% in case the consolidation is done by heavy mechanical machinery to arrive at the net quantity of excavation for payment. No such deduction shall, however, be made in case of consolidation by heavy mechanical machinery at optimum moisture content, or when the consolidated filling is in confined situations such as under floors.

3.11.4.1 RECORDING MEASUREMENTS FOR EARTH LEVELLING WORK

a) ***Level Books:*** In case of levelling operations and earthwork, measurements are required to be recorded in level books in addition to Measurement Books. The Level Books should be numbered, accounted for and handled like Measurement Books.

b) ***Preparatory Works:*** Before starting the earth work, following steps should be taken:

i. Original ground levels should be recorded in the Level Book in the presence of the contractor or his authorized representative and should be signed by him and the Department Officer who records the levels. All the local mounds and depressions should be indicated clearly in the drawing and the field Level Book and should be checked by the Assistant Engineer/Executive Engineer or consultant's representative before the levelling work is started.

ii. A suitable baseline should be fixed with permanent masonry pillars at distances not exceeding

iii. 150 metres to provide a permanent reference line for facilitating check work. The base line (s) should be entered in the Level Book with co-ordinates. These baselines should be maintained till the final payment for the work has been made.

iv. While recording the levels, it should be ensured that the circuit is closed by taking final levels of the starting point or any other point, the R.L. of which was previously determined.

v. (Plans showing initial levels, location of bench marks and reduced levels, should be prepared and signed by both the parties and attached to the agreement before commencement of the work.

3.11.4.2 TEST CHECK OF THE LEVELS

a) Assistant Engineer or consultant's representative should exercise test check at least to the extent of 50%, and the Executive Engineer or Resident Engineer of consultant at least to the extent of 10% where the value of this item of work exceeds 10% of the tender acceptance power of the Assistant Engineer.

b) The test check of the levels should be carried out independently by each officer, and the readings should be recorded in the prescribed Level Book in red ink against the old levels which should be neatly scored out wherever necessary. If the test check carried out reveals serious mistakes in the original levels, these should be taken or re-taken and re-checked.

c) The test check carried out by an officer should be as representative as possible for the entire work done.

d) On completion of work, the levels should again be recorded in the Level Book and the contractor's signatures obtained. These levels should also be test checked by the Assistant Engineer/Executive Engineer or consultant's representative to the same extent as indicated above within one month of the date of completion of the earth work, and according to the procedure as laid down in the case of initial levels as indicated above.

e) The formation levels as per final execution of the work should be compared with the proposed formation levels and the work got rectified within permissible tolerance.

3.11.4.3 PAYMENT OF LEVELING WORK

Every fourth running bill and the final bill should be paid on the basis of levels. Intermediate payments can, however, be made on the basis of borrow pit measurements. The Executive Engineer on Resident Engineer of Consultant should take care that the quantities thus assessed are not in any case more than the actual work done.

a) Large Scale Leveling Work

In case of large scale levelling work involving both cutting and filling, an accurate site plan should be prepared before the work is commenced. The portions requiring cutting and filling shall then be divided into squares and corresponding squares into filling, which are complementary to the squares in cutting given the same number.

A table may be written upon the plan showing leads involved between the various complementary squares. This would form a lead chart for the work to be done. Before the work of levelling is commenced, the lead chart shall be checked by the Assistant Engineer in the presence of the contractor or his authorized representative and his signatures shall be obtained on the same. This should form an integral part of the contract and should be duly signed by both the integral parties before commencement of the work. The quantity payable for earthwork shall be lower of the quantity derived from cutting or filling. The payment for lead shall be based on lead chart prepared in the aforesaid manner.

b) Import of Earth

In case of earth to be imported, the area from where the earth is to be imported, should be pre-determined wherever possible before the start of the work, and wherever feasible, the average lead should be worked out and stipulated in the tender. After this is determined, initial levels of the area to be filled should be recorded. The levels should be properly checked during the progress of work and on completion

3.11.5. EXCAVATION IN TRENCHES FOR PIPES, CABLES ETC. AND REFILLING

a) General

This shall comprise excavation to any depth in trenches for pipes, cables etc. and returning the suitable excavated material to fill the trenches after pipes, cables etc. are laid and their joints tested and passed, and disposal of surplus excavated material.

b) Refilling

Filling in trenches shall be commenced soon after the joints of pipes, cables, conduits etc. have been tested and passed. The space all around the pipes, cables conduits etc. shall be cleared of all debris, brick bats etc. Where the trenches are excavated in hard/ soft soil, the filling shall be done with earth on the side and top of pipes unless otherwise approved in layers not exceeding 20cm in depth. Each layer shall be watered, rammed and consolidated. All clods and lumps of earth exceeding 8cm in any direction shall be broken or removed before the excavated earth is used for filling. In case of excavation trenches in ordinary/ hard rock, the filling up to a depth of 30cm above the crown of pipe, cable, conduits etc. shall be done with fine material like earth, moorum or pulverized/ decomposed rock according to the availability at site. The remaining filling shall be done with boulders of size not exceeding 15cm mixed with fine material like decomposed rock, moorum or earth as available to fill up the voids, watered, rammed and consolidated in layers not exceeding 30cm. Excavated material containing deleterious material, salt peter earth etc. shall not be used for filling. Ramming shall be done with iron rammers where feasible and with blunt ends of crow bars where rammers cannot be used. Special care shall be taken to ensure that no damage is caused to the pipes, Cables, Conduits etc. laid in the trenches.

i) **Measurements**

Trenches for pipes, cables, conduits etc. shall be measured in running metre correct to the nearest cm in stages of 1.5 m depth

Where two or more categories of each work are involved due to different classification of soil within the same stage of trench depth or where the soil is soft loose or slushy requiring increase in the width of trench or sloping sides or shoring, trenches for pipes, cables, conduits, etc. shall be measured in cubic metres. Extra excavation, if any, on account of collar/ socket of pipes shall neither be measured nor paid for separately.

c) Planking and Strutting - General

When the depth of trench in soft/loose soil exceeds 2 metres, stepping, sloping and/ or planking and strutting of sides shall be done. In case of loose and slushy soils, the depths at which these precautions are to be taken, shall be as approved by the Engineer-in-Charge according to the nature of soil. Planking and strutting shall be ‘close’ or ‘open’ depending on the nature of soil and the depth of trench. The type of planking and strutting shall be as proposed by Contractor and approved by the Engineer-in-Charge. It shall be the responsibility of the Contractor to take all necessary steps to prevent the sides of trenches from collapse.

d) Close Planking and Strutting

Close planking and strutting shall be done by completely covering the sides of the trench generally with short upright, members called ‘poling boards’. These shall be 250x38 mm in section or as approved by the Engineer-in-Charge-.

The boards shall generally be placed in position vertically in pairs, one board on either side of cutting. These shall be kept apart by horizontal wallings of strong wood at a maximum spacing of 1.2 metres cross strutted with ballies, or as directed by Engineer-in-Charge-. The length and diameter of the ballies strut shall depend upon the width of the trench.

Where the soil is very soft and loose, the boards shall be placed horizontally against the sides of the excavation and supported by vertical ‘wallings’ which shall be strutted to similar timber pieces on the opposite face of the trench. The lowest boards supporting the sides shall be taken in the ground for a minimum depth of 75 mm. No portion of the vertical side of the trench shall remain exposed. The withdrawal of the timber members shall be done very carefully to prevent collapse of the trench. It shall be started at one end and proceeded systematically to the other end. Concrete or masonry shall not be damaged while removing the planks. No claim shall be entertained for any timber which cannot be withdrawn and is lost or buried, unless required by the Engineer-in-Charge to be left permanently in position.

e) Open Planking and Strutting

In case of open planking and strutting, the entire surface of the side of the trench is not required to be covered. The vertical boards 250 mm wide & 38 mm thick, shall be spaced sufficiently apart to leave unsupported strips of 50cm average width. The detailed arrangement, sizes of the timber and the distance apart shall be subject to the approval of the Engineer-in-Charge. In all other respect, specifications for close planking and strutting shall apply to open planking and strutting.

f) Conversion Factors

Prior to the descriptions of conversions factor for converting loose materials into compact the following definition of terms is given for understanding the 3 states.

Solid State:- The materials is in its natural state prior to excavation.

Packed State:- This include the materials undergoes spreading, levelling and / or filled, compacted through any means.

Loose State:- These include the materials undergoes spreading and damping only or in pile stock state and not in compacted state.

Following table showing the multiplications factor from which a loose state can be measure into the solid state, it is important to mention that unsuitable soil and any other organic matter shall be separated from the other excavated soils.

Sr No	In-situ State	Multiplication Factor		Remarks
		Soils	Rocks	
1	Loose	0.80	0.60	These figures accurate or otherwise, shall be binding on all parties.
2	Packed	0.89	0.67	
3	Solid	1.00	1.00	
4	90-100% Modified AASTHO	1.10	Nil	

3.11.6. FILLING IN PLINTH, UNDER FLOOR ETC.

3.11.6.1 EARTH FILLING

Normally excavated earth from same area shall be used for filling. Earth used for filling shall be free from shrubs, rank, vegetation, grass, brushwood, stone shingle and boulders (larger than 75mm in any direction), organic or any other foreign matter. Earth containing deleterious materials, salt peter earth etc. shall not be used for filling. All clods and lumps of earth exceeding 8cm in any direction shall be broken or removed before the earth is used for filling.

The space around the foundations and drains shall be cleared of all debris, brick bats etc. The filling unless otherwise specified shall be done in layers not exceeding 20cm in depth. Each layer shall be watered, rammed and consolidated. Ramming shall be done with iron rammers where possible and with blunt end of crow bars where rammers cannot be used. Special care shall be taken to ensure that no damage is caused to the pipes, drains, masonry or concrete in the trenches. In case of filling under floor, the finished level of filling shall be kept to the slope intended to be given to the floor.

a) **MEASUREMENTS**

Filling Side of Foundations: The cubical contents of bed concrete levelling course and masonry/concrete in foundations upto the ground level shall be worked out and the same deducted from the cubical contents of earthwork in excavation for foundations already measured under the respective item of earth work to arrive at the quantity for filling sides of foundation. The quantity shall be calculated correct to two places of decimal.

Filling in Plinth and under Floors: Depth of filling shall be the consolidated depth. The dimensions of filling shall be on the basis of pre-measurement correct to the nearest cm and cubical content worked out in cubic metres correct to two places of decimal.

3.11.6.2 SAND FILLING IN PLINTH

Sand shall be clean and free from dust organic and foreign matter. Sand filling shall be done in a manner similar to earth filling in plinth specified above except that consolidation shall be done by flooding with water. The surface of the consolidated sand filling shall be dressed to the required level or slope and shall not be covered till the Engineer-in-Charge has inspected and approved the sand filling.

a) **MEASUREMENTS**

The length, breadth and depth of consolidated sand shall be measured with steel tape correct to the nearest cm and cubical contents worked out in cubic metres correct to two places of decimal.

3.11.7. SITE CLEARANCE

The surface area of the ground to be occupied by all banks, spoils, borrow pits shall be cleared of all roots, grass, shrubs, brush, trees, fences and such other works as may either cause hindrance with the execution of works or may decay and form dangerous pockets.

3.11.8. SURFACE DRESSING

Surface dressing before placement of fill and construction of embankment shall include cutting and filling upto a depth of 15cm and clearing of shrubs, rank vegetation, grass, brushwood, trees and saplings of girth upto 30cm measured at a height of one metre above the ground level and removal of rubbish and other excavated material upto a distance of 50 metres outside the periphery of the area under surface dressing. High portions of the ground shall be cut down and hollows and depressions filled upto the required level with the excavated earth so as to give an even, neat and tidy look.

a) MEASUREMENTS

Length and breadth of the dressed ground shall be measured correct to the nearest cm and the area worked out in square metres correct to two places of decimal.

3.11.9. JUNGLE CLEARANCE

Jungle clearance shall comprise uprooting of rank vegetation, grass, brushwood, shrubs, stumps, trees and saplings of girth upto 2.5 ft. measured at a height of one metre above the ground level.

3.11.9.1 UPROOTING OF VEGETATION'S

The roots of trees and saplings shall be removed to a depth of 60cm below ground level or 30cm below formation level or 15cm below sub-grade level, whichever is lower. All holes or hollows formed due to removal of roots shall be filled up with earth rammed and levelled. Trees, shrubs, poles, fences, signs, monuments, pipe lines, cable etc., within or adjacent to the area which are not required to be disturbed during jungle clearance shall be properly protected by the contractor at his own cost and nothing extra shall be payable.

3.11.9.2 CLEARANCE OF GRASS

Clearing and grubbing operation involving only the clearance of grass including removal of rubbish upto a distance of 50m. outside the periphery of the area under clearance shall not be measured and paid for separately. Its costs shall be deemed to be included in the unit rate for earthwork.

3.11.9.3 MEASUREMENTS

The length and breadth shall be measured correct to the nearest cm and area worked out in square metres correct to two places of decimal.

3.11.10 FELLING TREES

While clearing jungle, growth trees above 30cm girth (measured at a height of one metre above ground level) to be cut, shall be approved by the Engineer-in-Charge- and then marked at site. Felling trees shall include taking out roots upto 60 cm below ground level or 30 cm below formation level or 15 cm below sub-grade level, whichever is lower. All excavation below general ground level arising out of the removal of trees, stumps etc. shall be filled with suitable material in 20cm layers and compacted thoroughly so that the surfaces at these points conform to the surrounding area. The trunks and branches of trees shall be cleared of limbs and tops and cut into suitable pieces as directed by the Engineer-in-Charge-.

3.11.11 STACKING AND DISPOSAL

All useful materials obtained from clearing and grubbing operation shall be stacked in the manner as directed by the Engineer-in-Charge. Trunks and branches of trees shall be cleared of limbs and tops and stacked neatly at places indicated by the Engineer-in-Charge. The materials shall be the property of the Government. All unserviceable materials which in the opinion of the Engineer-in-Charge cannot be used or auctioned shall be removed up to a distance of 50 ft. outside the periphery of the area under clearance. It shall be ensured by the contractor that unserviceable materials are disposed of in such a manner that there is no likelihood of getting mixed up with the materials meant for construction.

3.11.11.1 MEASUREMENTS

Cutting of trees above 30 cm in girth (measured at a height of one metre above level) shall be measured in numbers

3.11.12 OTHER PHYSICAL OBSTRUCTIONS

Other physical obstructions like structures, fencing appearing on ground shall be cleared and accounted as approved by the Engineer-in-Charge.

3.12. EMBANKMENT CONSTRUCTION

3.12.1 MATERIAL REQUIREMENTS

Material for embankment shall consist of suitable material excavated under the foregoing items 105 and 107 and approved by the Engineer-in-Charge. Borrow material however, shall be used when is no suitable material available from the roadway or form structural excavation. Wet excavated material that will be suitable when dry and if approved by the Engineer-in-Charge shall first be allowed to dry before being placed in the embankment.
The material under this Section shall conform to the following specification.

a) The Contractor shall use AASHTO Class A-1, A-2, A-3, A-4 soil as specified in AASHTO M 145 or other material as defined in AASHTO Soil Classification System Table given before.

b) The material for embankment, except the top thirty (30cm), shall have a minimum soaked CBR value of five (5) % unless otherwise stated on the Drawings. The CBR shall be determined in accordance with AASHTO T 193 at a maximum dry density, corresponding to required compaction of the embankment and under a minimum surcharge load of 4.5 kg. for top thirty (30) cm, however, the CBR shall not be less than eight (8) % determined as above at ninety-five (95) % laboratory maximum dry density determined by AASHTO T-180 method. The swalling recorded during 96 hours soaking should not exceed 2%.

c) In case sandy material (P.I < 4) is used for embankment formation, it shall be properly confined with a material having plasticity index value from four (4) to (10) as approved by the Engineer-in-Charge.

d) In area subject to flood and prolonged inundation of the embankment

3.12.2 MEASUREMENTS

All measurement and payments shall be made in accordance with 3.11.4

3.12.3 SOURCE OF FILL MATERIAL

The fill material for construction of embankment shall comply with the provisions of Clause 3.8 and the work shall be carried out as shown on drawings and approved by the Engineer-in-Charge-.

If sufficient suitable materials are not available from the required excavations to construct the embankment, diversion, coffer dams, backfill and other earthwork construction shown on the approved drawings or directed in writing by the Engineer-in-Charge, suitable materials shall be excavated from borrow-pits located in specified areas approved by the Engineer-in-Charge.

In case sandy material is used for embankment formation, it shall be properly confined with cohesive material to the extent, as approved by the Engineer-in-Charge- but with no extra payment. Sandy material shall not be used on slopes of embankment.

Borrow pits shall be located so that the nearest edge of the pit is at least thirty (30) meters from the roadway toe of slope unless otherwise directed by the Engineer-in-Charge.

In case of flood and marginal banks, earth shall be obtained from borrow pits on the river side of the banks. No borrow pit shall be excavated on the land side of the bank, unless permitted by the Engineer-in-Charge- in writing depending upon the depth of borrow pits and height of embankment. However, the minimum berm width between the toe of the bank and the edge of the borrow pits on the river side shall be 15 metres and that between the toe of the bank and the edge of the borrow pits on the land side 25 metres.

Guide-banks shall be constructed from material obtained from excavation for laying stone aprons and further borrow pits excavated if necessary, according to the directions of the Engineer-in-Charge.

3.12.4 FOUNDATION PREPARATION & LAYOUT OF EMBANKMENTS

The foundations of the embankment shall be ploughed to a depth of 15 to 25cm. All clods shall be broken into fine earth and the area roughly levelled. The surface shall then be well watered before the earth work is started. Before commencement of filling the centre and toe lines of the embankment shall be marked by pegs driven into the ground at 15 metres intervals and by continuous nicking (das belling) to indicate the limits of the construction. Bamboo and string profiles shall be erected at every 60 metres interval in straight reaches and 15 metres apart in curved portions.

3.12.5 FILL PLACEMENT FOR EMBANKMENT COMPACTION

3.12.5.1 FILL PLACEMENT

Embankment material shall be laid in 20cm layers which shall be continuous and parallel to the finished grade. The placing of earth fill shall be done in the full width of embankment including slopes, and the section of formation shall be kept slightly sloping away from the centre to avoid pools of water forming due to rain. The height of filling in different sections shall be uniform as far as possible. All clods shall be broken while the earth is being placed. Organic matter of any kind shall be removed and disposed of as directed by the Engineer-in-Charge. Joining of old and new embankments shall be done by stepping in an overall slope of about 1 to 5. Each layer of earth shall be adequately watered to aid compaction. The specified compaction shall be achieved by using appropriate compaction equipment as approved by the Engineer-in-Charge.

If the material delivered for fill is too wet it shall be dried by aeration and exposure to the sun, till the moisture content is acceptable for compaction. The embankment if required shall be rolled with roller of minimum 1/2 tonne weight, not less than 5 times and further if required till it gets evenly and densely consolidated with wooden or steel rammers of 7 to 10 kg weight having a base of 20 cm square or 20 cm diameter. The labour for ramming shall be at-least one rammer to six diggers. Every third layer of earth and the top most layer shall be well consolidated with a power roller of minimum 8 tonnes weight, rolled not less than 5 times, till the soil behaves as an elastic material and gets compressed only elastically under the load of roller.

3.12.5.2 DRESSING

The embankment shall be dressed neatly as per designed section and grade, after it has been completed and thoroughly consolidated. The top and slopes shall be protected from any damage and maintained, till the work is completed and handed over to the Engineer-in-Charge.

3.12.5.3 MEASUREMENTS

All measurement and payments shall be made in accordance with 3.11.4

3.12.6 EMBANKMENT COMPACTION

3.12.6.1 GENERAL

The Compaction of the embankment may be required at specified relative density according to ASTM D 1556 at optimum moisture content or otherwise compaction as required.

3.12.6.2 EMBANKMENT CONSTRUCTION (UNDER OPTIMUM MOISTURE CONDITIONS)

a) General

The optimum moisture contents for specified density shall be determined by contractor in laboratory in advance of start of construction.

The optimum moisture contents for specified density shall be determined by contractor in laboratory in advance of start of construction. Control on compaction in the field shall be exercised through frequent moisture content and density determinations. A systematic record of these shall be maintained. At all times during construction the top of the embankment shall be maintained in a profile to shed water and prevent pounding.

b) Density Measurement and Acceptance Criteria

Measurement of density shall be made for each 500 sq.m of compacted area or for a smaller area as decided by the Engineer-in-Charge. Each measurement shall consist of at least 5 density determinations and the average of these 5 determinations shall be treated as the field density achieved.

In general, the control at the top 40 cm thickness of the formation shall be stricter with density measurements being done at the rate of one measurement for 250 sq.m. of compacted area. Further for the determination of the mean density the number of tests in one measurement shall not be less than 10 and the work will be accepted if the mean dry density equals or exceeds the specified density.

When density measurements reveal any soft areas in the embankment, the Engineer-in-Charge shall direct that these be compacted further. If in spite of that the specified compaction is not achieved the material in the soft areas shall be removed and replaced by approved materials and compacted as specified to the satisfaction of the Engineer-in-Charge .

c) Control Tests on Borrow Material

Soil suitable for consolidation under O.M.C. conditions should preferably have the following characteristics:

a)	Minimum percentage of clay	10%
b)	Liquid limit	14%
c)	Plasticity index (ASTM D-4318)	4%
d)	Percentage of silt should not exceed	5%
e)	Peat, muck and organic soils are unsuitable	Nil

The Engineer-in-Charge may, however, relax these requirements taking into account availability of materials, cost of transportation and other relevant factors. Various test required to be conducted on the borrow material with their recommended frequency are indicated below. All the test need not be stipulated on every project. Depending upon site condition etc. only some may be found necessary at a particular project. The frequency of testing indicated refers generally to the minimum number of tests to be conducted. The rate of testing must be stepped up as found necessary depending upon the variability of the materials and compaction methods employed at a project.

i. **Gradation:**
At least one test for each kind of soil. Usual rate of testing shall be 1 to 2 tests per 8000 cum of soil.

ii. **Plasticity:**
At least one test for each kind of soil. Usual rate of testing shall be 1 to 2 tests per 8000 cum of soil.

iii. **Proctor Tests:**
At the rate of 1 to 2 tests per 8000 cum of soil.

iv. **Deleterious Contents:**
As required.

v. **Moisture contents:**
One test for every 250 Cu. M. of soil.

3.12.6.3 EMBANKMENT CONSTRUCTION (WITHOUT OPTIMUM MOISTURE CONDITIONS)

Materials used in embankments shall be earth moorum, gravel, a mixture of these or any other material approved by the Engineer-in-Charge. Such materials shall be free of logs, stumps, roots, rubbish or any other ingredient likely to deteriorate or affect the stability of the embankment. The work shall be so planned and executed that the best available materials are saved for the top portion of the embankment. Highly expansive clays exhibiting marked swell and shrinkage properties may be deposited only at the bottom of the embankment and no such material shall be placed nor permitted to remain in the top 500 mm portion of the embankment below the sub-grade.

3.12.6.4 EMBANKMENT AROUND STRUCTURES

To avoid interference with the construction of abutments, wing walls or return walls of culvert/bridge structure, the contractor shall at points to be determined by the Engineer-in-Charge suspend work on embankments forming approaches to such structures, until such time as the construction of the latter are sufficiently advanced to permit the completion of approaches without the risk of interference of damage to the bridge works.

Unless directed otherwise, the filling around culverts, bridges and other structures upto a distance of twice the height of the embankment shall not be done. The fill material shall not be placed against any abutment or wing wall unless permission has been given by the Engineer-in-Charge but in any case, not until the concrete or masonry has been in position for 14 days. The embankment shall be brought up simultaneously in equal layers on each side of the structure to avoid displacement and unequal pressure. The sequence of work in this regard shall be got approved from the Engineer-in-Charge. Where the provision of any filter medium is specified behind the abutment, the same shall be laid in layers simultaneously with the laying of fill material. The material used for filter material shall conform to the requirements for filter medium as specified. Payment for providing filter material shall be made separately under relevant items.

Where it may be impracticable to use power roller or other heavy equipment, compaction shall be carried out by mechanical tempers or other methods approved by the Engineer-in-Charge. Care shall be taken to see that the compaction equipment's does not hit or come too close to any structural member so as to cause any damage to it.

3.12.7 EARTHWORK FOR WIDENING EXISTING ROAD EMBANKMENT

a) **Embankment**

When an existing embankment is to be widened and its slope is steeper than 4:1 continuous horizontal benches each at least 0.3-metre-wide, shall be cut into the old slope for ensuring adequate bond with the fresh embankment material to be added. The material obtained from cutting of benches could be utilised in the widening of the embankment. However, when the existing slope against which the fresh material is to be placed is flatter than 4:1 the slope surface may only be ploughed or scarified instead of resorting to benching.

Where the width of the widened portion is insufficient to permit the use of standard rollers compaction shall be carried out with the help of sheep's foot roller mechanical tampers or other approved equipment. End dumping of material from trucks for widening operations shall be avoided except in difficult circumstances when the extra width is too narrow to permit the movement of any other type of hauling equipment.

b) **Cutting**

Where the formation level of the road is lower than the ground level, cutting shall be done up to formation level. Side slopes except in rock cutting shall be evenly and truly dressed.

c) **Disposal of Surplus Earth**

Earth from cutting shall be utilised for filling in embankment as directed by the Engineer-in-Charge. Earth not required for embankment shall be disposed of as directed by the Engineer-in-Charge. The area where the surplus earth is disposed of shall be levelled and neatly dressed. The surplus earth is disposed of beyond free lead shall be paid as provided.

d) Measurements

All measurement and payments shall be made in accordance with 3.11.4

3.12.8 EARTHWORK BY MECHANICAL MEANS

Earth work by mechanical means involves careful planning keeping in view site conditions i.e. type of soil, nature of excavation, distances through which excavated soil is to be transported and working space available for employing these machines. The earth moving equipment should be accordingly selected.

The contractor shall submit for approval of the Engineer-in-Charge his detailed Method statement for carrying out the work. The approval of Method statement by the Engineer-in-Charge shall not relieve the contractor for carrying out the work according to Contract Agreement as approved by the Engineer-in-Charge. The earth moving equipment consists of excavating and transporting equipment. Excavating equipment's may be further classified as excavators and tractor based equipment's. The major items which may be used in Construction are listed below.

3.12.8.1 MEASUREMENTS

All measurement and payments shall be made in accordance with 3.11.4

3.12.8.2 EXCAVATORS

Excavators generally used at site are as follows:

a) **Dipper–shovel**

It is used for excavating against a face or bank consisting of open-top bucket or dipper with a bottom opening door, fixed to an arm or dipper stick which slides and pivots on the jib of the crane. It is suitable for excavating all clay chalk and friable materials and for handling rock and stone. However, it is not suitable for surface excavation for which a skimmer is used.

b) **Backhoe**

It is similar to face shovel except that the dipper stick pivots on the end of the jib and the dipper or bucket works towards the chassis and normally has no bottom door but is emptied by swinging away from the chassis to invert the bucket. It may be designed to carry both a front–mounted bucket and a rear mounted backhoe. It is mainly used to excavate trenches and occasionally used for the excavation of open areas such as small basements.

In the backhoe mode the bucket lifts, swings and discharges materials while the undercarriage is stationary. When used in the 'loader' mode the machine loads or excavated through forward motion of the machine, and lifts, transports and discharges materials.

c) **Skimmer**

This arrangement is similar to the face shovel except that in this case the bucket slides on rollers directly along the jib and thus has a more restricted movement. It is used for surface excavation and levelling in conjunction with transport to haul away the excavated material.

d) **Dragline**

It is usually fitted with a long slender boom or jib and the bucket, which in operation faces towards the machine and has no door, is supported by cable only as on a crane. It works from the side of the excavation at normal ground level and is used for excavating large open excavations such as basements when the depth is beyond the limit of the boom of a backhoe. It is commonly used for open cast mining operations.

e) **Clamshell**

It comprises two hinged half-buckets or jaws pivoted to a frame which is suspended by cable from a long jib of an excavation. The grab is used for deep excavations of limited area on all types of soil except rock. Crane and Grab is a variant of this type of equipment.

3.12.8.3 TRACTOR BASED EQUIPMENT

It is a self–propelled crawler or wheeled machine used to exert a push or pull force through mounted equipment. It is designed either as attachments to normal tracked or wheeled tractors or as machines in which the earth moving attachments and the tractor are designed as a single integrated unit. A tractor, which is hydraulically operated, can be rigged as:

a) **Loaders**

It is used for loading, light dozing, scraping and grabbing operations, lifting and transporting the materials (loose earth, rubble, sand, gravel aggregate etc.) at various sites through forward motion of the machine.

b) **Tractor Shovel**

This consists of a tipping bucket at the front attached by strong pivoted arms or booms to the frame of the machine. It is used for stripping top soil, excavating against a face, bulldozing and for loading spoil or loose materials. It is similar to crawler dipper-shovel.

c) **Trench Digger**

It operates on the same principle as a backhoe excavator except that the bucket is controlled by hydraulic rams instead of cables and pulleys.

d) **Scraper**

Scrapers provide unique capability to excavate, load, haul and dump materials. Scrapers are available in various capacities by a number of manufacturers with options such as self – loading with elevators, twin engines or push-pull capability. They are cost effective where the haul distance is too long for bulldozers, yet too short for trucks. This distance typically ranges from 120 m. to 1200 m. however, the economics should be evaluated for each project. Scraper has an open bowl with a cutting edge positioned between the axles, which cuts, loads, transports, discharges and spreads through forward motion of the machine. Loading through forward motion of the machine can be assisted by a powered mechanism (elevator) fixed to the scraper bowl.

e) **Bulldozer and Angle-dozer**

The most common equipment used for clearing and levelling activities is a bulldozer. The term bulldozer is used to define a tractor mounted with a dozing blade. The bulldozer consists of a rectangular steel blade with renewable cutting edge set at right angles (capable of only tilting but not angling) to the direction of travel and attached by steel arms to the side frames of a crawler tractor. It may be used for excavating natural soil or for moving loose soil or debris, which is pushed forward as the tractor forces it ahead. Angle dozer is capable of both tilting and angling.

3.12.8.4 TRANSPORTING EQUIPMENT

This implies horizontal movement primarily but it can involve some vertical movement too.

a) Dumpers

These are self-propelled wheeled machines, having an open body. It is designed for the transport of excavated materials and consists of a shallow tipping hopper or skip mounted on a wheeled chassis, such as, power barrow, dumper, multi-skip dumpers, high discharge dumpers, dump truck, etc. These can be rear dump, side dump or bottom dump

b) Trolley.

It is designed for the transport of Construction material and are highly used for carrying materials and dust from place to place. These trolleys are of two types, Single wheel and Double wheel, and are easily available in Pakistan.

3.13 ANTI-TERMITE TREATMENT

Sub-terrane a termites are responsible for most of the termite damage in buildings. Typically, they form nests or colonies underground. In the soil near ground level in a stump or other suitable piece of timber in a conical or dome shaped mound. The termites find access to the super-structure of the building either through the timber buried in the ground or by means of mud shelter tubes constructed over unprotected foundations.

Termite control in existing as well as new building structures is very important as the damage likely to be caused by the termites to wooden members of building and other household article like furniture, clothing, stationery etc. is considerable. Anti-termite treatment can be either during the time of construction i.e. pre-constructional chemical treatment or after the building has been constructed i.e. treatment for existing building.

Prevention of the termite from reaching the super-structure of the building and its contents can be achieved by creating a chemical barrier between the ground, from where the termites come and other contents of the building which may form food for the termites. This is achieved by treating the soil beneath the building and around the foundation with a suitable insecticide.

3.13.1 MATERIALS

Chemicals:

Any one of the following chemicals in water emulsion to achieve the percentage concentration specified against each chemical shall be used:

a. Chlorphriphos emulsifiable concentrate of 20%
b. Lindal emulsifiable concentrate of 20%

Anti-termite treatment chemical is available in concentrated form in the market and concentration is indicated on the sealed containers. To achieve the specified percentage of concentration, Chemical should be diluted with water in required quantity before it is used. Graduated containers shall be used for dilution of chemical with water in the required proportion to achieve the desired percentage of concentration. For example, to dilute chemical of 20% concentration, 19 parts of water shall be added to one part of chemical for achieving 1% concentration.

Engineer-in-Charge shall procure the chemical of required concentration in sealed original containers directly from the reputed and authorized dealers, chemical shall be kept in the custody of the Engineer-in-Charge or his authorized representatives and issued for use to meet the day's requirements. Empty containers after washing and concentrated chemical left unused at the end of the day's work shall be returned to the Engineer-in-Charge or his authorized representative.

3.13.1.1 MEASUREMENTS

Concentrated chemical in sealed containers shall be measured in litres. Chemicals of different types and concentration shall be measured separately.

3.13.2 SAFETY PRECAUTIONS

Chemical used for anti-termite treatment are insecticides with a persistent action and are highly poisonous. This chemical can have an adverse effect upon health when absorbed through the skin, inhaled as vapours or spray mists or swallowed.

The containers having emulsifiable concentrates shall be clearly labelled and kept securely closed in stores so that children or pet cannot get at them. Storage and mixing of concentrates shall not be done near any fire source or flame. Persons carrying out chemical soil treatments should familiarize themselves and exercise due care when handling the chemicals whether in concentrated or in diluted form. After handling the concentrates or dilute emulsion, worker shall wash themselves with soap and water and wear clean clothing especially before eating and smoking. In the event of severe contamination, clothing shall be removed at once and the skin washed with soap and water. If chemical has splashed into the eyes, they shall be flushed with plenty of soap and water and immediate medical attention shall be sought.

The use of chemical shall be avoided where there is any risk of wells or other water supplies becoming contaminated.

3.13.3 ANTI-TERMITE TREATMENT -CONSTRUCTIONAL MEASURES

The construction measures specified below should be adopted for protection against subterranean termites originating both internally from within the plinth and externally from the area surrounding the building.

Earth free from roots, dead leaves, or other organic matter shall be placed and compacted in successive horizontal layers of loose material not more than 200 mm thick. Dry brick shall be inserted at last 50 mm in brick masonry for providing apron floor around the periphery.

3.13.4 TREATMENT FOR EXISTING BUILDING (POST CONSTRUCTION TREATMENT)

3.13.4.1 CHEMICALS

Any one of the following chemicals conforming to international Standards in water emulsion may be used for soil treatment in order to protect a building from termite attack.

Chemical with Percent (Active Ingredient)	Concentration by weight
Chlorpyrfos 20 EC	1.0
Lindane 20 EC	1.0

These chemicals are available in concentrated form in the market and concentration is indicated on the sealed containers. To achieve the specified percentage of concentration, chemicals should be diluted with water in required quantity before it is used. Graduated containers shall be used for dilution of chemicals with water in the required proportion to achieve the desired percentage of concentration. For example, to dilute chemical of 20% concentration, 19 parts of water shall be added to one part of chemical for achieving 1% concentration. Oil or kerosene based solution of chlorpyrifos 20 EC or Lindane 20 EC, 1.0 percent (by weight) concentration is useful for treatment of wood. Engineer-in-Charge shall procure the chemical of required concentration in sealed original containers directly from the reputed and authorized representative. Chemical shall be kept in the custody of the Engineer-in-Charge or his authorized representatives and issued for use to meet the day’s requirements. Empty containers after washing and concentrated chemical left unused at the end of the day’s work shall be returned to the Engineer-in-Charge- or his authorized representative.

3.13.4.2 MEASUREMENTS

Concentrated chemical in sealed containers shall be measured in litres. Chemicals of different types and concentration shall be measured separately.

3.13.5 SAFETY PRECAUTIONS

3.13.5.1 TREATMENT

Once the termites have an ingress into the building, they keep on multiplying and destroy the wooden and cellulosic materials, and as such it becomes essential to take measures for protection against termites. Anti-termite measures described below are necessary for the eradication and control of termites in existing building. To facilitate proper penetrations of chemical in to the surface to be treated, hand operated pressure pump shall be used. To have proper check for uniform penetration of chemical, graduated containers shall be used. Proper check should be kept so that the specified quantity of chemical is used for the required area during the operation. Chemical treatment for the eradication and control of subterranean termites in existing building shall be done. Treatment shall be got done only from the approved specialized agencies using the chemical procured directly by the Engineer-in-Charge from reputed and authorized dealers.

a) Treatment along outside of foundations

The soil in contact with the external wall of the building shall be treated with chemical emulsion at the rate of 7.5 litres per square metre of vertical surface of the sub-structure to a depth of 300 mm. To facilitate this treatment, a shallow channel shall be excavated along and close to the wall face. The chemical emulsion shall be directed towards the wall at 1.75 litres per running metre of the channel. Rodding with 12 mm. diameter mild steel rods at 150 mm apart shall be done in the channel. If necessary, for uniform dispersal of the chemical to 300 mm depth from the ground level. The balance chemical of 0.5 litre per running metre shall then be used to treat the backfill earth as it is returned to the channel directing the spray towards the wall surface.

If there is a concrete or masonry apron around the building, approximately 12 mm diameter holes shall be drilled as close as possible to the plinth wall about 300 mm apart, deep enough to reach the soil below and the chemical emulsion pumped into these holes to soak the soil below at the rate of 2.25 litres per linear metre. In soils which do not allow percolation of chemicals to desired depth, the uniform disposal of the chemical to a depth of 300 mm shall be obtained by suitably modifying the mode of treatment depending on site condition.

In case of RCC foundations the soil (backfill) in contact with the column sides and plinth beams along with external perimeter of the building shall be treated with chemical emulsion at the rate of7.5 litres/sq.m. of the vertical surface of the structure. To facilitate this treatment, trenches shall be excavated equal to the width of the shovel exposing the sides of the column and plinth beams upto a depth of 300 mm or upto the bottom of the plinth beams, if this level is less than 300 mm. The chemical emulsion shall be sprayed on the backfill earth as it is returned into the trench directing the spray against the concrete surface of the beam or column as the case may be.

b) Treatment of Soil under Floors

The points where the termites are likely to seek entry through the floor are the cracks at the following locations:

a. At the junction of the floor and walls as result of shrinkage of the concrete;
b. On the floor surface owing to construction defects;
c. At construction joints in a concrete floor, cracks in sections; and
d. Expansion joints in the floor.

Chemical treatment shall be provided in the plinth area of ground floor of the structure, wherever such cracks are noticed by drilling 12 mm holes at the junction of floor and walls along the cracks on the floor and along the construction and expansion joints at the interval of 300 mm to reach the soil below. Chemical emulsion shall be squirted into these holes using a hand operated pressure pump to soak the soil below until refusal or upto a maximum of one litre per hole. The holes shall then be sealed properly with cement mortar 1:2 (1 cement: 2 coarse sand) finished to match the existing floors. The cement mortar applied shall be cured for at least 10 days as per instruction of Engineer-in-Charge.

c) Treatment of Voids in Masonry

The movement of termites through the masonry wall may be arrested by drilling holes in masonry wall at plinth level and squirting chemical emulsions into the holes to soak the masonry. The holes shall be drilled at an angle of 45 degrees from both sides of the plinth wall at 300 mm intervals and emulsion squirted through these holes to soak the masonry using a hand operated pump. This treatment shall also be extended to internal walls having foundations in the soil. Holes shall also be drilled at wall corners and where door and window frames are embedded in the masonry or floor at ground. Emulsion shall be squirted through the holes till refusal or to a maximum of one litre per hole. Care shall be taken to seal the holes after the treatment.

d) Treatment at Points of Contact of Wood Work

The wood work which has already been damaged beyond repairs by termites shall be replaced. The new timber shall be dipped or liberally brushed at least twice with chemical in oil or kerosene. All existing wood work in the building which is in contact with the floor or walls and which is infested by termites, shall be treated by spraying at the points of contacts with the adjoining masonry with the chemical emulsion by drilling 6 mm holes at a downward angle of about 45 degrees at junction of wood work and masonry and squirting chemical emulsion into these holes till refusal or to a maximum of half a litre per hole. The treated holes shall then be sealed.

Infested wood work in chowkats, shelves, joints, purlins etc., in contact with the floor or the walls shall be provided with protective treatment by drilling holes of about 3mm diameter with a downward slant to the core of the wood work on the inconspicuous surface of the frame. These holes should be at least 150 mm centre to centre and should cover in entire frame work. Chemicals shall be liberally infused in these holes. If the wood is not protected by paint or varnish two coats of the chemicals shall be given on all the surfaces and crevices adjoining the masonry.

3.13.6 MEASUREMENTS

All dimensions shall be measured correct to a cm. The measurements shall be made of the surface actually provided with anti-termite treatment. Measurements shall be done separately for treatment of foundations, soils under floors, voids in masonry and wood work as detailed below:

Treatment along outside of foundations: The measurements shall be made in running metres taking length along the plinth of the building.
Treatment of soil under floors: The measurements shall be made in square metres, inside clear dimensions of rooms, verandah etc. shall be taken.
Treatment of voids in masonry: The measurements shall be made in running metres along the plinth of the building.
Treatment of wood work: The measurements shall be made in running metres for chowkhats, joints, purlins, beams etc.

3.14 MEASUREMENT AND PAYMENT

3.14.1 LABOUR RATE

The measurement and payment for the items of the work of Earthwork hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurement transportation, performance in all respects and completion of work as specified including site clearance, as approved by the Engineer-in-Charge except the cost of materials to be provided by Department at designated location as defined in the Contract Agreement.

3.15 GLOSSARY

a) Burjis:

Short pillars of brick/ stone having top surface finished with cement plaster for marking etc.

b) Formation or Profile:

Final shape of the ground after excavation or filling up.

c) Lead:

All distances shall be measured over the shortest practical route and not necessarily the route actually taken. Route other than shortest practical route may be considered in cases of unavoidable circumstances and approved by Engineer-in-Charge-in-charge along with reasons in writing.

d) Lead distance:

It shall mean the shortest possible horizontal route between the centre of gravity of the material excavated and centre of gravity of the material finally placed

e) Lift:

The vertical distance for removal with reference to the ground level.

f) Safety Rules:

Safety rules as laid down by the statutory authority shall be followed.

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4. DISMANTLING (DEMOLITION)

4.0 SCOPE

The work shall comprise dismantling/demolishing whole or part of work including all relevant items consisting of but not limited to stone work, brick work, concrete, floorings, roofing and metal work structural steel roofs, trusses as specified and or shown on the drawings.

Only such work or part of works which are designated on the Drawings or by the Engineer to be removed shall be included in the work to be done under these specifications.

When approved by the Engineer, the contractor shall remove the dismantled/demolished works required to be removed and clear the site, as specified or directed by the Engineer.

4.1 DISCONTINUITY AND DIVERSION OF UTILITY SERVICES

Before the commencement of dismantling works, the Contractor shall be responsible to ensure that all the utility services including water supply, electric supply, gas supply, telephone connection and sewerage have been cutoff / discontinued. Wherever, directed by Engineer-in-Charge the Contractor shall also divert these services and install the same as per written instruction of the Engineer-in-Charge.

4.2 SERVICEABLE AND UNSERVICEABLE MATERIALS

Upon written instructions of Engineer-in-Charge, the Contractor shall make a list of all such items which in opinion of Engineer-in-Charge can be re-used. The Contractor shall take such measures to protect these materials / items from damage during dismantling process. The Contractor shall provide labour and other arrangements to properly stack / store such items safely until handed over to the Engineer-in-Charge.

All unserviceable materials, rubbish etc. shall be disposed off as directed by the Engineer-in-Charge.

4.3 PRECAUTIONS

a) Before commencement of dismantling/demolition, the Contractor shall prepare and submit his proposals and program for proceeding with the work for approval of the Engineer-in-Charge. Generally, the Contractor will be permitted to demolish the structures only through approved means, Blasting can be permitted only where specified by written approval of the Engineer-in-charge provided the necessary precautions are taken to protect the Works, public and private property and all persons in the vicinity of the Works.

b) The work should generally be performed in reverse order of the one in which the structure was constructed. Necessary propping, shoring and or under pinning shall be provided to ensure the safety of the workers, adjoining work or property before dismantling and demolishing is taken up and the work shall be carried out in such a way that no damage is caused to the adjoining work or property. Temporary enclosures or partitions and necessary scaffolding wherever specified shall also be provided, as directed by the Engineer-in-Charge.

c) Necessary steps/ precautions should be taken to keep noise and dust nuisance to a minimum. If specified or directed by the Engineer-in-Charge, the Contractor shall provide, erect and remove screens of canvas or other suitable material to minimize the nuisance from dust and shall provide for watering as the work of demolition proceeds. The Contractor shall ensure provision of all human safety items and its use at site including helmets, goggle, safety belts etc. All materials which are likely to be damaged by dropping from a height or by demolishing roofs, masonry etc. shall be carefully removed first and lowered using appropriate methods. Chisels and cutters may be used carefully as directed. The dismantled articles should be removed manually or lowered to the ground and then properly stacked as directed by the Engineer-in-Charge.

d) No demolition work should be carried out at night especially when the building or structure to be demolished is in an inhabited area. Screens shall be placed where necessary to prevent injuries due to falling pieces. Water may be used to reduce dust while tearing down plaster from brick work. Safety belts shall be used by labourers while working at higher level to prevent falling from the structure. First-aid equipment shall be got available at all demolition works of any magnitude.

4.4 MEASURES TO BE ADOPTED FOR DEMOLITION OF CERTAIN ELEMENT OF STRUCTURES

4.4.1. ROOF TRUSSES

The roof structure should be removed to wall plate level manually. Sufficient purloins and bracing should be retained to ensure stability of the remaining roof trusses while each individual truss is removed progressively. Temporary bracing should be introduced, where necessary, to maintain stability. The end frame opposite to the end where dismantling is commenced, should be independently and securely guyed in both directions before commencement of work. The bottom tie of roof trusses should not be cut until the principal rafters are prevented from making outward movement.

4.4.2. HEAVY FLOOR BEAMS

Heavy bulks of timber and steel beams should be supported before cutting at the farthest point and should then be lowered to a safe working place.

4.4.3. JACK ARCHES

Where tie rods are present between main supporting beams, these should not be cut until the arch or series of arches in the floor have been removed. Due care should be exercised and full examination of this type of structure undertaken before demolition is commenced. The floor should be demolished in strips parallel to the span of the arch. rings (at right angles to the main floor beams).

4.4.4. BRICK ARCHES

Full time supervision should be given by experienced persons fully conversant in the type of work to ensure that the structure is stable at all times. Dead loads as much as possible may be removed provided it does not interfere with the stability of the main arch rings but it should be noted that the load-carrying capacity of many old arches relies on the filling between the spandrels. The restraining influence of the abutments should not be removed before the dead load of the spandrel fill and the arch rings are removed.

Special temporary support shall be provided in the case of skew bridges. A single span arch can be demolished by hand by cutting narrow segments progressively from each springing parallel to the span of the arch until the width of the arch has been reduced to a minimum which can then be collapsed. Where it is impossible to allow debris to fall to the ground below, centering designed to carry the load should be erected and the arch demolished progressively. The design of the centering should make appropriate allowance for impact.

Where deliberate collapse is feasible the crown may be broken by the demolition ball method working progressively from edges to the centre. Collapse of the structure can be effected in one action by the use of explosives. Charges should be inserted into boreholes drilled in both arch and abutments. This method is the most effective for demolition of tall viaducts.

In multi-span arches before individual spans are removed, lateral restraint should be provided at the springing level. Demolition may then proceed as for a single span care being taken to demolish the spandrels down to the springing line as the work proceeds. Where explosives are used it is preferable to ensure the collapse of the whole structure in one operation to prevent the chance of leaving unstable portions standing.

4.4.5. CANTILEVERS (NOT PART OF A FRAMED STRUCTURE)

A cantilever type of construction depends on the super imposed structure for its stability. Canopies, cornices, staircases and balconies should be demolished or supported before the tailing down load is removed.

4.4.6. IN-SITU REINFORCED CONCRETE

Before commencing demolition, the nature and condition of the concrete, the condition and position of reinforcement, and the possibility of lack of continuity of reinforcement should be ascertained. Attention should be paid to the principles of the structural design to determine which parts of the structure depend on each other to maintain overall stability. Demolition should be commenced by removing partitions and external non-load bearing cladding. It should be noted that in some buildings the frame may rely on the panel walls for stability. Where hard demolition methods are to be used, the following procedures should be adopted.

a) Reinforced Concrete Beams

For beams, a supporting rope should be attached to the beam. The concrete should than be removed from both ends by pneumatic drill and the reinforcement exposed. The reinforcement should then be cut in such a manner so as to allow the beam to be lowered under control to the floor.

b) Reinforced Concrete Columns

In case of columns, the reinforcement should be exposed at the base after restraining wire guy ropes have been placed around the member at the top. The reinforcement should then be cut in such a manner so as to allow the column to be pulled down to the floor under control.

c) Reinforced Concrete Walls

Reinforced concrete walls should be cut into strips and demolished.

4.5 WASTE HANDLING

4.5.1. CHUTES

Debris waste and other materials shall not be thrown, tipped or shot down from a height where they are liable to cause injury to any person on or near the site.

Existing lift shaft, light well and openings on floor may be used to convey debris down the building floors. Areas adjacent to the openings of these features used as a chute shall be barricaded when they are not in use. Warning signs shall be posted to prevent workers from entering the area. As an option, plastic chutes may be used inside the floor openings and lift wells to minimize noise and confine the falling debris.

a) Lift Shaft

Lift shaft may be used to convey debris inside the building. The openings to the elevator shall be adequately enclosed to prevent spilling out of debris.

b) Light Well

All the glass windows in the light well shall be taken out or protected before using the light well for conveyance of debris in order to minimize any dangerous situation.

c) Opening on Floor

Openings on the floor may be used to convey debris. If openings are created on the floor, the total openings shall be less than 25% of the total aggregate floor area. Each opening shall not be larger than 900 mm × 900 mm unless otherwise substantiated with standard justifications with regard to the safety of the remaining structure and minimizing the possible risks arising from the impact force induced. Openings shall not cut through structural support elements that may affect the stability of any structural components.

d) Exterior Chutes

No demolition materials shall be allowed to fall freely outside the building unless it is confined within a chute. If exterior chutes are used, adequate clear spaces shall be provided for their operation. Temporary refuse chutes, assembled from old metal barrels shall not be used. The chutes shall not cause any obstruction to the public. A dust barrier shall be provided if the chute outlet is near public access. The chute shall be designed and constructed with adequate strength and support to allow safe conveyance of debris.

4.5.2. DEBRIS RECYCLING

Better site management and practice would not only prevent the mixing of the inert portion together with the non-inert portion of construction and demolition waste, but could also facilitate and allow on site sorting, and separation at source of construction and demolition waste.

The method of 'selective demolition' should be adopted as far as practicable. It involves demolition and removal of wastes of the same category one at a time. The goal is to facilitate recycling of wastes for beneficial reuse, thus minimizing the burden on municipal landfills and public filling areas. In general, domestic wastes such as furniture, household appliances, etc., metal components such as window frames, pipes, etc., timber components such as doors, wooden floors, etc., other wastes such as tiles, asphaltic materials, ceramic products should be removed first. Most of these materials may be recycled. The building demolition shall begin after all the above non-structural materials have been stripped and removed.

The sequence of demolition shall be planned to allow the separation and sorting of building materials.

Concrete and/or brick debris shall be broken down into smaller sizes and separated from reinforced steel for disposal.

Concrete debris may be pulverized into aggregate size and used for temporary haul roads, fill materials or aggregates for concrete. Old bricks may be salvaged for reuse as architectural features or other uses.

Broken concrete may be disposed of at construction and demolition (C&D) materials recycling facilities for processing into recycle products and aggregates for beneficial reuse. In the event that broken concrete is mixed with some other wastes, broken concrete should be sorted out on site from the mixture of wastes, before disposal at a C&D materials recycling facilities. As regards the way for facilitating the recycling of broken concrete, Authorized Persons / Registered Structural Engineers may seek advice from Civil Engineering and Development Department during the planning stage for demolition.

4.5.3. DUST MINIMIZATION

To prevent dust generation during the debris hauling, water spraying shall be applied during the hauling process. However, the Registered Specialist Contractor (Demolition) shall ensure proper control of water supply and floor drainage system in order to avoid flooding which is a nuisance and may cause overloading of floors.

4.5.4. DEBRIS ACCUMULATION

In general, the debris accumulation on the floors is not allowed unless the debris accumulation is justified by engineering calculations. Debris shall not accumulate against the hoarding or external wall. Excessive accumulation of debris may cause overloading condition and may induce lateral loading on the walls and shall be avoided. The propping design shall include the debris loading.

4.5.5. DEBRIS DISPOSAL AND MANAGEMENT SYSTEM

The debris disposal plans shall generally consist of following details:

a) Method of handling demolished building debris.
b) The routing and movement of debris from each floor to on grade holding area prior to leaving the site;
c) Means of transportation of debris off site.
d) Time and frequency of debris disposal off site.
e) Record scheme on the tonnage of each truck load, truck licence plate, driver's name, trip tickets and location of dump site.
f) The site supervisory personnel responsible for the debris disposal.

4.5.6. DEBRIS LOADING

In the case when loaders and trucks have to work, the following conditions shall be considered:

a) The route of loaders and trucks shall be checked to avoid conflict with temporary propping supports.
b) The working headroom shall be checked, any local strengthening to suit removal of mezzanine floor or first floor beams shall be properly designed.
c) Loading of the debris shall conform to the Code of Practice for the Loading of Vehicles by the Transport Department.

4.5.7. WASTE MANAGEMENT

On-site sorting of surplus construction and demolition (C&D) material is strongly recommended so that inert material can be disposed of at public filling areas as far as practicable, and the remaining C&D waste disposed of at landfills. Care shall be taken for delivering waste disposal to public filling areas require that material to be disposed of at public filling areas must comprise only earth, building debris, broken rock and concrete. Such materials shall be free from marine mud, household refuse, plastic, metal, industrial and chemical waste, animal and vegetable matter and other matter considered unsuitable. Small quantities of timber mixed with otherwise suitable material may be permitted.

All construction and demolition materials arising from or in connection with demolition work shall be sorted on-site and be separated into different groups for disposal at landfills, public filling areas, or recycling as appropriate.

4.6. WRECKING BALL

4.6.1. GENERAL

The wrecking ball application consists of a crane equipped with a steel ball. The destruction of the building is by the impact energy of the steel ball suspended from the crawler crane.

The wrecking ball operates outside the building. This method is suitable for dilapidated buildings, silos and other industrial facilities. However, the operation requires substantial clear space. The application also demands high level skill operators and well-maintained equipment.

4.6.2. RECOMMENDED CRITERIA

The recommended criteria for the use of wrecking ball are presented in the following:

a) Except for special application, the balling of each section of the structure shall proceed from top to bottom. Care shall be taken to maintain the stability of the structure;
b) Recommended techniques for the wrecking ball operations include:

i. Vertical Drop - free falling of the wrecking ball onto the structure.
ii. The boom angle when balling should not be more than 60 degrees to the horizontal. The top of the boom should not be less than three meters above the wall being knocked down.
iii. Any other building nearer than a distance equal to half the height of the building being demolished is in danger.
iv. Keep the public well away from balling operations.
v. Keep employees clear of the demolition area and make sure that the area is clear each time demolitions resume after break.
vi. Remember that the shocks from a building being knocked down can be felt in any attached building. Avoid damage to attached buildings by detaching them: hand demolition is necessary for this.
vii. When a building is being demolished by ball and crane, the crane should provide for sufficient drop height and the ball should be of sufficient weight to enable suitable force to pass through all floors levels of the building.
viii. Avoid build-up of debris on floors and against walls.
ix. A heavy-duty swivel joint must be provided between the ball and the end of the crane rope.
x. Check the ball, swivel, rope and the rigging hourly.
xi. Note the location of all overhead power lines and be aware of these when turning the crane from the normal work face.
xii. Swing in line - swinging of the ball in-line with the jib. A second dragline will normally connect to the ball horizontally to control the ball motion. The ball shall be swung into the building. The ball shall strike at the top of the member so as to avoid the member from falling outside the building

   Slewing the jib is not recommended. The motion of the ball by slewing the jib is difficult to control. It demands expert knowledge of the machine and structure as well as operating skills to safely perform the task. Slewing can potentially induce a tremendous amount of stress on the jib, as such, its use shall be avoided.

c) The jib or boom shall be operated with no less than 3 m above the portion of the structure being demolished.
d) Clear space for operation between the crane and the structure being demolished shall be 50% of the height of structure, the clear distance between the site boundary and the building to be demolished shall not be less than 50% of the building height plus an additional 6 m for the crane to man oeuvre, these criteria shall apply to all sides of the building to be demolished by wrecking ball.
e) The demolition ball shall be connected with swivel type anti-spin device to prevent twisting and tangling of the wire during operation.
f) The wire and boom of the machine used for balling shall have a rated capacity, at the working radius, of at least 5 times the weight of the ball.

g) The strength of the wire shall be at least twice the tensile strength of the nominal steel reinforcement of the floor slab and beams. The high strength wire allows the pullout of the wrecking ball from potential traps.

4.7. OTHER METHOD

4.7.1. NON EXPLOSIVE DEMOLITION AGENT

Non Explosive Demolition Agent (NEDA) is a static demolition agent. When the reaction takes place in a confined drill hole, the NEDA generates an expansive pressure to crack and break concrete and stone.

The NEDA is a suitable application in a restrictive environment where noise, flying debris and vibration are less tolerated. A drilling pattern shall first be designed. For large projects, test breaking shall be performed. The NEDA shall be mixed with water to form a slurry and immediately placed into the pre-drilled holes. The loading intensity and water content shall be controlled to optimize the expansive pressure and prevent blow-out of the NEDA. The breaking effect of NEDA is relatively small comparing to explosives. Secondary efforts are required to further break down and remove the debris by mechanical means.
NEDA may be used on foundation works, pile caps or structures that are fully supported.
When used in rock, NEDA should be contained within strong, flexible, impermeable bags to prevent uncontrolled entry into rock joints.

4.7.2. SAW CUTTING

Saw cutting is suitable for alteration and additional works where accuracy in the cutting is important and the tolerance to noise and vibration is very limited. It can be used to cut concrete slabs and wall elements into segments. An entire building may be dismantled by saw cutting. Saw cutting generally includes conventional disc saw and chain saw, diamond core stitch drilling and wire saw.

a) Wire Saw Cutting

Wire saw cutting comprises a special steel wire often impregnated with diamond beads to increase its cutting ability. The wire saw method is a suitable application for projects that require precision and total control of demolition work. A hole shall first be pre-drilled for the passage of the diamond wire, the wire cutting operation follows. Because of its flexibility, it may be used for “hard to reach” areas. A diamond wire saw may also be applied in cutting off piling of marine structures and bridges.

b) Diamond Core Stitch Drilling

Diamond core stitch drilling may be adopted to cut concrete elements by continuously coring a set of holes to carve up the concrete structure. The thickness of the concrete to be cut depends on the depth of the drilling or coring equipment. Diamond core stitch drilling is particularly suitable in the removal of existing pile cap for construction of large diameter bored pile foundation.

c) Management of Process Water

The sawing and drilling operations require large amounts of water to cool down the blade which cuts through the concrete at high speed. Provision shall be made to provide a water source for the operation and for the disposal of the cooling water.

4.7.3. DEMOLITION BY PUSHER ARM

Hydraulically- operated excavators and loaders can be fitted with various attachments for demolition work. Excavator buckets, boom- mounted hydraulic percussion breakers and pusher arm equipment have been successfully used with these machines.
The main advantage pf such machine are that they are extremely mobile, have a high output, and are able to work on vertical faces and floors above standing level. Their

disadvantage are that the machine need adequate access, a firm and relatively flat base to work from, and can only work within the reach of their booms. To operate these machine efficiently, the length of boom when fully extended should be at least 1.5 meters above the height of the building being demolished.
The pusher arm method is not suitable for large buildings of confined sites, but it is good for masonry infill structure. The building is pushed over in stage by a horizontal force from the machine. An arm is fitted to the lower boom instead of a bucket. The arm is extended forward against the facing wall and force of the excavator pressing forward provides the push.

When using this method, always take the following precautions:

i. Ensure that the site has been secured safely to prevent unintentional entry by unauthorized personal during demolition.
ii. Work from outside the building, never let anyone enter the building while plant is wrecking the building.
iii. Be sure that the operator has been trained in the work, or is being instructed by a trained person.
iv. Use hand demolition to get the building to a level where pushing can start.
v. Separate the building from any attached buildings using hand methods.
vi. Make sure that debris does not build up too high against the wall: this may push the wall onto the machine.
vii. If terraces (ramping) of debris are used to enable the machine and its pusher arm to gain height, ensure that the terraces are well-consolidated and the machine can be maintained level during operation.

4.7.4. DEMOLITION BY WIRE ROPE PULLING

This method is a form of deliberate collapse. Cables and wire ropes are fixed to key structural members, then pulled down by tractors or winches. It is suitable for detached buildings where there is plenty of surrounding room. The method can be used for timber-framed buildings, bridges, bricks, masonry or steel chimneys, and for spires and masts

When using this method, always take the followings precautions:

i. Use wire ropes od at least 16 mm in diameter, and check them regularly. Wire ropes must have a factor of safety of 6.
ii. Anchor the machine securely, and set it so that the rope is flatter than 1 inch.
iii. Do not let anyone stand between the tractor and the building, or beside the rope.
iv. Have a full ROPS AND FOPS canopy on the tractor to protect the operator from broken ropes and falling objects.
v. Never let anyone enter the building while pulling is in progress.
vi. Ensure the ropes are properly secured before commencing the pull.
vii. Ensure that the pulling ropes are kept clear of overhead power lines, especially when taking up the rope slack.
viii. Remember that pylons and masts can twist as they are pulled. If the legs are different lengths, the pylon could fall at right angles to the pull.

4.8. MEASUREMENT AND PAYMENT

All work shall be measured net in the decimal system, as fixed in its place, subject to the following limits, unless otherwise stated hereinafter. Dimensions shall be measured correct to a cm. Areas shall be worked out in sqm correct to two places of decimal. Cubical contents shall be worked out to the nearest 0.01 cum.

Parts of work required to be dismantled and those required to be demolished shall be measured separately. Measurements of all work except hidden work shall be taken before demolition or dismantling and no allowance for increase in bulk shall be allowed. Specifications for deduction for voids, openings etc. shall be on the same basis as that adopted for new construction of the work. Work executed in the following conditions shall be measured separately.

i. Work in or under water and/or liquid mud
ii. Work in or under foul position.

4.8.1 ROOFS

i. Roof coverings generally including battens boarding, mats or other subsidiary supports shall be measured in square metres except lead sheet roof covering which shall be measured in Kgs and stone slab roof covering which shall be measured in cubic metres.
ii. Ridges, hips and valleys shall be girthed and included with the roof area. Corrugated or semi corrugated surfaces shall be measured flat and not girthed.
iii. Mud phuska on roofs shall be measured in cubic metres.
iv. Lead sheets in roofs shall be measured in kgs and hips, valleys, flashings, lining to gutter etc. shall be included in this weight.
v. R.B. or R.C.C. roofs shall be measured as specified in 4.14.
vi. Supporting members, such as rafters, purlins, beams joists, trusses etc. of wood shall be measured in cubic metres and steel or iron sections, in kgs.

4.8.2 CEILING

i. The stripping of ceilings shall be measured in square metres.
ii. Dismantling of supporting joists, beams, etc. shall be measured in cubic metres or in kgs as specified in 4.8.1(vi).
iii. Height above floor level, if it exceeds 3.5 m shall be paid for separately.

4.8.3 FLOORING AND PAVINGS

Dismantling of floors (except concrete and brick floors) shall be measured in square metres. Supports such as joints, beams etc. if any shall be measured as per 4.8.1(vi). Concrete and bricks paving shall be measured as per 4.8.4.

4.8.4 CONCRETE AND BRICK ROOFS AND SUSPENDED FLOORS

Demolition of floors and roofs of concrete or brick shall be measured in cubic metres. Beams cantilevers or other subsidiary supports of similar materials, shall be included in the item. In measuring thickness of roofs provide with water proofing treatments, the thickness of water proofing treatment shall be ignored.

4.8.5 WALLS AND PIERS

i. Taking down walls and independent piers or columns of brick, stone or concrete shall be measured, in cubic metres. All copings, corbels, cornices and other projections shall be included with the wall measurements.

ii. In measuring thickness of plastered walls, the thickness of plaster shall be ignored.
iii. Ashlar face stones, dressed stone work, pre-cast concrete articles, etc. if required to be taken down intact shall be so stated and measured separately in cubic metres.
iv. Cleaning bricks stacking for measurements including all extra handling and removal and disposing off the rubbish as stated shall be enumerated in thousand of cleaned bricks.
v. Cleaning stone obtained from demolished/dismantling stone masonry of any description including ashlar facing dressed stone work, stone slabs or flagging and pre-cast concrete blocks including all extra handling and disposing off the rubbish as stated shall be measured in cubic metres of cleaned stone.
vi. Honey comb works or cavity walls of bricks stone or concrete shall be measured as solid.

4.8.6 REINFORCED CONCRETE AND BRICK WORK

Reinforced concrete structures and reinforced brick roofs and walls shall be measured in cubic metres and if reinforcement is required to be salvaged, it shall be so stated. Where reinforcement is required to be separated, scraped and cleaned, the work shall be measured separately in quintal of salvaged steel.

4.8.7 PARTITIONS WORK ETC.

Partitions or light walls, of lath and plaster, trellis work, expanded metal, thin concrete or terracota slabs and other similar materials including frame work if any shall be measured in square metres stating the over all thickness.

4.8.8 WOOD WORK

All wood work including karries average 40 sq cm or over in section, shall be measured in cubic metres, while that under 40 sq cm in section, in running metres. Ballies shall be measured in running metres.

Boarding including wooden chajjas and sun shades along with supports shall be measured in square metres in its plane.

4.8.9 STEEL AND IRON WORK

(i) All steel and iron work shall be measured in quintals. The weight shall be computed from standard tables unless the actual weight can readily be determined.
(ii) Riveted work, where rivets are required to be cut, shall be measured separately.
(iii) Marking of structural steel required to be re-erected shall be measured separately.
(iv) In framed steel items, the weight or any covering material or filling such as iron sheets and expanded metal shall be included in the weight of the main article unless such covering is not ordered to be taken out separately.

4.8.10 DOORS AND WINDOWS

Dismantling of doors, windows, ventilators etc. (wood, metal or plastic) whether done separately or along with removal of wall by making recess in the wall shall be enumerated. Those exceeding 3 sqm each in area shall be measured separately. The item shall include removal of chowkhats architraves, holdfasts and other attachments. If only shutters are to be taken out it shall be measured separately.

4.8.11 PIPES AND SEWER LINES

i. Water pipe lines including rain water pipes with clamps and specials, sewer lines (salt glazed ware or concrete) etc. shall be described by their diameter and length measured in running metres inclusive of joints.
ii. If the joints, special and fittings etc. are required to be separated, it shall be so stated and enumerated.
iii. Pucca drains shall be measured under relevant items.
iv. Valve cistern, public fountain platform, fire hydrants, etc. shall be enumerated.
v. Manholes and inspection chambers shall be enumerated stating the size and depth of manhole/inspection chamber. They shall be classified into different groups depending upon the depth, in unit of half and one metre depth. The depth of the manhole shall be the distance between the top of manhole cover and invert level of the drain.
vi. Ventilating shafts, gully traps, flushing cisterns and other appurtenant items of work shall be enumerated.

4.8.12 POSTS OR STRUTS

Posts or struts (wood, steel or RCC) section including taking out embedded portion shall be measured in running metres.

4.8.13 FENCING WIRE MESH

Wire mesh fencing of any type with frame shall be measured in square metres.

4.8.14 GLAZING

Taking out any portion of serviceable glass except polished plate, from old sashes, skylights, etc. (any thickness, weight or size) raking out old putty, etc. shall be measured in square metres.

Irregular circular panes shall be measured as rectangle or square enveloping the same. The width and height being measured correct to the nearest 0.5 cm.

4.8.15 ROAD WORK

(i) Different types of road surfaces shall be measured separately.
(ii) Road surfaces metalling or soling (base) shall be measured in square metres.
(iii) Concrete paving shall be measured as in 4.8.3 or 4.8.4 as the case may be.

4.8.16 COMPOSITE RATE

The measurement and payment for the items of the work of Dismantling hereof shall be made corresponding to the applicable CSR items as provided in Contract Agreement and shall constitute full compensation, for procurement, transportation, performance in all respects and completion of work as specified including the site clearance as approved by the Engineer-in-Charge.

4.8.17 LABOUR RATE

The accepted quantities measured as provided above shall be paid for at the Contract unit price respectively for the items shown in Bill of Quantities, which price and payment shall constitute full compensation for dismantling, removal and disposal of material as directed by the Engineer.

The measurement and payment for the items of the work of Dismantling hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurement transportation, performance in all respects and completion of work as specified including site clearance, as approved by the Engineer-in-Charge except the cost of materials to be provided by Department at designated location as defined in the Contract Agreement.

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5. PLAIN AND REINFORCED CONCRETE

5.1 SCOPE

The work shall include furnishing of all labour, materials, plant, equipment, accessories and services as required to complete the concrete items as shown on the drawings, specified herein and/or as directed by the Engineer-in-Charge. The materials herein specified shall be proportioned, mixed, formed and placed in accordance with the herein stated requirements. The stipulations and requirements herein set forth shall apply except when such stipulations and requirements are specifically modified by the Engineer-in-Charge for any particular item of work.

The Contractor shall submit method statement before starting of concreting operations. The method statement shall provide the procedures and resources planned to be employed for completion of construction and maintenance of work as specified.

5.1.1 CLASSIFICATION OF CONCRETE

In order to meet the strength and durability of the requirements, the concrete is divided into the following categories in the context of this Baluchistan Schedule Rates

5.1.1.1 VOLUMETRIC PROPORTION (CEMENT: SAND: AGGREGATE)

a) 1:1:2

Concrete made by using Ordinary Portland Cement (OPC) and other basic ingredients i.e. course aggregate, fine aggregate and water. The concrete having Volumatic proportions of 1:1:2 (1 Cement: 1 Fine Aggregate: 2 Coarse Aggregate). Nominal 28 days Cylinder Compressive Strength of such concrete is **28 MPa (4000 psi).** However, it may vary depending on physical and chemical properties of aggregates.

b) 1:1.5:3

Concrete made by using Ordinary Portland Cement (OPC) and other basic ingredients i.e. course aggregate, fine aggregate and water. The concrete having Volumatic proportions of 1:1.5:3 (1 Cement : 1.5 Sand : 3 Aggregate). Nominal 28 days Cylinder Compressive Strength of such concrete is 21 MPa (3000 psi). However, it may vary depending on physical and chemical properties of aggregates. It shall be used for structural members (RCC slabs, beams, columns, walls, partitions etc) or any other structural work where such strength is specified by the designer.

c) 1:2:4

Concrete made by using Ordinary Portland Cement (OPC) and other basic ingredients i.e. course aggregate, fine aggregate and water. The concrete having Volumatic proportions of 1:2:4 (1 Cement : 2 Sand : 4 Aggregate). Nominal 28 days Cylinder Compressive Strength of such concrete is 16.5 MPa (2400 psi). However, it may vary depending on physical and chemical properties of aggregates. It shall be used for structural members (RCC slabs, beams, columns, walls, partitions etc) or any other structural work where such strength is specified by the designer.

d) 1:3:6

Concrete made by using Ordinary Portland Cement (OPC) and other basic ingredients i.e. course aggregate, fine aggregate and water. The concrete having Volumatic proportions of 1:3:6 (1 Cement : 3 Sand : 6 Aggregate). Nominal 28 days Cylinder Compressive Strength of such concrete is 10.5 MPa (1500 psi). However, it may vary depending on physical and chemical properties of aggregates. It shall be generally used for some structural members like foundation, hard standings, concrete blocks etc, and any other works where such strength is specified.

e) 1:4:8

Concrete made by using Ordinary Portland Cement (OPC) and other basic ingredients i.e. course aggregate, fine aggregate and water. The concrete having Volumatic proportions of 1:4:8 (1 Cement : 4 Sand : 8 Aggregate). Nominal 28 days Cylinder Compressive Strength of such concrete is 8 MPa (1200 psi). However, it may vary depending on physical and chemical properties of aggregates. It shall be used for no structural works like floor underlay, lean concrete etc.

5.1.1.2 MIX DESIGN

For ease of use, it is further classified into the following types;-

TYPE A:

The concrete requiring minimum 28 days estimated Cylinder Compressive strength, equal or more than **6000 psi** or requiring special features to meet higher strength, environmental, architectural and survivability requirements. Such concrete will be comprehensively designed. It shall be used for structural members (RCC Bridge Girders etc.) or any other structural work where such strength is specified by the designer.

TYPE B:-

The concrete having minimum 28 days Cylinder Compressive strength **5000 psi**, it shall be used for structural members (RCC slabs, beams, columns, PCC work etc) or any other structural work where such strength is specified by the designer.

TYPE C:-

The concrete having minimum 28 days Cylinder Compressive strength **4000 psi,** it shall be used for structural members (RCC slabs, beams, columns, walls, partitions etc) or any other structural work where such strength is specified by the designer.

TYPE D:-

The concrete having minimum 28 days Cylinder Compressive strength **3000 psi**, it shall be generally used for some structural members like (RCC slabs, beams, columns, walls, partitions etc) or any other structural work where such strength is specified by the designer.

5.1.2 TYPES OF CONCRETE WORKS

Under Ground Concrete

Concrete poured below Natural Surface Level with or without shuttering and shoring.

On Ground Concrete

Concrete poured by erecting formwork with necessary bracings on ground.

Elevated Concrete

Concrete poured by erecting props, bracing and towers to support the formwork at higher levels.

5.2 DRY RAMMING OF BRICK OR STONE BALLAST

5.3.1. BRICK BALLAST

The brick ballast, wherever specified for use in concrete shall be obtained by breaking bats of 1st class well burnt bricks to the specified sizes usually 1½ inches to 2 inches (40 mm to 50mm). They shall be screened through the appropriate sieves to remove dust and under size ballast.

5.3.2. PLACING & RAMMING OF BRICK BAT

Wherever brick bats is specified for placement in foundations to provide a firm base, the ballast from pre-approved stacks shall be placed evenly in layers, not exceeding 6 inches (15 cm) thickness in the foundation trench and thoroughly consolidated by means of small plate compactor (may be hand operated) or square rammer. If required/directed by the Engineer-in-Charge small quantity of water may be sprinkled on the brick ballast by means of can fitted with hose. The quantity of water will be just enough to facilitate the consolidation and it should not make the foundation muddy.

5.3 PLAIN & REINFORCED CEMENT CONCRETE

5.3.1 MATERIALS

5.3.1.1 CEMENT

a) **General**

Cement shall be fresh, furnished in sacks or in bulk form as approved by the Engineer-in-Charge. Unless otherwise permitted, cement from not more than two plants shall be used and in general, the product of only one plant shall be used in any particular section of the work. Cement recovered through cleaning of sacks shall not be used.

b) **Portland Cement**

Portland cement shall be of Pakistan origin and manufacture unless otherwise approved by the Engineer-in-Charge. Portland cement shall conform to Pakistan Standard 232 or to British Standard 12 or to ASTM C 150 Type I. Portland cement conforming to ASTM C 150, Rapid hardening type III or Sulphate Resistant, Type-V or conforming to BS 4027 or ASTM C-150 may also be used in certain parts of the Works as specified or directed by the Engineer-in-Charge. Where specified Low Heat Cement complying with BS 1370 shall be used. The Contractor shall use Pozzolanic materials (blast-furnace slag or fly ash or calcined clay) by blending the materials with Ordinary Portland Cement/Sulphate Resisting Cement (whichever is specified in the Contract when alkaline reactive aggregates are used) by replacing up to maximum of 40% of cement. The slag cement thus formed shall conform to BS 146 or ASTM C 595. Raw or Calcined natural pozzolan shall conform to ASTM C618 Class N or Class F. The granulated iron blast-furnace slag shall be finely ground and shall conform to ASTM C989 Grade80, 100 or 120.The final proportions of OPC/SRC and Pozzolanic materials shall be determined by the Contractor and approved by the Engineer-in-Charge before each mix. The mix will normally be designed by the Contractor to have:

i) A mortar bar reduction not less than 75% at 14 days when tested in accordance with ASTM C441, and
ii) A heat of hydration of less than 70 calories per gram of Pozzolanic materials (blast-furnace slag or fly ash or calcined clay) at 7 days when tested in accordance with ASTM C186.

c) Types of Cement

Different types of the cements along with their usage is shown in the given table

Type	Use
I	Ordinary Portland Cement, general purpose cement, where there is no extenuating conditions.
II	Modified Cement, aids in providing moderate resistance to Sulphate attack.
III	Rapid Hardening Cement, when high early strength is required.
IV	Low Heat Cement, where low heat of hydration is desired (in massive structures)
V	Sulphate Resistance Cement, where high sulphate resistance is required (especially in RCC sewer pipes, Manhole, Septic Tanks)
I A	Type I Cement, containing an integral air – entraining agent.
II A	Type II Cement, containing an integral air – entraining agent.
III A	Type III Cement, containing an integral air – entraining agent.

Where Suplhate Resistant Cement is ordered and used, it should be Sulphate Resistant Portland Cement of the approved make fully conforming to ASTM C-150/BSS 4027.

d) **TRANSPORTATION OF CEMENT**

Transportation of the cement from the factory to the Site stores and to the point of use shall be accomplished in such a manner that the cement is completely protected from exposure to moisture. Cement which has been adversely affected by moisture, as determined by the Engineer-in-Charge, shall be rejected. Cement in sacks shall be delivered in strong, well-made sacks, each plainly marked with the manufacturer's name, brand, type of cement and the weight of cement contained therein. Packages varying from the standard weight marked thereon may be rejected and if the average weight of packages in any consignment as shown by weighing fifty packages taken at random, is less than that marked on the packages, the entire consignment may be rejected. Packages received in broken or damaged condition shall be rejected or may be accepted only as fractional packages as determined by the Engineer-in-Charge.

e) **STORAGE OF CEMENT**

Cement shall be stored at Site in dry, weather tight and properly ventilated stores. All storage facilities shall be subject to approval and shall be such as to permit easy access for inspection and identification of each consignment. Adequate storage capacity shall be furnished to provide sufficient cement to meet the peak needs of the project. The following special precautions shall be observed for storage of cement:

1. Reduce the time of storage as much as possible.
2. The sack should be stacked closely on damp proof or timber raised a foot or so from the ground with the air space below.
3. To avoid bursting of bags and setting under pressure the height of stack should be limited to eight (8) bags.

The best method of storage is that adopted by the cement manufacturers viz; in bulk; and bins of loose cement 6′ (six feet) or more in depth can be intact for longer than one year.

The Cement stored for more than three months or through a monsoon, shall be used only after it has been approved by the Engineer– in- charge. The Contractor shall use cement in the approximate chronological order in which it is received at the Site.
Cement storage facilities shall be emptied and cleaned by the Contractor when so directed. However, the interval between required cleaning normally will not be less than four months. Suitable, accurate scales shall be provided by the Contractor to weigh the cement in stores and elsewhere on the Site, if required, and he shall also furnish all necessary test weights.

f) **Sampling, Cement Usage**

Sampling of cement shall be in accordance with AASHTO T 127. Mill Test Certificates shall accompany delivery of the material to the work.

> "Cement shall be delivered in sufficient quantities to ensure that there is no suspension of the work of concreting at any time. Different brand or different types of cement from the same mill, or the same brand or type from different mills shall not be mixed or used alternately in the same item of construction unless authorized by the Engineer in Charge after preparing new mix design."

5.3.1.2 AGGREGATES

a) General Requirements

i) Cleanliness.

The aggregates should be free from injurious amount of clay, salt, alkali, organic matter, shale, loam, soft flaky particles and other deleterious substance. Aggregate when not obtained in clean state are invariably washed before use. All deleterious substance shall not exceed 5% in fine aggregates and shall not exceed 3% in course aggregate. The extent of these impurities are determined by various field and laboratory tests as described in the testing requirements of fine and coarse aggregates

ii) Shape.

Crushed aggregate should be sharp, angular and of hard grains, approximately cubical in size and those obtained from natural source be rounded, well-shaped and of hard grains. The fine aggregate should be such shape that it covers the maximum voids between coarse aggregates.

iii) Size.

To obtain high crushing strength of concrete the maximum size of aggregate should be as large as conveniently possible but it should not be normally greater than one- fourth in plain concrete and one-fifth in reinforced concrete of the smallest dimension in the structure. The maximum size of aggregate may be up to 6 ins. For mass concrete, but a size of up to 9 ins. has also been used in dams. Aggregate of size requires carefully designed mixes to avoid segregation and it is probably wise to limit the maximum size to 3 ins. Large stones which are embedded in mass concrete work are called "plums" plums should be sound and hard. The spacing between two plums or a plum and the outer surface should not be less than six inches, for heavily reinforced member the nominal maximum size of aggregate should be ¼ in. less than the minimum distance between the reinforcement bars or minimum cover of concrete over the reinforcement whichever is less, provided that the concrete can be placed without difficulty so as to surround all reinforcement thoroughly and fill corners of form work.
Similarly, the nominal maximum size of the aggregates shall not be larger than one fifth of the narrowest dimension of the finished wall or slab, or larger than three fourth of the minimum clear spacing between the reinforcing steel and embedment. These limitations may be waived

if, in the judgement of the Engineer-in-Charge, workability and method of consolidation be such that the concrete can be placed without honey-combs or voids.

iv) Grading.

Aggregate are required to be graded into different size and mixed in desired proportions for producing mortar and concrete of specified quality and strength. The graded aggregate is one that contains all size of particles between extremes of limits proportions to produce a dense and economical mixture which will use minimum of cement per unit volume to give required strength. The aggregates are graded into minimum of cement per unit volume to give required strength. The aggregates are graded into nominal size by sieving and their fineness Modulus determined. The fineness Modulus id calculated by dividing by 100, the sum of the total, percentage retained on designated sieves in the standard sieve Analysis. A smaller value of the fineness modulus indicated the presence of large proportions of fine particles. The testing requirements are discussed in the relevant sections of testing requirements of fine and coarse aggregates.

v) Durability.

Aggregates should be hard to resist grading actions; tough to withstand impact and sound to remain whole during changes in weather conditions. the resistance to grinding action is determined by Los Angles Abrasion Test. The soundness test is carried out by means of Sodium Sulphate Test. Crushing strength test is carried out to determine the strength. The specific gravity test is required to determine the density. The testing requirements are discussed in the relevant sections of testing requirements of fine and coarse aggregates.

vi) Storage.

Storing on dusty, muddy or grassy spots, should be avoided. Dump must be protected from exposure to dust. Old steel sheet or wooden planks may be used as platforms for storage. On large works storage bins and usually used.

Aggregate which has deteriorated or which has been contaminated shall not be used for concrete

vii) Composition

The use of natural sand or a combination of natural and manufactured sand may be permitted, provided that the fine aggregate meets the applicable requirements of the Specifications for the particular use intended. Coarse aggregate shall consist of gravel, crushed stone or a combination thereof.

The aggregates shall be non-alkaline reactive in accordance with the provisions of ASTM C-227, C-289.

viii) Source

The Contractor shall obtain concrete aggregate from deposits of natural sand and gravel or shall procure crushed aggregate from approved quarries (refer to construction material source study) which produce aggregates meeting with the Specifications contained herein.

ix) Processed Aggregates

The Contractor in procuring the processed aggregates or in planning his aggregate processing operations shall ensure that the aggregates, as delivered to the mixer, consist of clean, hard and uncoated particles; light weight elements (chalk, clay, coal) are separated by segregation under water by vibration where required and the fines are removed from the coarse aggregate by adequate washing. The coarse aggregate shall be re-screened just prior to delivery to the concrete mixer bins. The moisture content of coarse and fine aggregates shall be as directed by the Engineer-in-Charge. Compliance with the aggregate grading and uniformity requirements shall be determined before the material is delivered at the mixer. All aggregates shall be sieved and washed with clean water. The aggregates shall conform to the specific requirements given hereinafter.

b) Test Requirements for Fine Aggregate

The fine aggregate shall consist of sand, stone screenings or other approved inert materials with similar characteristics, or a combination thereof, having clean, hard, strong, sound, durable, uncoated grains free from injurious amount of dust, lumps, soft or flaky particles, shale alkali, organic matter, material reactive with alkalis in the cement loam or other deleterious substances and shall not contain more than three (3) % of material passing the No. 200 sieve by washing nor more than one percent of clay lumps or one (1) % of shale..

For exposed work, the fine aggregate shall be free from any substance that will discolor the concrete surface.

The fine aggregate shall be uniformly graded and when tested in accordance with AASHTO T 11 and T 27 shall meet the following grading requirements:

Table 5.2
GRADING OF FINE AGGREGATES

Sieve Designation	Percentage Passing by Weight
3 / 8 inch	100
No. 4	95~100
No. 16	45~85
No. 50	10~30
No. 100	2~10
No. 200	0~3

Fine concrete aggregate shall meet the following requirements. Deleterious substances such as, but not limit to, pyrites, coal or micas shall not exceed two percent (2%) by weight.

Fineness Modulus, AASHTO M6	2.3 to 3.1
Sodium Sulphate Soundness, AASHTO T-104, 5 cycles, percent loss	10 Maximum
Clay Lumps and Friable Particles AASHTO T-112, Percent	1 Maximum
Test for Organic Impurities, AASHTO Than standard T-21	Lighter
Sand Equivalent AASHTO T-176	75 Minimum
Potential Cement – Aggregate Reactivity ASTM C 289, as supplemented by ASTM C 227	Innocuous

Petrographic analysis shall be done against alkali- silica reactivity.

For the purpose of determining the degree of uniformity, a fineness modulus determination shall be made upon representative samples submitted by the Contractor from such sources as he proposes to use. Fine aggregate from any one source having a variation in fineness modulus of greater than 0.20 either way from the fineness modulus of mix design samples submitted by the Contractor may be rejected till new trial mixes are prepared and tested by the Contractor.

i) Sand for Mortar

All sand for mortar used in the construction of brick paving, brick lining and brick masonry shall be natural sand and when tested by means of standard screens (ASTM Designation: E11) shall conform to the following limits:

Screen No.	Percentage by weight, passing screen
8	100
100	15 (Maximum)

Within the above range, the sand shall be well-graded and as coarse as practicable for the production of workable mortar.

c) Test Requirements for Coarse Aggregates (Aggregates)

The coarse aggregate shall consist of crushed or broken stone, gravel or other approved inert materials with similar characteristics, or a combination thereof, having clean, hard, strong, sound, durable uncoated particles, free from injurious amount of soft, friable, thin elongated, or laminated pieces, alkali, organic or other deleterious matter and conforming to the requirements of these Specifications.

The coarse aggregate shall be of uniform grading with maximum sizes as required for the various classes of concrete as shown in Table 5.2 and when tested in accordance with AASHTO T 11 & T 27 shall meet the following grading requirements.

TABLE 5.2
GRADING OF COARSE AGGREGATES

Designated Sizes	**Percentage by Weight Passing Laboratory Sieves, in inches, Having Square Openings**							
	2 ½	**2**	**1 ½**	**1**	**¾**	**½**	**3/8**	**No. 4**
½" to No. 4	-	-	-	-	100	90~100	40~70	0~15*
¾" to No. 4	-	-	-	100	90~100	-	20~55	0~10*
1" to No. 4	-	-	100	95~100	-	25~60	-	0~10*
1½" to No. 4	-	100	95~100	-	35~70	-	10~30	0~5
2" to No. 4	100	95~100	-	35~70	-	10~30	-	0~5
1½" to¾"	-	100	90~100	20~55	0~15	-	0~5	-
2" to 1"	100	90~100	35~70	0~15	-	0~5	-	-

- Not more than five (5) % shall pass No. 8 sieve.

Coarse aggregate gradation should conform to the requirements of ASTM C 33. Coarse aggregate shall contain no more than one (1) % by weight of material passing the No. 200 sieve by washing and not more than five (5) % of soft fragments.

It shall have an abrasion loss of not more than forty (40) % at five hundred (500) revolutions, when tested in accordance with AASHTO T 96.

When tested in accordance with AASHTO T 104, for five cycle, the loss with the sodium sulphate soundness test shall be not more than 12 percent.

Natural aggregates shall be thoroughly washed before use.

The aggregate shall be non-alkali/silica reactive where the concrete is to be poured under water or exposed to humid conditions. In case the Contractor proposes to use the aggregate having the alkaline/siliceous characteristics with the intention to use it with Blast Furnace Slag Cement, he will undertake to carry out the job without any extra cost and shall arrange to conduct the necessary tests as directed by the Engineer in Charge.

Coarse aggregate shall not contain materials such as iron pyrites, coal, mica, laminated materials or other materials which may adversely affect the strength and durability of the concrete.

Coarse aggregates shall meet the following requirements:

Sodium Sulphate Soundness, AASHTO T-104

5 cycles, percent loss	12 Maximum
Clay Lumps and Friable Particles AASHTO T-112, Percent	1 Maximum
Soft Fragments and Shale, AASHTO M-80, Percent	5 Maximum
Flakiness Index BS 812: Part 105: Sectoin105.1 15	
Potential Cement – Aggregate Reactivity ASTM C 289, as supplemented by ASTM C 227	Innocuous

Petrographic examination and description, including approximate composition against alkali-silica reactivity shall be done as per ASTM C 295. Under no circumstances shall the contractor use Dacite Andesite Hyolite, Opal Cherts or Tuffs.

d) Tests & Approval

All aggregates shall be subject to testing which shall be carried out by the contractor at his own expanse upon instructions of Engineer-in-Charge. Aggregates not meeting the requirements of these Specifications as determined by tests or inspection may be rejected.

TABLE 5.3

Grading Requirements for Coarse Aggregate (ASTM C-33-03)

Sr. No.	Nominal Size (Sieves with Square Openings)	Amounts Finer than Each Laboratory Sieve (Square openings) Weight Percentage												
		4”	3½”	3”	2½”	2”	1½”	1”	¾”	½”	3/8”	No.4	No.8	No.100
1.	3½” to 1½”	100	90 to100	_	25 to 60	_	0 to 15	_	0 to 5	_	_	_	_	_
2.	2½” to 1½”	_	_	100	90 to 100	35 to 70	0 to 15	_	0 to 5	_	_	_	_	_
3.	2” to 1”	_	_	_	100	90 to 100	35 to 70	0 to 15	_	0 to 5	_	_	_	_
4.	2” to No. 4	_	_	_	100	95 to 100	_	35 to 70	_	10 to 30	_	0 to 5	_	_
5.	1½” to ¾”	_	_	_	_	100	90 to 100	20 to 55	0 to 15	_	0 to 5	_	_	_
6.	1½” to ¾”	_	_	_	_	100	95 to 100	_	35 to 70	_	10 to 30	0 to 5	_	_
7.	1” to ½”	_	_	_	_	_	100	90 to 100	20 to 55	0 to 10	0 to 5	_	_	_
8.	1” to ¾”	_	_	_	_	_	100	90 to 100	40 to 85	10 to 40	0 to 15	0 to 5	_	_
9.	1” to No.4	_	_	_	_	_	100	95 to 100	_	25 to 60	_	0 to 10	0 to 5	_
10.	¾” to ⅜”	_	_	_	_	_	_	100	90 to 100	20 to 55	0 to 15	0 to 5	_	_
11.	¾” to No.4	_	_	_	_	_	_	100	90 to 100	_	20 to 55	0 to 10	0 to 5	_
12.	½” to No.4	_	_	_	_	_	_	_	100	90 to 100	40 to 70	0 to 15	0 to 5	_
13	⅜” to No.8	_	_	_	_	_	_	_	_	100	85 to 100	0 to 30	0 to 10	0 to 5

d) Water

The water for curing, for washing aggregates and for mixing shall be subject to the approval of the Engineer in charge. Generally it should be free from oil and the turbidity limit shall not exceed 2000 parts per million and the pH value shall range between 6.0 to 8.0.

In no case shall the water contain an amount of impurities that will cause a change in the setting time of Portland cement of more than twenty-five (25) % nor a reduction in the compressive strength of mortar at fourteen (14) days of more than five (5) % when compared to the result obtained with distilled water

The water shall be free from oil, alkali, vegetable matter, salt and other impurities. If the specific conductance is less than fifteen hundred (1500) microhms per centimeter, the total solids content requirement may be waived. Water for washing aggregates, mixing, and curing shall contain no chlorides as Cl, nor sulfates as exceeding the values for the type of the work as follows:

Type of Work	Chlorides (Parts per million)	Sulphates (Parts per million)
Conventionally Reinforced	500	1000
Pre-stressed Concrete	500	1000

In non-reinforced concrete work, the water for curing, for washing aggregates and for mixing shall be free from oil and shall not contain more than two thousands (2,000) parts per million of chlorides nor more than one thousand five hundreds (1,500) parts per million of sulfates as SO_4.

In addition to the above requirements, water for curing concrete shall not contain any impurities in a sufficient amount to cause discoloration of the concrete or produce etching of the surface.

When required by the Engineer in charge, the quality of the mixing water shall be determined by the Standard Method of Test for Quality of Water to be used in concrete, AASHTO T 26.

Combined Aggregate

The coarse and fine aggregate shall be combined in the proportions according to the approved trial mixes for each class of concrete.

Changes from one gradation to another shall not be made during the progress of the work unless approved by the Engineer in Charge, and shall meet the following requirements for the combined aggregate:

Material passing the 200 sieve by weight	3% Maximum
Water soluble Chlorides	0.04%Maximum
Water soluble Sulphates	
Pre-stressed concrete	0.05% Maximum
Reinforced concrete	1.0% Maximum

Non-reinforced concrete	2.0%

The water soluble chlorides and sulfates limits specified for the fine and coarse-aggregate individually, are subject to the following overriding requirement:

The total water-soluble chloride content (AASHTO T 260) in any mix from all sources, including any chloride present in other materials and the mixing water, shall not exceed the following limits as a percentage of the weight of cement in the mix.

Reinforced concrete in humid environment and exposed to chloride	0.1%
Reinforced concrete in humid environment but not exposed to chloride	0.15%
Pre-stressed concrete	0.06%

In case of any likeliness of alkali reactivity the following further tests shall be conducted, as soon as practicable after the Contract is awarded to the Contractor.

(1) Potential Reactivity Tests

- Gel Pat Test
- ASTM Test C 289 (Standard Test Method For Potential Alkali-Silica
- Reactivity Of Aggregates- Chemical Method)
- ASTM Test C 227 (Standard Test Method For Potential Alkali-Silica
- Reactivity Of Aggregates –Mortar Bar Method)

(2) Shrinkage

The properties of the aggregates shall be such that Drying Shrinkage of concrete prepared and tested in accordance with the United Kingdom Building Research Station Digest No 35 (second series) shall not exceed forty-five thousand this percent (0.045%).

The initial Drying Shrinkage of all the proposed concrete mixes prepared and tested in accordance with BS 1881 shall not exceed six hundredths percent (0.06%).

(3) Reactivity

Aggregates for use in concrete or mortar that will be subject to wetting, extended to humid atmosphere, or contact with moist ground, shall not contain any materials that are deleteriously reactive with the alkalis in the cement, or any which may be additionally present in the aggregates and mixing water or water in contact with the concrete or mortar, in amounts sufficient to cause excessive localized or general expansion of concrete or mortar.

e) Admixtures

An admixture can be defined as a chemical product which, except in special cases, is added to concrete mix in quantities not more than 5% by mass of cement during mixing or during an additional mixing operation prior to the placing of the concrete, for achieving a specific modification, to normal properties of the concrete. Admixture may be organic or inorganic in composition, but their chemical character as distinct from mineral, is their essential feature. Admixture are commonly classified by their function in concrete.

Classification of admixtures as per ASTM C-494 is given as under

Type A	Water Reducing (Normal Plasticizing)
Type B	Retarding
Type C	Accelerating
Type D	Water Reducing and Retarding
Type E	Water Reducing and Accelerating
Type F	High Range, Water Reducing or Super Plasticizing.
Type G	High Range, Water Reducing and Retarding or Super Plasticizing and Retarding

i) Approval Required

Admixtures, including air-entraining admixtures, foaming chemicals and water-reducing admixtures, shall not be used, except with the prior approval of the Engineer-in-Charge.
Before using admixtures in concreting process, trial mixes shall be made to determine the mix design by laboratory testing.

ii) Air-Entraining Admixtures

The source and brand of air-entraining admixtures, if required, shall be proposed by the Contractor and approved by the Engineer-in-Charge. The air-entraining admixture will be an approved substance or compound conforming to the requirements of ASTM C 260, which will produce entrained air in the concrete as hereinafter specified. The air-entraining admixture shall be added to the batch in solution in a portion of the mixing water. This solution shall be batched by means of a mechanical batcher capable of accurate measurement and in such a manner as to ensure uniform distribution of the admixture throughout the batch during the specified mixing period.

Measurement

Where so specified, Air Entraining Admixture of approved quality shall be added to the concrete mixture in accordance with the manufacturer's specification stating the quantity of water proofing material in litres or kg as specified in Composite Schedule of Rates will be paid for separately

iii) Water-Reducing Admixtures

The source, brand, types of suitable water reducing cement dispersing admixtures, if required, shall be proposed by the Contractor and approved by the Engineer-in-Charge.. The quantities of water-reducing, c admixture to be used shall be in accordance with the instructions of the manufacturers as approved by the Engineer-in-Charge. Water reducing admixture shall conform to the requirements of ASTM C-494.

Measurement

Where so specified, Water Reducing Admixtures of approved quality shall be added to the concrete mixture in accordance with the manufacturer's specification stating the quantity of water proofing material in litres or kg as specified in Composite Schedule of Rates will be paid for separately

iv) Foaming Chemicals

The source, brand and types of suitable foaming chemicals, if required, shall be as approved by the Engineer-in-Charge. The foaming agent shall conform to ASTMC-869.

f) Water stops

i) PVC Water-stops

Except as otherwise shown on the Drawings, water-stops shall be installed with an approximately equal width of material embedded in concrete on each side of the joint. Water stops shall be sealed to other cut off systems as shown on the Drawings or as directed by the Engineer-in-Charge. All water-stops shall be installed and carefully positioned so as to form a continuous water tight diaphragm in each joint. All splices shall be neat with the ends of the joined materials in true alignment.

Concrete shall be carefully placed and vibrated around water stops to ensure maximum concrete imperviousness and density, the complete filling of the forms in the vicinity of the waterstop and complete contact between the concrete and all surfaces of water stop.

PVC (polyvinylchloride) water-stops shall be extruded from an elastomeric plastic compound, the basic resin of which shall be polyvinylchloride. The compound shall contain such additional resins, plasticizers, stabilizers or other materials needed to ensure that when the material is compounded and extruded to the shapes and dimensions shown and tested it shall have the physical characteristics as shown in Table 5.4.

Splices in the continuity or at the intersections of run of PVC water-stops shall be performed by heat sealing the adjacent surfaces in accordance with the manufacturer's recommendations or as directed by the Engineer-in-Charge. A thermostatically controlled electric source of heat shall be used to make all splices. The correct temperature at which splices should be made will differ with the material used but should be sufficient to melt but not char the plastic. After splicing, a remoulding iron with ribs and corrugations to match the pattern of the water-stop shall be used to reform the ribs at the splices. The continuity of the characteristic components of the cross-section of the water-stop design (ribs, tubular center axis, protrusions, and the like) shall be maintained across the splice. The splices joints shall be tested in accordance with the applicable standards and as directed by the Engineer-in-Charge.

Table 5.4
Physical Characteristics of PVC Waterstop

Physical Characteristics	Test Method	Typical Values
Ultimate Elongation	ASTM D 638 (CRD C 573)	350 % min
Tensile Strength	ASTM D 638 (CRD C 573)	1750 psi (12.07 Mpa) min

Low Temperature Brittleness	ASTM D 746 (CRD C 570)	No Failure @ - 35 F (-37 C)
Stiffness in Flexure	ASTM D 747 (CRD C 571)	400 psi (2.76 Mpa) min
Specific gravity	ASTM D 792	1.37 max
Hardness, Shore A	ASTM D 2240	70 - 80

ii) Metal Water-stops

COPPER:

Copper water-stops shall conform to the requirements of ASTM B-370 and shall have the weight as shown in the Drawings.

STAINLESS STEEL:

Stainless steel water and grout stops shall conform to the requirement of ASTM A-167, Type 302 or 304.

STEEL:

Sheet steel for steel water-stops shall conform to the requirements of ASTM A-366 or ASTM A-569 where no welding is required and to ASTM A-4256 where welding is required.

ALUMINIUM:

Aluminium sheet for water-stops shall conform to the requirements of ASTM B-209.

COPPER:

Copper sheet water-stops shall conform to the requirements of ASTM B-152-97(a).

Copper, stainless steel, steel and aluminium water-stops shall be installed in joints at the locations shown on the Drawings. The thickness, shape, dimensions and splicing of metal water-stops shall be as shown on the Drawings or as approved by the Engineer-in-Charge.

g) Joint Sealing Compound

Sealing compound shall be either of the cold application type conforming to ASTM D-1850 or of the single or multiple component type or of the hot poured type conforming to the requirements of ASTM D-1190 or their equivalents.

Measurements

The length and breadth of the finished work shall be measured in metre correct to cm. The area should be calculated in sq. metre correct to two places of decimal.

I) Non-Shrink Grout

Non-shrink grout of a thickness less than 25mm shall consist of one part cement, one part clean sharp sand and 1:22000 to 1:15000 part of grained aluminium powder containing non-polishing agent. Non-shrink grout 25mm or more in thickness shall be proportioned as above except that 1.5 parts of 9mm to 6mm (pea-size) gravel shall be added to the mix. The above composition may be varied if so required by the Engineer-in-Charge. In each case, however, the Contractor shall, at his own cost, prepare optimum mix design and conduct testing of the grout composition for strength and non-shrink performance. Pre-mix non-shrink grout from approved manufacturers may also be used.

5.3.2 PROPORTIONING & MIXING OF CONCRETE MIX

5.3.2.1 PROPORTIONING OF INGREDIENTS

a) The proportioning of the concrete for its ingredients namely cement, sand and coarse aggregates is specified for CSR items on volume basis and on weight basis for the specified use. The proportioning and batching of concrete mix shall accordingly be done on volume basis.

The proportion in which the various ingredients are to be used for different parts of the work shall be as determined from time to time during the progress of the work and as tests are made of the aggregates and the resulting concrete. Mix proportions and water- cement ratio shall be so determined as to produced concrete having suitable workability, density, im-permeability, durability or strength. The contractor shall not be entitled to any compensation because of these adjustments.

b) The amount of water used in the concrete shall be so regulated as to secure concrete of a proper consistency and to adjust for any variation in the moisture contents, or grading of the aggregates as they enter the mixer. Water shall not be allowed to be added to undo the stiffening of the concrete resulting from excessive over-mixing or objectionable drying before placing. Uniformity in concrete consistency from batch to batch shall be required. Unless otherwise specified or directed by the Engineer-in-Charge the slump of concrete after it has been deposited, but before it has consolidated, shall have the following values under different situations:

Sr. No.	Purpose	Slump (inches)
2.	High strength reinforced and pre-stressed concrete section, paving and mass concrete compacted by vibration.	0 – 1
3.	Normally reinforced concrete sections compacted by vibration, hand compacted mass concrete.	1 – 2
4.	Heavily reinforced concrete sections compacted by vibration, hand compacted concrete in normally reinforced slabs, beams, columns and walls.	2 – 4
5.	Heavily reinforced concrete sections compacted without vibration and work where compaction is particularly difficult.	4 – 6

5.3.2.2 PROPORTIONING ON VOLUMETRIC BASES

For volumetric proportioning suitable gauge boxes shall be used. Cement shall be taken as weighing 50 Kg as per standard bag of 0.035 cubic meter (1.25 ft^3). The bulking effect of aggregates shall be taken into the consideration.

The Engineer in Charge shall ensure preparations for various strength requirements, based on the availability of local materials. Depending upon the variations in site condition and locally available aggregate (both coarse and fine) the Engineer in Charge shall ensure preparation of Concrete mix designs as specified by the Designer and get them tested from an authenticated Government Material Testing Laboratory at the expense of the contractor before commencement of the Job. The following table shows the proportions of the concrete ingredients on volumetric bases: -

Table 5.5
Estimated Mix Proportions for Regular / Normal Concrete
For Various Strength Requirements

Minimum 28 Days Cylinder Compressive Strength	Type	Approximate Concrete Mix for Estimation	Estimated Quantities per Cum		
			Cement Kg	Aggregate (Cum)	
				Fine	Coarse
24 MPa (3500 psi)	B	1:1.5:3	415.5	0.436 (15.4 ft^3)	0.872 (30.8ft^3)
21 MPa (3000 psi)	C	1:2:4	327	0.457 (16.14 ft^3)	0.914 (32.28 ft^3)
10.5 MPa (1500 psi)	D	1:3:6	228.5	0.480 (16.95 ft^3)	0.960 (33.90 ft^3)

Proportioning By Weight Bases

The proportions by weight of cement, fine aggregates, coarse aggregates and water necessary to produce concrete of the required strength and consistency shall be approved by the Engineer in Charge. Such approval may be withdrawn at any time and changes in the proportions may be required for the purpose of required workability, density, impermeability, durability and strength.

Based on the approved mix proportions, the Contractor shall prepare lists showing the number of kilograms of the various material to be used in the batch size adopted. The required consistency shall also be shown. Such lists are subject to approval by the Engineer in Charge and shall be posted at the mixer. The amount of water in the mix is the total amount of free water, including the free water held by the aggregates.

No concrete shall be placed in the Works until the results of the twenty-eight (28) days' test indicate that the design proportions are satisfactory as per requirements. Adjustment of the proportions shall be subject to the following provisions:

i. Adjustment for variation in workability - If it is found impossible to obtain concrete of the desired workability with the proportions originally approved, the Engineer in Charge shall make such changes as are necessary.

ii. Adjustment for new materials - No change in the source or character of the material shall be made without due notice to the Engineer in Charge and no new materials shall be used until the Engineer has accepted such materials and has approved new proportions based on trial mixes.

The Contractor's attention is drawn to the time required to prepare and test trial batches and the Contractor shall be responsible for production of trial batches at a sufficiently early date so that the progress of the work is not delayed.

The Contractor shall provide the Engineer in Charge with access at all times to laboratory facilities and personnel during the preparation of trial mixes. The trial mixes prepared by the contractor shall produce dense concrete mixtures containing the minimum cement content and having the specified consistency and minimum compressive strength for each

Class of concrete listed in the Bill of Quantities. The compressive strength reported shall be the average cylinder strength of either three (3) or two (2) individual cylinder test results.

The maximum aggregate size in all classes of concrete included in the specifications, except blinding concrete, shall be not larger than one-fifth of the narrowest dimension between sides of forms, one – third of the depth of slabs nor two-thirds of the minimum clear spacing between individual reinforcing bars or bundles of bars.

After the Contractor completes the necessary mix design testing and obtains approval of the job-mix proportions for each class of concrete by the Engineer in Charge, he shall sample all materials used in the design of the concrete mixtures along with a copy of the approved job-mix reports and submit them. All material samples shall be certified by the Engineer in Charge as being representative of those used in the testing procedure and shall be in sufficient quantities for the conduct of all specified physical and chemical tests as well as for preparation of the required test specimens for strength evaluation purposes.

When the materials proposed for use by the Contractor are of such a nature or are so graded that proportions based on minimum cement content cannot be used without exceeding the maximum allowable water content, the proportions shall be adjusted to produce concrete with the required consistency and workability without exceeding such allowable water content. No increase in payment shall be allowed when such changes cause an increase in cement content.

Six (6) test cylinders shall be prepared for each trial mix and each class of concrete to be furnished. The Contractor shall provide facilities for the proper curing of the test cylinders. The Contractor, after giving notice to the Engineer in Charge and providing an opportunity for the Engineer in Charge to be present, shall break three (3) cylinders after seven (7) days curing and the remaining three (3) cylinders after twenty-eight (28) days curing. The concrete temperature shall be recorded for 21 days from the time of placement of concrete

After receipt of the Contractor's mix design report, the Engineer in Charge shall review the information. When the trial mix information, for any class of concrete, fails to meet the specifications, the Engineer in Charge will direct the Contractor to prepare additional trial mixes. When the Engineer in Charge has determined that the Contractor's recommended concrete materials and mix proportions conform to the specifications he shall allow production of concrete to begin. No class of concrete shall be produced or placed until the Engineer in Charge has reviewed trial mix information and allowed production to begin.

The approval of mix proportions by the Engineer in Charge , to the Contractor in establishing those proportions, shall not relieve the Contractor from responsibility for producing concrete which conforms to the specifications.

All costs connected with furnishing laboratory facilities and personnel, testing all materials, preparing every required trial mix, reporting the information to the Engineer in Charge and all other tasks associated with preparing design mixes for all specified classes of concrete shall be borne by the Contractor

Consistency

Concrete shall have a consistency such that it will be workable in the required position. It shall be of such a consistency that it will flow around reinforcement steel but individual particles of the coarse aggregate when isolated shall show a coating of mortar containing its proportionate amount of sand. The consistency of concrete shall be determined to be as dry as it is practicable to satisfy the requirements for transportation and placing of the concrete as described hereinafter. Consistency of concrete shall be determined as specified in AASHTO T 119.

c) **Water Cement Ratio**

the selection of water cement ratio as a basis for designing a concrete mixture involves consideration of both the degree of exposure to which the concrete is to be subjected and the strength requirements of the structure. The general, the mix design shall provide for water – cement ratios by weight with aggregate at saturated surface dry condition, which will be determined on the basis of producing concrete having suitable workability, density, im-permeability, durability and the required strength without the use of excessive amount of cement.

It is expected that water– cement ratio by weight will vary from 0.45 for concrete in thin sections to 0.65 for mass concrete in severe weather conditions. Maximum permissible water cement ratio will also vary from 0.67 for low strength concrete to 0.38 for the concrete 28 days strength of 4000 Psi and above.

5.3.2.3 STRENGTH EQUIVALENCY OF CUBE AND CYLINDER STRENGTH

28 days 6 inches x 12 inches (15cm x 30 cm) cylinder strength corresponding to 28 days cube strength in the Table are given hereunder:

28 days cube strength (Psi)	6” x 12” cylinder strength (Psi)
4500	4000
3750	3000
3000	2200
2000	1500

Lower grade concrete with greater proportions of sand and coarse aggregates could be used as specified. The cube strength for these mixes shall be determined in field for reference.

5.3.3 MIXING

The mode of mixing (i.e. hand mixing or machine mixing) shall be as specified and determined by the Engineer-in-Charge keeping in view the size of work.

5.3.3.1 HAND MIXING

Hand mixing shall not be carried out without the approval of the Engineer in Charge.

Unless otherwise specified or directed, hand mixing shall be done on the following lines:

a) Wooden batch boxes of one to three cubic feet capacity shall be used. Hand mixing shall only be done on a smooth watertight platform large enough to allow efficient turning over of the various ingredients both before and after the addition of water. The platform shall be wooden and rectangular in shape having close fitting joints between the boards or long sheet iron troughs. The platform shall in no case be utilized for storing material other than that required for immediate mixing.

Size of each batch shall be regulated by the proportions of the ingredients. A batch mixed at a time shall not contain more than one bag of cement.

In case concreting has to be done at a faster speed different gangs of labourers shall prepare different batches at the same time.

b) The measured quantity of cement shall be placed on top of the measured quantity of fine aggregate and then both of these shall be mixed dry three times or more till they attain a uniform colour. The measured quantity of Coarse aggregate shall then be added and mixed with it. The required quantity of water, which shall be measured or weight for each batch, shall then be added with a rose. The mixture shall be turned over and the process continued at least three times or till the entire mass has become wet and a homogeneous mixture of the required consistency has been obtained.

c) The re-tempering of concrete or mortar which has partially set (that is remixing with or without additional cement aggregate or water is absolutely prohibited. Under no circumstances shall concrete which has partially hardened be deposited in the work.

5.3.3.2 MACHINE MIXING

Concrete Mixtures

Concrete mixers may be of the revolving drum or the revolving blade type and the mixing drum or blades shall be operated uniformly at the mixing speed recommended by the manufacturer. The pick-up and throw-over blades of mixer shall be restored or replaced when any part or sections is worn two and a half ($2^1/_2$) cm or below than the original height of the manufacturer's design. Mixers and agitators, which have an accumulation of hard concrete or mortar, shall not be used

When bulk cement is used and volume of the batch is one cubic meter or more, the scale and weigh hopper for Portland cement shall be separate and distinct from the aggregate hopper or hoppers. The discharge mechanism of bulk cement weigh hopper shall be interlocked against opening before the full amount of cement is in the hopper. The discharging mechanism shall also be interlocked against opening when the amount of cement in the hopper is underweight by more than one percent or overweight by more than three (3) % of the amount specified.

When the aggregates contain more water than the quantity necessary to produce a saturated surface-dry condition, representative samples shall be taken and the moisture content determined for each kind of aggregate.

The temperature of mixed concrete, immediately before placing, shall be not more than) thirty (30) °C. Aggregates and water shall be cooled as necessary to produce concrete within this temperatures limit. If ice is used to cool the concrete, discharge of the mixer will not be permitted until all ice is melted.

The batch shall be so charged into the mixer that some water will enter in advance of cement and aggregates. All water shall be in the drum by the end of the first quarter of the specified mixing time.

Cement shall be batched and charged into the mixer by means that will not result in loss due to the effect of wind, or in accumulation of cement on surfaces of conveyors or hoppers, or in other conditions that reduce or vary the required quantity of cement in the concrete mixture.

The entire contents of a batch mixer shall be removed from the drum before materials for a succeeding batch are placed therein. The materials composing a batch except water shall be deposited simultaneously into the mixer.

All concrete shall be mixed for a period of not less than one and a half (11/2) minutes after all materials, including water, are in the mixer. During the period of mixing, the mixer shall operate at the speed for which it has been designed.

Mixers shall be operated with an automatic timing device that can be locked by the Engineer in Charge. The time device and discharge mechanism shall be so interlocked that during normal operation no part of the batch will be discharged until the specified mixing time has elapsed. In case of failure of the timing device, the Contractor will be permitted to operate while it is being repaired, provided he furnishes an approved timepiece equipped with minute and second hands. If the timing device is not repaired within twenty-four (24) hours, further use of the mixer will be prohibited until repairs are made.

The first batch of concrete material placed in the mixer shall contain cement, sand and water in excess to the requirement of mix, to ensure that the drum does not extract mortar from the mix changing its design characteristics. When mixing is to stop for a period of one hour or more, the mixer shall be thoroughly cleaned.

Plant Mixing

At central mixing plant, batches shall be discharged from the weighing hopper into the mixer either directly by gravity or by an elevating container large enough to contain the batch. The plant shall be arranged to ensure that there is no loss of cement during transfer from weighing hopper to the mixer drum. The mixing time shall neither be less than fifty (50) second, nor more than ninety (90) seconds.

The plasticizer, accelerator or retarder or water-reducing admixture, if required, shall be fed separately at the rate recommended by the manufacture, or as established by laboratory trials.

Transit Mixing

Truck mixers, unless otherwise authorized by the Engineer in Charge, shall be of the revolving drum type, watertight and so constructed that the concrete can be mixed to ensure a uniform distribution of materials throughout the mass. All solid materials for the concrete shall be accurately measured and charged into the drum at the proportioning plant. The truck mixer shall be equipped with a device by which the quantity of water added can be readily verified. The mixing water may be added directly to the batch, in case the concrete batch is poured within twenty-five (25) minutes of adding water.

The maximum size of batch in truck mixers shall not exceed the maximum rated capacity of the mixer as stated by the manufacturer and stamped in metal on the mixer. Truck mixing shall be continued for not less than fifty (50) revolutions after all ingredients, including water, are in the drum. The mixing speed shall be neither less than six (6) rpm nor more than ten (10) rpm.

Mixing shall begin within thirty (30) minutes after the cement has been added either to the water or aggregate, but when cement is charged into a mixer drum containing water or surface-wet aggregate and when the temperature is above thirty-two (32) °C, this limit shall be reduced to fifteen (15) minutes. The limitation in time between the introduction of the cement to the aggregate and the beginning of the mixing may be waived when, in the judgment of the Engineer in Charge, the aggregate is sufficiently free from moisture, so that there will be no harmful effects on the cement.

Partial Mixing at the Central Plant

When a truck mixer, or an agitator provided with adequate mixing blades, is used for transportation, the mixing time at: the stationary plant mixer may be reduced to thirty (30) seconds and the mixing completed in a truck mixer/agitator. The mixing time in the truck mixer or agitator equipped with adequate mixing blades shall be as specified for truck mixing.

Stiff Concrete Mix

For mixing concrete of zero slump to be laid by pavers, slip form, gravity mixer shall not be used. Only force mixer of moving blades shall be allowed to ensure homogenous mix.

Type and Capacity

All concrete shall be produced in a batching and mixing plant or by means of a mechanical mixer.

The ingredients of concrete, except the full quantity of water, shall be mixed in batch mixer for not less than 11/2 minutes. The mixing time will be increased where the batch mixer has a capacity of more than two cubic yards. The Engineer-in-charge reserve the right to increase this time when the charging and mixing operations fail to produce a concrete batch of evenly distributed ingredients and the consistency is not uniform. The concrete shall be the concrete shall be uniform in composition or consistency are required. Water shall be added prior to, during and following the mixer-charge operations. Excessive over-mixing required the addition of water to preserve the required concrete consistency will not be permitted.

The capacity of the plant shall be such that the proposed arrangement will produce adequate quantity of concrete to meet with all the other requirements of these Specifications and the construction schedule. The batched materials shall be thoroughly combined into a uniform mixture before the addition of water and admixtures. The water shall be added gradually and the mixer operated for specified duration of time so as to obtain a thoroughly mixed concrete of uniform colour and quality.

Mixers

The mixers provided by the Contractor shall be capable of combining the materials into a uniform mixture and of discharging without segregation. Mixers shall not be charged in excess of the capacity recommended by the manufacturer and shall not be recharged before completely discharging the previous batches. Over mixing requiring additions of water will not be permitted. The mixers shall be operated at a drum speed designated by the manufacturer. The mixers shall be cleaned frequently and maintained in satisfactory operating condition, and mixer drums shall be replaced when worn down more than 10 per cent of their length and or thickness.

Truck mixer will be permitted only when they produce concrete of uniform consistency and grading throughout the mixed batch and from batch to batch. Any concrete retained in truck mixers for so long a time that it cannot be satisfactorily placed without additional water shall be wasted at the expense of the contractor.

Any mixer that at any time produce unsatisfactory results shall be repaired promptly and effective or shall be replaced. Mixer in centralized batching and mixing plants shall be so arranged that mixing action can be observed from the section of the mixing plant operator. Mixer shall not be loaded in excess of their rated capacity, unless specifically authorized. Each mixer shall preferably be equipped with a mechanically operated timing and signalling device which will indicate the completion of the required mixing period and will count the batches.

Water Batcher

A suitable water measuring device shall be provided by the Contractor which shall be capable of measuring water within the specified requirements for each batch. The mechanism for delivering water to the mixer shall be such that no leakage will occur when the valves are closed.

Locations

The concrete plant/mixer shall be installed at the Site at locations selected by the Contractor and approved by the Engineer-in-Charge.

Arrangement

Separate bins and compartments shall be provided for each size or type of aggregate and Portland cement. The compartments shall be of adequate size and so constructed that the materials will be maintained separated under all conditions. Batching equipment/arrangement shall be capable of delivering concrete within the following limits of accuracy as shown in Table 5.6.

Table 5.6
Tolerances for Weights of Concrete Batching Ingredients

Material	Percent by weight
Cement	±1%
Water	±1%
Aggregate smaller than 19 mm (3/4 inches)	±2%
Aggregate larger than 19 mm (3/4 inches)	±3%

For volume batching suitable measuring boxes shall be used. The batching should preferably be for one full bag of cement (50 Kgs.) corresponding to a volume of 1¼ Cu.ft. (0.035 Cu.M.) or such other amount as may be determined by the Engineer-in-Charge as a result of tests of bulking effect of aggregates shall be take into consideration.

Cooling

Adequate cooling facilities shall be provided to ensure that the temperature of concrete when discharged from the mixers is sufficiently low to meet the temperature requirements as specified in sub-section 5.3.4(c). Cool mixing water, ice, pre-cooled aggregate, shading the stockpiles with roofing or any other arrangements may be used to ensure the pre-cooling of the concrete, subject to the written approval of the Engineer-in-Charge, but approval shall not in any way relieve the Contractor of his responsibility of placing concrete at temperatures at or below the specified limits. The Engineer-in-Charge if required shall order the following to meet the temperature requirements.

1. Avoiding the placement of concrete during the hottest part of day.
2. Placement only at night.

Scales

Adequate weight and volume batching facilities, as approved by the Engineer-in-Charge, shall be provided by the Contractor for the accurate measurement and. control of each of the materials entering each batch of concrete. The accuracy of the weighing equipment shall conform to the requirements of applicable standards. The weighing equipment shall be arranged so that the concrete plant operator and Engineer-in-Charge can observe the dials or indicators. Volumetric measurements, if approved by the Engineer-in-Charge, shall be made by means of accurate measuring boxes.

Mixing Time

The mixing periods specified in Table 5.7 are based on proper control of the speed of rotation of the mixer in accordance with Plant Manufacturer's recommendation and of the proper introduction of the materials into the mixer. The mixing time will be increased when such increase is necessary to secure the required uniformity, workability and consistency of the concrete. The mixing time for each batch after solid materials are in the mixer drum, provided that all the mixing water is introduced before one fourth of the mixing time has elapsed, shall be as follows:

Table 5.7
Mixing Periods for Concrete

Capacity	Mixer Mixing Time (Minutes)
Upto 1.5 cubic metres (2 cu.yds)	2.0
from 1.5 to 2.5 cubic metres (2.0 to 3.25 cu.yds)	2.5

The time for higher capacity mixing shall be according to plant manufacture's recommendation.

5.3.4 CONVEYING

Concrete shall be conveyed from mixer to the place of final deposit as rapidly as practicable, by methods which will prevent segregation or loss of ingredients and in accordance with ACI-304. Any wet batch hopper through which the concrete passes shall be conical in shape. There shall be no vertical drop greater than one metre except where the use of such equipment is approved in writing by the Engineer-in-Charge, in advance of any use. Each type or class of concrete shall be visually identified by placing a coloured tag or marker or routing slip clearly marking quantity, slump, type of mix, time of batching/ discharge and name of part of structure for which it is tended so that the concrete may be positively identified and placed in the structure forms in the desired position.

5.3.5 PLACING

(a) General

(I) The method and equipment used for transporting concrete must ensure that concrete having the required composition and consistency are delivered to the workout objectionable or loss of slump.

(II) Concrete shall be placed only in presence of the Engineer-in-charge.

(III) Any concrete which has become so stiff that proper placing cannot be assured shall be wasted and no payment shall be made to the contractor for such wasted concrete, including contained cement. Concrete shall be deposited direct in all cases as near as practicable to its final position and shall not flow in a manner to permit or cause segregation.

(IV) Concrete shall not be placed during rains unless proper protection is afforded.

(V) Concrete bucket, where used, shall be capable of promptly discharging the low-slump concrete mixes specified and the dumping mechanism shall be designed to permit the discharge of as little as four cubic feet portion of the load in one place.

(VI) Each layer of concrete shall be consolidated to the maximum practicable density so that it is free from pockets of aggregates, and close snugly against all surface of forms and embedded materials.

(VII) In consolidating each layer of concrete the vibrating head of the vibrator shall be secured to form or allowed to penetrate and revibrate the concrete in the upper portion of the underlying layer. All concrete shall be consolidated with electric or pneumatic power-driven vibrators having a frequency of not less than 5000 cycles per minute. Additional layers of concrete shall be placed after the layers previously placed have been worked thoroughly so that no air bubble comes to the surface. He operations shall be carried out by a person trained in the job.

(VIII) Special care shall be taken in placing concrete when it has to be dropped from a height, especially when reinforcement is in the way, and every effort shall be made to reduce this drop to the minimum. In any case the drop shall not be more than 5 feet.

(IX) SLOPING BEDS NOT ALLOWED- Unless otherwise specified, no peripheral slopes shall be allowed in the bed when it becomes necessary for any reason to terminate placing operations. Such termination shall be against forms stepped as directed by the Engineer-in-charge.

(X) Ducts, recess, rebates and holes shall be moulded in the concrete during placing at their proper position as shown on the drawing or as directed by the Engineer-in-charge.

b) Placing of Concrete under water

When the space to be filled with concrete contains water which cannot be removed in some practical way or when so specified or directed by the Engineer-in-charge the concrete shall be deposited under water according to the following stipulations.

(I) Unless otherwise specified a nominal mix 1:1-1/2:3 shall be used for all concreting under water. Cement and aggregate shall be mixed for a period of 2 minutes with sufficient water to produce concrete having a slump not less than 6 inches and not more than 6 inches for concrete placed by bottom dump bucket or concrete placed in sacks.

(II) Caissons, coffer dams or form shall be sufficiently tight to prevent loss of mortar or flow or water through the space in which the concrete is to be deposited.

(III) Pumping shall not be done during the course of placing concrete and 24 hours afterwards.

(IV) The surface shall be examined by a competent diver and the result reported to the Engineer-In-charge who shall grant permission to start placing concrete only after he is satisfied that the bottom surface is level. The service of the diver shall be arranged by the contractor as his own expense.

(V) Concrete shall be deposited continuously till it has attained the desired level. During placing the top surface shall be kept as nearly level as possible by taking sounding and avoiding the formation of laitance planes or removing it, if formed.

(VI) Unless otherwise specified or directed by the Engineer-In-charge anyone of the following methods of placing shall be employed after getting approval from the Engineer-In-charge.

i. TREMIE- The top section of the tremie shall be hopper large enough to hold one complete batch of the mix or the entire contents of the transporting bucket when it is used. The tremie pipe shall not be less than 8 inches in diameter and shall be large enough to allow a free flow of concrete and strong enough to withstand the external pressure of water in which it is suspended, even if a partial vacuum develops inside the pipe. Unless otherwise specified, flanged steel pipe od adequate strength to sustain the greater length and weight shall be used. A separate lifting device shall be provided for each tremie pipe with an approved automatic check valve, the upper end shall be plugged with a wadding of gunny sacking or other approved materials, before delivering the concrete to the termie pipe through the hopper. The hopper shall be forced to and out of bottom end of the pipe by filling the pipe with concrete. The tremie shall be raised slowly to cause a uniform flow of the concrete, but it shall not be emptied so that water enters above the concrete in pipe. From the time the placing of concrete starts till it finishes, the lower end of the termite pipe shall be below instead of flowing out over the surface, to avoid formation of laitance layers. If the charge in the termite is lost while depositing, the termite shall be raised above the concrete surface, and if not sealed by a check valve it shall be replugged at the top end, as at the beginning, before refilling for depositing concrete.

ii. Bottom DUMP BUCKET- The bottom dump bucket shall be of the type that cannot be opened till it has rested, with its load, on the surface upon which concrete is to be deposited. The bottom doors shall be so equipped as to be automatically unlatched by the release of tension on the supporting line or cable of the bucket and shall open downward and outward as the bucket is raised. The top of the bucket shall be fitted with double, overlapping canves flaps, or other approved covers, to cover the contained concrete and to protect it from being washed as the bucket enters the water and descends to the bottom. The buckets shall preferably be so designed that the hinged bottom doors shall operate inside a steel skirt, which shall surround the bucket while the bottom doors are shut and shall extend below the bucket as the bottom door open, and thus minimize turbulence and motion while the concrete is being deposited. The bucket shall be submerged slowly till it is completely under water. The nominal dive speed after that shall not exceed 200 feet per minute. After the bucket has released the surface on which concrete is to be deposited, it shall be raised slowely for the first six to eight feet to allow concrete to be deposited properly.

iii. SACKS OF CONCRETE- When only a little quantity of concrete is to be deposited under water, it shall be placed in sacks, unless otherwise specified. The space to be concretes shall be filled with sacks of concrete carefully placed in header and stretcher formation, so that they become interlocked. Sacks used for this purpose shall be made of jute or other coarse material, free from deleterious materials and duly approved by the Engineer-In-charge. They shall be filled about two-thirds with concrete and their opening securely tied.

(VII) In case where it is possible to place under water concrete of a limited thickness in the bottom of caisson of cofferdam and completely seal the structure, water shall be pumped out and concrete deposited in air after cleaning the exposed surface.

c) **Placing of concrete under Sea water**

Unless otherwise specified, concreating under sea water shall be governed by the following stipulations: -

(I) The nominal mix employed shall under no condition be leaner than 1:1:2.

(II) An air-entrant agent or admixture duly approved by the Engineer-In-charge shall be added to give three to six per cent entrained air in the concrete.

(III) Sea water shall not be allowed to come in contact with the concrete till it has hardened for at least 4 days.

(IV) Reinforcement or other corrodible metal shall be place not less than 3” from any plane or curved surface, and 4” adjacent surface at corners.

(V) If specially required the face of concrete shall be protected from serve chlimatic conditions or serve abrasion by the stone of suitable quality, dense verified shale bricks or creosoted timber as shown on the drawings or as directed by the Engineer-In-charge

d) **Placing Concrete in Saline Soil**

Unless otherwise specified, concreting in saline soil shall be done keeping in view the following:

(i) The nominal mix used shall be 1:1:2 or richer as actually specified by the Engineer-In-charge depending upon the degree of salinity.

(ii) Reinforcement or other corrodible matel shall not be place closer than two inches from the surface of the concrete.

e) **Placing Concrete in Cold Frosty Weather**

Unless otherwise specified, concreting at temperature below 38 F shall be avoided. If it cannot be avoided the following conditions shall be observed.

(I) Water and frozen aggregates shall be heated before mixing.

(II) Mixing water shall not be heated above 180 F to prevent the occurrence of flash set, and cement sall only be added after the heated aggregate and water have been well mixed. The resulting temperature of aggregate and waste shall not exceed 90 F.

(III) The Temperature of the concrete shall not be allowed to go below 40 F during or after its placing till it has been thoroughly cured and hundred. The temperature of the concrete surface shall be determined by thermometers placed against the surface. Provision shall be made from construction to permit the removal of small sections of form to accommodate thermometers at locations designated by the Engineer-In-charge or his authorized subordinates.

In determining temperature at angles and corners of a structure, thermometers shall be placed not more than eight inches away from the angles and corners. In the case of horizontal surface, thermometers shall rest on the surface under the protection covering normal to the section.

(IV) If allowed by the Engineer-In-charge rapid hardening cement and 12 per cent calcium chloride shall be used for preparing concrete.

(V) Floor slabs and all exposed surface shall be covered immediately after their placing with the protective materials like straw blankets by the Engineer-In-charge.

No concrete is to be placed until all the preparatory works have been satisfactorily completed and the reinforcement and embedded items have been checked and approved by the Engineer-in-Charge. Concrete placing shall follow the practice given in ACI-304. No concrete shall be placed until all formwork, reinforcement, installation of parts to be embedded, bracing of forms and preparation of surfaces involved in the placing and the method of placement have been approved by the Engineer-in-Charge. Approval of the method of placement proposed will not relieve the Contractor of his responsibility for its adequacy and Contractor shall remain solely responsible for the satisfactory construction of all work under the Contract. Before concrete is placed, all surface upon or against which concrete is to be placed shall be free from standing water, mud, debris or loose material. All surfaces of forms and embedded material that have become encrusted with dried mortar or grout from concrete previously placed shall be cleaned of all such mortar or grout before the surrounding or adjacent concrete is placed. The surfaces of absorptive materials against or upon which concrete is to be placed shall be moistened thoroughly so that the moisture will not be drawn from the freshly placed concrete.

Concrete shall be worked into the corners and angles of the forms and around all reinforcement and embedded items without permitting the material to segregate. Concrete shall be deposited as close as possible to its final position in the forms. The depositing of concrete shall be regulated so that the concrete may be effectively compacted with a minimum of lateral movement into horizontal layers generally 6 inches to 12 inches for reinforced concrete and 15 inches to 18 inches for mass concrete or as approved by the Engineer-in-Charge. No concrete that has partially hardened or been contaminated by foreign materials shall be deposited in the structure, nor shall re-tampered concrete be used unless approved by the Engineer-in-Charge.

The surfaces of construction joints shall be kept continuously wet for at least eighteen hours during the twenty-four hour period prior to placing concrete except as otherwise directed by the Engineer-in-Charge. All free water shall be removed and the construction joint shall be completely surface dry prior to placement of concrete. All concrete placing equipment and methods shall be subject to approval of the Engineer-in-Charge. Concrete placement will not be permitted, if in the opinion of the Engineer-in-Charge, weather conditions prevent proper placement and consolidation. It is advisable during wet weather to maintain a large slope on any large area of fresh concrete, sufficient to result in drainage of water.

f) **Time Interval Between Mixing and Placing**

Concrete mixed in stationary mixers and transported by non-agitating equipment shall be placed within thirty minutes after it has been mixed, unless otherwise authorized. When a truck mixer or an agitator is used for transporting concrete, the concrete shall be delivered to the site of the work and discharge shall be completed within 1.5 hours after introduction of the cement to the aggregates. The concrete shall be placed within 30 minutes after it has been discharged. In all cases, concrete shall be placed and compacted well within the initial setting time.

g) **Placing Temperature**

Placing temperature unless otherwise approved by the Engineer-in-Charge shall conform to the requirements herein specified for thin, moderate and mass sections. The Engineer-in-

Charge's determination as to the type of section and applicable placing temperatures shall govern. Concrete shall be placed at temperatures as follows:

THIN SECTIONS:

Concrete for thin sections shall be delivered to the forms at the coolest temperature which is practicable to produce under current conditions but in no case at a temperature in excess of 30oC. Except as otherwise determined by the Engineer-in-Charge, sections to which this provision shall apply shall be less than 20 inches (50 cms) in thickness.

MODERATE SECTIONS:

Concrete for moderate sections shall have a temperature of not more than 21^{o}C when placed. A moderate section will be one that is greater than twenty inches (fifty centimetres) but less than 40 inches (one metre) in thickness.

MASS CONCRETE SECTIONS:

Concrete having a measure of 40 inches (one metre) or more in thickness shall have a temperature not exceeding 18^{o}C.

h) **Blinding Concrete**

Where concrete is to be placed on a flat excavated surface or on an excavated surface inclined at not more than lV: 1.75 H, a 3 inches (75 mm) layer of blinding concrete, if not otherwise shown on the Drawings, shall be placed immediately after completion of excavation and cleaning. The upper surface of the blinding concrete shall not be higher than the required cover below the lowest layer of the reinforcing steel. The final excavated level shall be calculated to allow for the 75 mm thickness of the blinding layer.

i) **Lifts in Concrete**

Concrete shall be placed in lifts or depths as shown on the Drawings. The placement of concrete shall be carried on at such a rate and in such a manner that formation of cold joints is prevented. Slabs shall be placed in one lift, unless otherwise authorized or directed. In walls, lifts shall terminate at such levels as shall conform to structural details. Where slabs and beams are placed continuously with walls and columns, the concrete in walls and columns shall have been in place for at least two hours, or for a longer period when directed by the Engineer-in-Charge, before placing concrete in the slabs and beams. The top surface of vertically formed lifts shall be generally levelled. The concrete in columns shall be placed in one continuous operation, unless otherwise authorized. In general, the construction joints in beams and slabs shall be located as shown on the Drawings and concrete shall be placed in the sequence indicated on the Drawings or as authorized by the Engineer-in-Charge. The maximum differential in height between the various pours of the structure shall be as shown on the Drawings or as directed by the Engineer-in-Charge.

j) **Elapsed Time between Placement of lifts**

Except as otherwise approved on the basis of lift drawings submitted by the Contractor, a minimum of 72 hours shall elapse between the placing of successive lifts of walls and thin sections and 120 hours shall elapse between placing lifts of moderate and mass sections.

k) **Time between Adjacent Pours**

The time between adjacent pours shall be defined as the time elapsing from the end of the striking off of one pour to the start of placing the next pour. The minimum time elapsing between adjacent pours shall be five days for thin and moderate sections and fourteen days for mass section.

l) **Concrete above and Around Openings**

If concrete is placed monolithically around openings having vertical dimensions greater than 0.6 metres, or if concrete in floor slabs or other similar parts of structures is placed monolithically with supporting concrete, the following instructions shall be strictly observed:

- Placing of concrete shall be delayed from one to three hours at the top of openings and at the bottom of bevels under floor slabs, or other similar parts of structure when bevels are specified and at the bottom of such structural members when bevels are not specified; but in no case shall the placing be delayed so long that the vibrating unit will not readily penetrate on its own weight in the concrete placed before the delay. When consolidating concrete is placed after the delay, the vibrating unit shall penetrate and re-vibrate the concrete placed before the delay.
- The last 0.6 metres or more concrete placed immediately before the delay shall be placed with as low a slump as practicable and special care shall be exercised to effect thorough consolidation of the concrete.
- The surface of concrete where delays are made shall be clean and free from loose and foreign material, when concrete placing is started after. the delay.
- Concrete placed over openings and in slabs and other similar part of structures shall be placed with as low a slump as practicable and special care shall be exercised to effect thorough consolidation of the concrete.

m) **Concrete for Second Stage and Block-outs**

Block-outs for equipment and fittings and for such other work as indicated or directed shall be provided as indicated on the Drawings. After the said equipment and fitting have been installed and adjusted in their final location, the block out recesses shall be filled with concrete. Before installing the components to be embedded in block out concrete and before depositing any block out concrete, the concrete surfaces of the block out shall be cleaned in the manner specified for cleaning construction joints.

Second stage concrete for filling the openings left for the installation of equipment and fittings shall. be anchored to the first stage concrete. The size and spacing of the concrete fixing sockets, if any, to be embedded in the first stage concrete shall be subject to the approval of the Engineer-in-Charge. Different components of structures to be built from second stage concrete like partition walls, slabs, beams and other parts of structure indicated on Drawings as second stage shall be connected to the first stage concrete through dowels. Dowels not shown in first stage concrete Drawings shall be placed and fixed in position by drilling holes in concrete as approved by the Engineer-in-Charge.

o) **Placing Concrete through Reinforcement**

In placing concrete through reinforcement, care shall be taken that no segregation of the coarse aggregate occurs.

In certain cases, like the bottom of beams and slabs, the congestion of steel near the forms may make placing difficult. In such cases, as decided by the Engineer-in-Charge, a layer of mortar of a composition compatible with the required concrete strength shall be first deposited to cover the surface to a depth of 15mm.

p) **Vibration of Concrete**

Recommended Practice given in ACI 309 shall be followed for concrete consolidation. Concrete shall be compacted with mechanical or electrical vibrating equipment supplemented by hand spading and tamping. In no case shall vibrators be used to transport concrete inside the forms. The vibrating equipment shall be of internal type and shall at all times be adequate in number of units and power of each unit to properly consolidate all the concrete. Form or surface vibrators shall not be used unless specifically approved. The intensity (amplitude) of vibration shall be sufficient (frequency not less than 6,000 impulses per minute) to produce satisfactory consolidation. The duration of vibrations shall be limited to that necessary to produce satisfactory consolidation. Excessive surface working will not be permitted.

5.3.6 EXPANSION, CONTRACTION AND CONSTRUCTION JOINTS

a) **Expansion and Contraction Joints**

Expansion and contraction joints shall be provided at the locations indicated and according to the details shown on the Drawings. In no case shall any fixed metal, embedded in concrete, be continuous through an expansion or contraction joint.

Where indicated on the Drawings, expansion joint filler joint sealing compound, GI, Aluminium & Copper sheets shall be installed using materials of the type and quality indicated.

The surface of joint of set concrete shall be dry and shall be painted with two coats of bitumen, conforming to AASHTO M-115, and new concrete shall be placed against it only when the bitumen is dry.

b) **Construction Joints**

General:

As soon as a lift is completed, the top surface of concrete and reinforcing dowels shall be immediately and carefully protected from any condition that may damage the concrete surface and the dowels.

Cleaning:

Horizontal construction joints on lifts with relatively open and accessible surfaces shall be prepared for receiving the next lift by cleaning with either wet sandblasting or by air-water cutting. Approved wet sandblasting equipment shall be provided. If the surface of a lift is congested with reinforcing steel and is relatively inaccessible or if for any other reason it is considered undesirable to disturb the surface of a lift before it has hardened, surface cutting by means of air-water jets will not be permitted and the use of wet sandblasting will be required.

Air water cutting:

Air-water cutting of a. construction joint shall be performed when approved by the Engineer-in-Charge. The surface shall be cut with a high-pressure air-water jet to remove all laitance and to expose clean, sound aggregate, but not so as to undercut the edges of the larger particles of the aggregate. The air pressure used in the jet shall be 0.7 MPa plus or minus 10% (100 psi) and the water pressure shall be just sufficient to bring the water into effective influence of the air pressure. After cutting, the surface shall be washed and rinsed as long as there is any trace of cloudiness of the wash water. The surface shall again be washed with an air-water jet while the concrete is still green, say well within 6 hours of concreting, (depending upon the atmospheric conditions of humidity and temperature) prior to placing the succeeding lift. Where necessary to remove accumulated laitance, coatings, stains, debris and other foreign material, wet sandblasting will be required immediately before placing the next lift to supplement air-water cutting. When approved by the Engineer-in-Charge, a retarder may be applied to the surface of the lift in order to prolong the period of time during which airwater cutting is effective. Prior to receiving approval, the Contractor shall furnish technical data and samples of the retarder to be used and shall demonstrate the method to be used in its application.

Wet sandblasting:
When employed in the preparation of construction joints, wet sandblasting shall be performed immediately before placing the following lift. The operation shall be continued until all laitance, coating, stains, debris and other foreign materials are removed. The surface of the concrete shall then be washed thoroughly to remove all loose material.

Joints:
Vertical construction joints shall be prepared similar to the horizontal construction joints. Where allowed by the Engineer-in-Charge, the inner surface of the formwork may be coated with an 'approved set-retarder to facilitate the preparation of the vertical construction joint.

Water disposal:
The method used in disposing of water employed in cutting, washing and rinsing of concrete surfaces shall be such that the waste water does not stain, discolour, or effect exposed surfaces of the structure. Methods of disposal shall be subject to approval by the Engineer-in-Charge.

Specification:

(I) The location of all construction joints shall be subject to the approval of the Engineer-In-charge. The joints shall be constructed in accordance with the provision of these specifications.

(II) Construction and expansion joints shall be built by forming concrete on one side and allowing it to set before resuming concreting, the joint surface shall be thoroughly cleaned and loose material removed. Then without rewetting the surface, a thin layer of cement grout shall be worked well into it or cement and sand mortar mixed in the same proportions as the original concrete shall be placed. Special care shall be taken to obtain thorough compacting and avoid segregation along the joint plane. In horizontal joints, instead of treating surface with grout or mortar, the workability of first batch of the concrete placed in contact with the joint shall be slightly increased.

(III) Unless otherwise specified joints in column shall be made at the underside of the floor members and at the floor level. Haunches and column caps shall be considered as part of and continuous with floor or roof. Concrete shall be deposited in floor system at least two hours after it has been deposited in columns or walls joint in beams and slab at the centre or within the middle third of the span and horizontal joints in walls at the tops of plinth or top bottom of window openings shall be avoided.

(IV) Where a construction joint is required in a section of a building more than 100 feet long or where the space between two expansion joints is more than 100 feet special reinforcement shall be placed at right angle to the joint. Reinforcement shall extend in both directions of the joints and shall have 40 diameters in the case of deformed bars and 50 diameters in the case of plain bars. It shall be placed near the face of the member opposite to the main tensile reinforcement and shall not be less than 0.5% of the sections of the member cut by the joint. Any additional reinforcement required as a result of such additional construction joints shall be provided by the contractor as his own expense.

(V) Where the construction joints are required to be watertight, a continuous key-way shall be constructed in the face of first section of concrete placed, and continuous sheet of non-corrosive metal or any other approved material not less than 9 inches wide shall be placed so as extend the full length of the joint and embedded equally in the concrete on each side thereof.

Method of Measurement

The measurement shall be taken two places of decimal stating the depth and width of joint.

5.3.7 CURING

a) **General**

All concrete including concrete repair work shall be cured by an approved method or combination of methods in accordance with ACI 308. The Contractor shall have all equipment and materials needed for adequate curing and protection of the concrete on hand and ready to use before actual concrete placement begins. Means shall be provided for the protection of concrete from the sun, drying winds and traffic until the specified curing has been completed.
The curing medium shall be applied so as to prevent loss of moisture from the concrete. Concrete shall be protected from heavy rains for 24 hours. All concrete shall be adequately protected from damage. No fire or excessive heat, including the heat resulting from welding, shall be permitted near or in direct contact with the concrete at any time. All galleries, conduits and other formed openings through the concrete shall be closed during the curing period.
If during the specified minimum period of curing, the surface temperature of the concrete falls below 10^{o}C, the period of curing shall be extended to allow the concrete to reach sufficient maturity. The period of extension shall be as approved by the Engineer-in-Charge.
Horizontal concrete surface cured with water shall be kept wet for at least 14 consecutive days immediately following placement. They shall be covered with water saturated materials like gunny bags, canvas, clean sand, matting etc. or by any other improved method duly approved by the Engineer-In-charge which will keep these surface continuously (not periodically) wet.
Unless otherwise specified, the curing of vertical surface shall be done initially by leaving the forms in place, hanging canvas or hessian cloth over the completed work and keeping it wet or by covering plastic sheet or membrane.

Methods of Curing

b) **Moist Curing**

Concrete shall be moist-cured maintaining all surfaces continuously (not periodically) wet for 14 days immediately following the placing or until covered with fresh concrete. Precast elements shall also be water-cured for 14 days. Curing water shall be removed without allowing stagnant pools of water to form on the exposed lift surface. Water for curing shall comply with the applicable requirements of Sub-section 5.3.1.6 - Water. Where forms of tongue-and groove or shiplap sheeting are used and are left in place during curing, the sheathing shall be kept wet at all times. When in contact with concrete, steel forms shall be kept wet. Horizontal construction joints and finished horizontal surfaces cured with sand shall be covered with a minimum uniform thickness of 5 cm of sand and kept continuously saturated with water.

c) **Curing Compound Method**

An approved curing compound conforming to ASTM C-309 shall be applied in accordance with the manufacturer's recommendations immediately after any water sheen which may develop after finishing has disappeared from the concrete surface. It shall not be used on any surface against which additional concrete or other material is to be bonded unless it is proven that the curing compound will not prevent bond or unless positive measures are taken to remove it completely from such areas.

Surfaces exposed to the air may be cured by the application of an impervious membrane if approved by the Engineer in Charge.

The membrane-forming compound used shall consist of a practically colorless liquid. The use of any membrane forming compound that will alter the natural color of the concrete or impart a slippery surface to any wearing surface shall be prohibited. The compound shall be applied with a pressure spray in such a manner as to cover the entire concrete surface with a uniform film and shall be of such character that it will harden within 30 minutes after application. The amount of compound applied shall be ample to seal the surface of the concrete thoroughly. Power operated spraying equipment shall be equipped with an operational pressure gauge and means of controlling the pressure.

The curing compound shall be applied to the concrete following the surface finishing operation immediately after the moisture sheen begins to disappear from the surface, but before any drying shrinkage or craze cracks begin to appear. Type-2 liquid membrane curing compound as specified in AASHTO M 148 may be used as the initial and final curing agent on structural concrete. In the event of any delay in the application of curing compound, which results in any drying or cracking of the surface, application of water with an atomizing nozzle as specified under “Water Method”, shall be started immediately and shall be continued until application of the compound which shall not be applied over any free standing water surface. Should the film of compound be damaged from any cause before the expiration of seven (7) days after the concrete is placed in the case of structures, the damaged portion shall be repaired immediately with additional compound.

Curing compounds shall not hard settle in storage. They shall not be diluted or altered in any manner after manufacture. At the time of use, the compound shall be in a thoroughly mixed condition. If the compound has not been used within one hundred twenty (120) days after the date of manufacture, the Engineer in Charge may require additional testing before use to determine compliance to requirements.

An anti-settling agent or combination of anti-settling agents shall be incorporated in the curing compound to prevent caking.

The curing compound shall be packaged in clean barrels or steel containers or shall be supplied from a suitable storage tank located at the job-site. On-site storage talks shall have a permanent system designed to completely re-disperse any settled material without introducing air or any other foreign substance. Containers shall be well sealed with ring seals and lug type crimp lids. The linings of the containers shall be of a character that will resist the solvent of the curing compound. Each container shall be labeled with the manufacturer’s name, specification number, batch number, number of gallons and date of manufacture and shall have a label warning concerning flammability. The label shall also warn that the curing compound shall be well stirred before use. When the curing compound is shipped in tanks or tank trucks, a shipping invoice shall accompany each load. The invoice shall contain the same information as that required herein for container labels.

Curing compound may be sampled by the Engineer in Charge at the source of supply and at the job-site.

d) **Reinforced Water Proof Paper Method**

The exposed finished surfaces of concrete shall be sprayed with water, using a nozzle that so atomizes the flow that a mist and not a spray is formed, until the concrete has set, after which the waterproof paper shall be placed. The paper shall remain in place for a period of not less than seventy-two (72) hours.

Reinforced waterproof paper shall comply with ASTM C 171 specifications. It shall be composed of two sheets of Kraft paper cemented together with a bituminous adhesive and reinforced with fibre. The waterproof paper shall be formed into sheets of such width as to provide a complete cover of entire concrete surface.

- All joints in the sheets shall be securely cemented together in such a manner as to provide a waterproof joint. The joint seams shall have minimum lap of ten (10) cm.
- The sheets shall be securely weighted down by placing a bank of earth on the edges of the sheets or by other means satisfactory to the Engineer in Charge.
- Should any portion of the sheets be broken or damaged within seventy-two (72) hours after being placed, the broken or damaged portions shall be immediately repaired with new sheets properly cemented into place.
- Sections of sheets, which have lost their waterproof qualities or have been damaged to such an extent as to render them unfit for curing the concrete shall not be used.

Forms-in-Place Method

Formed surfaces of concrete may be cured by retaining the forms-in-place. The forms shall remain in place for a minimum period of seven (7) days after the concrete has been placed, except that for members over five (5) cm in least dimension, the forms shall be in place for a minimum period of five (5) days. Wooden forms shall be kept wet by watering during the curing period.

Steam Method

After placing and vibrating, the concrete shall be allowed to attain its initial set before steam is applied. During the placing of concrete and application of steam, provision shall be made to prevent surface drying by means of a coating of approved material. The optimum curing temperature shall not exceed sixty-five (65) °C.

Polyethylene Sheeting Method

The wet surface of fresh concrete shall be covered with white polyethylene sheeting as soon as possible without marring the surface and should cover all exposed surfaces of the concrete. The edges of the sheeting shall be weighted securely with a continuous windrow of earth or any other means satisfactory to the Engineer in Charge to provide an air-tight cover. Adjoining sheets shall overlap not less than thirty (30) cm and the laps shall be securely weighted with earth, or any other means satisfactory to the Engineer in Charge to provide an air-tight cover.

5.3.8 REPAIR OF CONCRETE

a) **General**

Concrete that is damaged from any cause; concrete that is honeycombed, fractured, or otherwise defective; and concrete which, because of excessive surface depressions, must be excavated and built up to bring the surface to the prescribed lines; shall be removed and replaced with dry pack mortar, or concrete, as hereinafter specified. The excavation to firm surface shall be carried carefully by hand or by using mechanical means without damaging the firm surface on which material is to be placed. Repair of concrete shall be performed only by skilled workmen and within 24 hours of removal of forms. The Contractor shall keep the Engineer-in-Charge advised as to when repair of concrete will be performed. Unless an inspection is waived in each specific case, repair of concrete shall be performed only in the presence of the Engineer-in-Charge. Repairs shall be made in accordance with the procedures approved by the Engineer-in-Charge or his representative.

b) **Material**

All materials used in the repair of concrete specified hereunder shall conform to the applicable requirements of the Specifications for Section 5 – Plain & Reinforced Concrete.

c) **Protrusions**

Where bulges and abrupt irregularities protrude outside the specified limits on formed surfaces not to be concealed permanently, the protrusions shall be reduced by bush-hammering and grinding so that the surface irregularities are within the specified limits.

d) **Depressions**

General:

All fillings for depressions shall be bonded tightly to the surfaces of holes and shall be sound and free from shrinkage cracks and drummy areas after the fillings have been cured and have dried. All fillings in surfaces of structures prominently exposed to public view shall contain sufficient white Portland cement to produce the same colour as that of the adjoining concrete. Repairs shall be made with non-shrink grout, guniting or dry pack filling except where repairs with epoxy concrete and/or epoxy mortar are directed to be made by the Engineer-in-Charge. Concrete, mortar, grouting, guniting or dry pack mortar filling as the case may be shall each be mixed in proportions approved by the Engineer-in-Charge to produce a repair at least equivalent in strength density and durability to the concrete in which the repair is required and shall match with the adjacent surfaces in texture, colour and shade.

Concrete filling:

Concrete filling shall be used for holes extending entirely through concrete sections; for holes in which no reinforcement is encountered and which are greater in area than 10 square inches (0.1 square metre) and deeper than 4 inches (10 cm); and for holes in reinforced concrete which are greater than 5 square inches(0.05 square metre) in area and which extend beyond the reinforcement.

Mortar filling:

Mortar filling (1 cement and 1 sand), placed under impact by use of a mortar gun, may be used for repairing defects on surfaces, not exposed to public view where the defects are too wide for dry pack filling and too shallow for concrete filling and no deeper than the far side of the reinforcement that is nearest to the surface.

Drypack mortar filling:

Dry pack mortar fillings shall be used for filling holes having a depth nearly equal to, or greater than, the least surface dimension; for narrow slots cut for repair of cracks; for grout pipes recesses; and for tie rod fastener recesses as specified. Dry pack mortar shall not be used for filling behind reinforcement or for filling holes that extend completely through a concrete section. If removal of the ends of form ties results in recesses, the recesses shall be filled with dry pack mortar provided that filling of recesses in surfaces upon or against which fill material or concrete is to be placed will be required only where the recesses are deeper than 25 mm in walls less than 300 mm thick.

Surface finishes of repaired areas:

The Contractor shall correct all imperfections on the concrete surface as necessary to produce surfaces that conform to the requirements specified for the adjacent area. Fins and encrustations shall be neatly removed from the surfaces.

5.3.9 FINISHES AND FINISHING

a) **General**

Allowable deviations from plumb or level and from the alignment, profile grades and dimensions shown on the Drawings or specified. Tolerances are defined as tolerances and are to be distinguished from irregularities in finish as described herein. The classes of finish and the requirements for finishing of concrete surfaces shall generally be as specified herein or as indicated on the Drawings. Finishing of concrete surfaces shall be performed only by workmen who are skilled concrete finishers.

The Contractor shall keep the Engineer-in-Charge informed as to when finishing of concrete will be performed. Unless inspection is waived in each specific case, finishing of concrete shall be performed only in the presence of the Engineer-in-Charge. Concrete surfaces will be tested by the Engineer-in-Charge where necessary to determine whether surface irregularities are within the limits hereinafter specified. Surface irregularities are classified as abrupt or gradual. Offsets caused by displaced or misplaced form sheathing or lining or form sections or otherwise defective form lumber will be considered as abrupt irregularities, and wilt be tested by direct measurements. All other irregularities will be considered as gradual irregularities and will be tested by the use of a template, consisting of a straight edge or the equivalent thereof for curved surfaces. The length of the template will be 5 ft. (1.5 metres).

The classes of finish for concrete surfaces shall be as shown on the Drawings or as directed by the Engineer-in-Charge. No grinding will be required on formed surfaces other than that necessary for repair of surface imperfections as specified herein.

b) **Ordinary Finish (OF)**

Ordinary finish (OF) applies to surfaces upon or against which fill material or concrete is to be placed. If unformed, the finishing operation shall consist of sufficient levelling and screeding to produce even uniform surfaces. When formed, the surfaces require no treatment after form removal except for repair of defective concrete and filling of holes left by the removal of fasteners from the end of the tie rods as required under Sub-section 5.3.8 -Repair of Concrete. Correction of surface irregularities shall be required for depressions only and only for those which exceed 25 mm when measured.

c) **Rough Concrete Finish (RC)**

Rough concrete finish (RC) applies to surfaces which are intended to receive tiles, metallic lining or other applications as indicted on the Drawings. After consolidation and levelling of the concrete to the specified tolerances, the surface shall be roughened with stiff brushes or rakes before final set. Where rough concrete finish is specified for wall surfaces, the same shall be obtained by use of formwork suitable to produce the required finish. Surface irregularities measured shall not exceed 6mm for floors and 3mm for walls.

d) **Ordinary Slab Finish (OS)**

Ordinary slab finish (OS) applies to floor surfaces which are not intended to receive any floor coverings. After the concrete has been placed, consolidated, struck-off and levelled, and its surface has stiffened sufficiently, floating shall be performed by use of hand or power driven equipment, and shall be the minimum necessary to produce a surface that is free from screed marks and is uniform in texture. Floating shall be continued until a small amount of mortar without excess water is brought to the surface so as to permit effective trowelling. Steel trowelling shall be started when the surface has hardened sufficiently to prevent excess of fine material from being drawn to the surface. Steel trowelling shall be performed with firm pressure such as will flatten the sandy texture of the floated surface and produce a dense uniform surface, free from blemishes and trowel marks. Surface irregularities measured as described in Sub-section 5.3.9(a) General, shall not exceed 6mm for abrupt irregularities and 12mm for gradual irregularities and 12mm for gradual irregularities

Ordinary surface form finish will follow AASHTO-SS-8.12.2. Non-shrinkable mortar will be used.

e) **Fair Faced Finish (FF)**

Fair Finish (FF) shall be applied to all exposed surfaces of walls and ceilings which are not to be covered by any other finish. Surface irregularities shall not exceed 3mm for abrupt irregularities and 6mm for gradual irregularities, when measured as described in Sub-section 5.3.9(a). All abrupt irregularities and all gradual irregularities in excess of 6mm shall be reduced by grinding to conform to the specified limit for gradual irregularities.

Surface Rendering

All faces of concrete that are to come in contact with back fill or pavement materials, shall be applied two coats of hot bitumen of approved quality, before placing any material around concrete.

Cracks

If cracks, which in the opinion of the Engineer in Charge may be detrimental to the stability, strength and durability of the construction, develop in concrete construction, the Contractor at his own expense shall test the structure. If under such test loads the cracks develop further, the Contractor shall dismantle the construction, carry away the debris, replace the construction and carry out all consequential work thereto.

If any cracks develop in the concrete construction, which in the opinion of the Engineer in Charge, are not detrimental to the stability of the construction, the Contractor at his own expense shall grout the cracks with epoxy grout or with other better composition as directed by Engineer In Chargeand also at his own expense and risk shall make good to the satisfaction of the Engineer in charge all other works such as plaster, moulding, surface finish, which in the opinion of the Engineer in Charge have suffered damage. The Engineer in Charge decision as to the extent of the liability of the Contractor in the above matter shall be final and binding.

External crack width shall be restricted to 0.2 mm on all structures. If cracks width is more than 0.2 mm or in the opinion of Engineer in Charge may be detrimental to concrete construction, the Contractor at his own expenses should test the structure.

(h) Defective Concrete

Badly executed work not conforming to requirements shall be removed wholly and re-executed at Contractor's cost and shall not be incorporated in the works. No plastering or repairs will be allowed to concrete. Decision of Engineer in Charge will be binding on the Contractor.

5.3.10 TESTING OF COMPRESSIVE STRENGTH

Concrete compressive strength requirements consist of a minimum strength at the age of twenty-eight (28) days and the minimum strength that must be attained before various loads or stresses are applied to the concrete. The various strengths required are specified in Table 1.

The compressive strength of concrete will be determined from test cylinders, which have been fabricated from concrete sampled and tested in accordance with AASHTO T 23 and T 22.

A set of six (6) cylinders shall be taken from each fifty (50) cu m of each class of concrete or fraction thereof placed each day, three (3) of the six (6) cylinders to be tested after seven (7) days and three (3) after twenty-eight (28) days.

a) The minimum average twenty-eight (28) days' test result of all samples tested at any time shall be the specified twenty-eight (28) days' strength.

b) No individual samples tested after 28 days shall show a test result lower than eighty-five (85) % of the required twenty-eight (28) days.

Concrete represented by any single test cylinders that fails to comply with the requirement under (b) above will be rejected unless the Contractor at his expense, provides evidence that the strength and quality of the concrete placed in the work are acceptable. If such evidence consists of tests made on cores taken from the work, the cores shall be obtained and tested in accordance with the specifications of AASHTO T 24.

Test results of the cores shall meet the following requirements:

i) Average test result of the cores shall not be less than the minimum required twenty-eight (28) days' strength.

ii) No individual core shall show a strength less than ninety-five (95) % of the required twenty-eight (28) days' strength.

Should the above test results fail to comply with the requirements, concrete of that particular pour shall be rejected and removed as directed by the Engineer in Charge. Furthermore, the Contractor shall redesign the concrete mix for approval of the Engineer in Charge.

In case, seven (7) days' strength shows less than seventy (70) % of the twenty-eight (28) days' strength (in case of type-I cement), Engineer in Charge may stop further work on that particular portion of concrete, unless twenty-eight (28) days' strength gives satisfactory results

Rejection of Concrete

If above test result fails to comply with the requirements, concrete or that particular pour will be rejected and removed as directed by the Engineer in Charge.

5.4 CONCRETE REINFORCEMENT

5.4.1 GENERAL

The work shall include providing, cutting, bending, fabricating, assembling and placing of all concrete reinforcement including rods and fabric in accordance with Drawings, Specifications and Standards as referred hereunder.

Reinforcement shall not be stacked on the ground to save it from mud, rust or other dangerous coatings. Different sizes shall be stacked separately to facilitate deification. The bent bars ready for fixing shall be correctly marked in order that there is no difficulty in selecting the correct bars. The bar to be fixed shall be free from dust, oil, paint, rust or loose scale. All bending of bars shall be done cold by the application of slow, steady pressure or with a suitable machine. No heating of bars shall be allowed except for fishtailing. Welding shall be permitted under suitable conditions and safeguards in accordance with Pakistan standard Specification for welding. Where the reinforcement is congested or complicated, spot welding shall be done for assembling of reinforcement.

5.4.2 RELATED WORKS

Section 5.3 - Plain and Reinforced Concrete.

Section 5.5 - Concrete Formwork

5.4.3 SUBMITTALS

The Contractor shall submit the following to the Engineer-in-Charge for his approval/record before execution of work:

a) Shop Drawings for fabrication, bending and placement of concrete reinforcement. ACI 315 shall be complied with showing bar schedules, stirrup spacing, diagrams of bent bars, arrangement of concrete reinforcement and special reinforcement required for openings through concrete structures.
b) Samples of materials as specified and as otherwise may be requested by the Engineer-in-Charge including names, sources and descriptions as required.
c) Mill certificates or laboratory test reports as required.

5.4.4 MATERIALS

a) Concrete reinforcement of diameter smaller than 35 mm shall be hot rolled deformed steel bars conforming to ASTM Designation A 615 and shall have a minimum yield strength of 275 MPa (40,000 psi). If specified plain mild steel conforming to BS 4449 shall be used.
b) Steel bars of a high strength, if required, shall have a minimum yield strength of 415 MPa (60,000 Psi) and shall conform to ASTM A-615 or PS 605.
c) Tor steel shall conform to the applicable British Standard.
d) Mesh reinforcement shall be welded wire fabric conforming to the requirements of ASTM A-185 or BS 4482 and 4483.

e) Supports, spacers or ties required shall conform with the Specifications and Standards for main reinforcing steel as per (a) & (b) above.

f) Binding wire shall be 1.6 mm dia (16 gauge) soft iron wire.

Deformed Bar

A reinforcing bar manufactured with surface deformations to provide bonding strength when embedded in concrete. The following table showing the different values of deformed bars as per ASTM A-615

Bar Designation No	Nominal Weight Kg/m (lb/ft)	Diameter mm (in)	Cross-Sectional Area mm^2 (in^2)
10 (3)	0.560 (0.376)	9.5 (0.375)	71 (0.11)
13 (4)	0.994 (0.668)	12.5 (0.500)	129 (0.20)
16 (5)	1.552 (1.043)	15.9 (0.625)	199 (0.31)
19 (6)	2.235 (1.502)	19.1 (0.750)	284 (0.44)
22 (7)	3.042 (2.044)	22.2 (0.875)	387 (0.60)
25 (8)	3.973 (2.670)	25.4 (1.00)	510 (0.790)
29 (9)	5.060 (3.400)	28.7 (1.128)	645 (1.00)
32 (10)	6.404 (4.303)	32.3 (1.270)	819 (1.27)
36 (11)	7.907 (5.313)	35.8 (1.410)	1006 (1.56)
43 (14)	11.380 (7.650)	43 (1.693)	1452 (2.25)
57 (18)	20.240 (13.600)	57.3 (2.257)	2581 (4.00)

Requirements for Deformation

Deformations shall be spaced along the bar at substantially uniform distances. The deformations on opposite sides of the bar shall be similar in size, shape, and pattern.

The overall length of deformations shall be such that the gap (measured as a chord) between the ends of the deformations on opposite sides of the bar shall not exceed 121⁄2 % of the nominal perimeter of the bar. Where the ends terminate in a longitudinal rib, the width of the longitudinal rib shall be considered the gap. Where more than two longitudinal ribs are involved, the total width of all longitudinal ribs shall not exceed 25 % of the nominal perimeter of the bar; furthermore, the summation of gaps shall not exceed 25 % of the nominal perimeter of the bar. The nominal perimeter of the bar shall be 3.1416 times the nominal diameter.

Measurement of Deformation

The average spacing of deformations shall be determined by measuring the length of a minimum of 10 spaces and dividing that length by the number of spaces included in the measurement. The measurement shall begin from a point on a deformation at the beginning of the first space to a corresponding point on a deformation after the last included space.

Spacing measurements shall not be made over a bar area containing bar marking symbols involving letters or numbers

Tensile Requirements

The strain shall be 0.5 % of gage length for Grade 40 [280] and Grade 60 [420] and shall be 0.35 % of gage length for Grade 75 [520]. When material is furnished in coils, the test sample shall be straightened prior to placing it in the jaws of the tensile machine. Straightening shall be done carefully to avoid formation of local sharp bends and to minimize cold work

Table from ASTM

Tensile Strength Min MPa (psi)	Steel 280 MPa (Grade 40)	Steel 420 MPa (Grade 60)	Steel 520 (Grade 75)
	420 (60,000)	620 (90,000)	690 (100,000)
Yield strength Min Mpa (psi)	280 (40,000)	420 (60,000)	520 (75,000)
Elongation in 203.2 mm (8 in) min %			
Bar Designation			
10 (3)	11	9	-----
13, 16 (4,5)	12	9	-----
19 (6)	12	9	7
22,25 (7,8)	------	8	7
29, 32,36 (9,10,11)	------	7	6
43,57 (14,18)	-------	7	6

Grade 40 bars are only furnished only from #3 to #6
Grade 75 bars are furnished only from #6 to #18.

Bending Requirements

The bend-test specimen shall withstand being bent around a pin without cracking on the outside radius of the bent portion. The requirements for degree of bending and sizes of pins are prescribed in Table. When material is furnished in coils, the test sample shall be straightened prior to placing it in the bend tester. The requirements for degree of bending is shown in the table given as under

Bar Designation No	Pin Diameter for Bend Tests		
	280 MPa (Grade 40)	420 Mpa (Grade 60)	520 MPa (Grade 75)
10, 13, 16 (3,4,5)	3 ½ d	3 ½ d	---------
19 (6)	5 d	5d	5d
22,25 (7,8)	---------	5d	5d
29, 32, 36 (9,10,11)	---------	7d	7d
43, 18 (14,18)	---------	9d	9d

Test & Retest

For bar sizes No. 3 to 11 [10 to 36], inclusive, one tension test and one bend test shall be made of the largest size rolled from each heat. If, however, material from one heat differs by three or more designation numbers, one tension and one bend test shall be made from both the highest and lowest designation number of the deformed bars rolled

For all bar sizes one set of dimensional property tests including bar weight [mass] and spacing, height, and gap of deformations shall be made of each bar size rolled from each heat.

If any tensile property of any tension test specimen is less than that specified, and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

Rejection

Material that shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

5.4.5 EXECUTION

a) Preparation

The Contractor shall furnish, cut, bend, and place all steel reinforcement including rods and fabric, as indicated on the Drawings or otherwise required. All reinforcement when surrounding concrete is placed, shall be free from loose flaky rust and scale, and free from oil, grease or other coating which might destroy or reduce its bond with the concrete. All placing and fixing shall be in accordance with Drawings furnished or approved by the Engineer-in-Charge. The use of high tensile cold worked reinforcement bars for the transmission of current for welding shall not be permitted. All reinforcement, including dowels, remaining exposed in the work shall be suitably protected against corrosion by a thick coat of cement slurry until embedded in concrete.

b) Cutting and Bending

The Contractor shall ensure that the bars do not get cracked or damaged during bending and fabrication. Steel reinforcement may be mill or field cut and bent. All bending shall be in accordance with ACI 315 and by approved machine methods. When bending is required, it shall be performed prior to embedding the bars in the concrete. In all such cases, the bars shall be cold bent. Bending or straightening of bars partially embedded in set concrete shall not be permitted except in isolated cases where corrective action or a field change is required and is specifically approved by the Engineer-in-Charge.

Tolerances

Cutting for all bars shall be within + 1 inch (+ 25 mm).Bending and placement tolerances for overall or an internal dimension of a bent bar shall be as given in Table 5.7.

Table 5.7
Bending & Placement Tolerances

Description	Tolerances	
	Plus	Minus
Bending		
Bars upto 1.00 meters long	5 mm	5 mm
Bars 1.00 to 2.00 meters long	5 mm	10 mm
Bars over 2.00 meters long	5 mm	25 mm
Placement		
Concrete cover to formed surfaces	5 mm	5 mm
Minimum spacing between bars	5 mm	5 mm
Top bars in slabs and beams		
- Members 200 mm deep or less	5 mm	5 mm
- Member more than 200mm but not over 600mm deep	10 mm	10 mm
- Member more than 600mm deep	25 mm	25 mm

c) Spacing of Bars

The spacing of bars shall be as shown on the Drawings or as directed in writing by the Engineer-in-Charge. The variation from indicated spacing, provided that the total area of reinforcement is in accordance with the Drawings, shall be as per Table 5.7.

d) Concrete Cover to Reinforcement

The cover for all main reinforcement shall conform to the dimensions shown on the Drawings and in no case less than ½ inch or diameter of the bar whichever is more. The protective covering shall not be less than, and shall not exceed by more than 6 mm the values specified on the Drawings. The dimensions, as shown on the Drawings, indicate the clear distance from the edge of the main reinforcement to the concrete surface. The concrete covering of stirrups, spacer bars, and similar secondary reinforcement may be reduced by the diameter of such bars.

Unless otherwise specified the following minimum thickness of concrete cover, exclusive of plaster or other decorating finish, shall be provided in all case: -

a) For each end of reinforcement bar, not less than 1 inch or twice the diameter of such bars.
b) For a longitudinal of such bars. In the case of columns with a minimum dimension of 7-1/2inches or less where bars do not exceed ½ inch diameter, one-inch cover shall be used.
c) For longitudinal reinforcement bar in a beam not less than one inch or the diameter of such bar.
d) For tensile, compressive, share or other reinforcement in a slab not less than ½ inches or the diameter of such reinforcement.
e) For any other reinforcement not less than ½ inches or the diameter of such reinforcement.
f) In case of works in saline or corrosive conditions a minimum of 1-1/2inches cover over bars, stirrups or links.

e) Wire Fabric

Wire Fabric of specified gauge and mesh shall be used where shown on the Drawings. To provide spacing between mesh and surface receiving mortar or concrete, hooked bolts or studs, anchors and soft iron wire not less than No. 18 U.S. Standard gauge shall be used.

f) Splicing

Except as otherwise shown on the Drawings or specified herein, all splices, lengths of laps, splice locations, placement and embedment of reinforcement shall conform to the applicable requirements of ACI 318. All splices and locations of laps in reinforcement shall be as shown on the Drawings or as directed by the Engineer-in-Charge. Lapped ends of bars may be placed in contact and securely wired or may be separated sufficiently to permit the embedment of the entire surface of each bar in concrete.

No welding, including tack welds, of reinforcing bars upto 35 mm in diameter shall be permitted unless shown on the Drawings or authorised in each case by the Engineer-in-Charge. Except as otherwise specifically shown on the Drawings, all reinforcing bars exceeding 35 mm in diameter shall be spliced by butt welding. Butt welding shall conform to the requirements of AWS D.12.1. All welds shall develop the full strength of the smaller bar. Concrete shall be protected from heat during welding operations. Splicing of the reinforcing bars by approved mechanical methods such as cad weld splices or other splices using positive connectors (mechanical splicing) shall be adopted where directed by the Engineer-in-Charge.

g) Supports

All reinforcement shall be secured in place by use of concrete supports. Chairs, spacers, or ties may be of metal or as approved by the Engineer-in-Charge. Such supports shall be of sufficient strength to maintain the reinforcement in place throughout the concreting operations. Concrete supports shall be manufactured of the same concrete strength as used in the structure to be concreted.

h) Embedded Items

Before placing concrete, care shall be taken to determine that all embedded items are properly placed as required under the Specifications and are firmly and securely fastened in place as indicated on the Drawings or as directed by the Engineer-in-Charge. Embedded items shall be free from oil and other foreign matter such as loose coatings of rust, paint and scale. The embedding of wood or other perishable materials in concrete is prohibited unless specifically authorized or directed.

5.4.6 DELIVERY AND STORAGE

a) All reinforcement bundled, tagged and marked with complete identification shall be delivered at Site.

b) Reinforcement shall be stored at Site clear of ground and protected from mud and other deleterious materials.

5.5. CONCRETE FORM WORK

5.5.1. GENERAL

The work shall include design, erecting, supporting, bracing and maintaining form work so that it will safely and rigidly support all vertical and lateral loads encountered during construction. The extent of formwork is indicated by the concrete work shown on the Drawings.

Unless otherwise specified, no separate measurement or payment shall be made for “Providing Erection and Removal of Formwork” as specified herein, as all cost thereof shall be considered to be included in the Contract unit prices for the various concrete items requiring formwork.

5.5.2. RELATED WORK

Section 5.3 - Plain and Reinforced Concrete
Section 5.4 - Concrete Reinforcement

5.5.3. SUBMITTALS

The Contractor shall submit the following to the Engineer-in-Charge for his information/review:

a) **Manufacturer's Data**

Two copies of manufacturer's data and installation instructions for proprietary materials including form coatings, manufactured form systems, ties and accessories.

b) **Shop Drawings**

Shop Drawings for fabrication and erection of architectural finished concrete surfaces as shown on the Drawings or specified.

General construction for forms including jointing of special formed joints or reveals, location and pattern of form tie placement and other items which affect the exposed concrete visually shall be shown on these Shop Drawings. However, the Engineer-in-Charge's review will be for general architectural and engineering applications and features only. Design of formwork for structural stability and sufficiency is the Contractor's responsibility.

5.5.4. FORM MATERIALS

a) **Form liners for Plain Concrete Finish**

TIMBER/PLYWOOD:

New Plywood 19 mm or timber planks 25 mm thick with continuous support for edges parallel to framing shall be provided. Timber form shall be will seasoned and free of loose knots.

Other Materials:

Approved type forms made of steel, plastic, or other suitable materials may be used in lieu of timber planks/plywood, provided the formed surfaces obtained conform to the requirements of finishes specified for the concrete surfaces.

Re-use of Wood Forms:

Projecting nails shall be withdrawn, concrete cleaned off, re-oiling done and Engineer-in-Charge’s approval obtained before re-using the wood forms.

The steel formwork surface in contact with concrete shall be free of rust.

b) **Form Ties**

Form ties shall be snap ties. Sample for Engineer in Charge approval shall be submitted before ordering. Spacing of ties and the rate of placement of concrete shall be consistent with the strength of ties. The Contractor must obtain approval prior to use of any special ties for metal forms.

c) **Form Coatings**

Commercial formulation form-coating compounds shall be provided that will not bond with, stain, nor adversely affect concrete surfaces, and will not impair subsequent treatment of concrete surfaces requiring bond, painting or adhesion nor impede the wetting of surfaces to be cured with water or curing compounds.

5.5.5. INSTALLATION

a) **General**

Forms shall be so constructed that the tolerances specified in ACI 347.203.1 are met. Openings, offsets, chamfers, blocking and other features as required on the work shall be provided. Easy removal of forms without damage to concrete surfaces shall be provided for. Formwork shall be kept clear of wood chips, clogs, and other deleterious material. All concrete surfaces shall be formed. Earth cuts shall not be used as forms for vertical surfaces of concrete work unless approved by the Engineer-in-Charge.

b) **Forms**

The formwork shall conform to the shape, lines and dimensions as shown on the Drawings and be so constructed as to remain sufficiently rigid during the placing and compacting of the concrete, and shall be sufficiently tight to prevent loss of liquid from the concrete. Unless otherwise specified, chamfer strips shall be placed in the corners of forms to produce bevelled edges on permanently exposed surfaces. Interior corners on such surfaces and the edges of the formed joints will not require bevelling unless required on the Drawings. Back joints with extra studs or grits shall be provided to maintain true, square intersections. Extra studs, washers and bracing shall be used as required to prevent bowing of forms between studs.

Reusable steel forms of approved design may be used for cast-in- place concrete.

c) **Form Ties**

Form ties shall be provided at exposed surfaces. Ties shall be set in straight rows and evenly spaced. Prior approval shall be obtained if any special ties for metal forms are to be used.

d) **Form Release Agents**

Form release agents shall be applied in accordance with manufacturer's instructions with special attention to rate and method of application.

Tolerances In Form Work:-

- Variation from plumb in lines and surfaces of piers, walls and rises, 6mm (1/4") per 3 M (10 ft) but not more than 25mm (1")
- For exposed corners, columns, central joints, grooves and other construction lines, 6mm(1/4") in any bay of 6M(20 ft)
- Variation from position of linear building lines and related columns, walls and partitions, 13mm (1/2") in any bay of 6M (20ft) max and 25 mm (1") in 12M (40 ft).
- Variation in size and location of sleeves, floors and wall opening, 6mm (1/4")
- Variation in cross sectional thickness of slab & walls be between -6mm(-1/4") and 12mm(1/2")
- Variation in footing plan dimensions to be between -12mm (-1/2") and 50mm (2"). Layout displacement not more than 12 mm(1/2") and verticality deviation not more than 1% of the footing width, in direction of displacement, but not more than 50mm (2") top.
- Suitable openings as required shall be provided in the formwork for the passage of piping ducts, channels etc. All exposed joints, edges and external corners shall be chamfered 37.5 mm (1/2") at 45°, except otherwise shown. Internal corners are fillet where indicated or required.

5.5.6. REMOVAL OF FORMS

Forms for various parts of the structure shall not be removed before the specified time has elapsed after placing the concrete. Consideration shall be given to the weather and other conditions influencing the setting of concrete, curing, and materials in the mix. The exact time shall be determined by the Engineer-in-Charge and will be dependant on curing conditions and the prevalent temperature.

Form shall be removed with care so to avoid any injury to concrete. In order to avoid excessive swelling of forms wooden forms for wall opening shall be loosened, as soon as this can be accomplished without any damage to concrete. Forms for the openings shall be constructed in such a manner as to be removed until the strength of the concrete is adequate that the removal of form will not result in perceptible cracking, spalling and breaking of edges of surfaces.

Beams and Slabs	14 days
Columns and Wall Faces	24 hours
Concrete Pedestal	24 hours
Sides of Beams, Caps, and Other Parts	24 hours

Personnel and concrete work shall be protected by re-shoring, if required.

Min Period for Form-work Removal

Position of Formwork	Minimum Period Over 10°C
Vertical or near vertical faces of mass concrete	24 Hours
Vertical or near vertical facesb of reinforced concrete walls beams and columns	48 Hours
Undersides of arches, beams and slabs (formwork only)	14 Days
Supports to underside of arches, beams and slab upto 3M (10 ft) span	14 Days
Supports and underside of beams, slabs larger than 3 M (10ft) span	14 Days

5.5.7. COORDINATION

Formwork shall be coordinated with the work of other trades as required for installation of inserts, conduit pipe sleeves, drains, hangers, supports, anchors and similar items. Embedment's shall be secured in position before concrete is poured. Sufficient time shall be allowed between erection of forms and placing of the concrete to allow various trades to install their work properly.

5.5.8. RE-USE OF FORMS

The forms that will provide surfaces of same quality as original shall only be reused.

5.6. FOAM CONCRETE

The structural lightweight concrete shall be of specified grade but for thermal insulation the concrete shall be low strength foam concrete and density as specified. Cement sand mortar in 1:2 ratio and admixture of foaming chemicals as approved by the Engineer-in-Charge shall be used. The amount of different ingredients needed to develop a certain density shall be according to the recommendations of the manufacturer for foaming agent and shall be determined by trial mixes under instructions of the Engineer-in-Charge. All materials and the producing, forming, placing, curing and repairing of the foam concrete shall be in accordance with the applicable requirements of this Plain and Reinforced Concrete Section.

5.7. MEASUREMENT & PAYMENT

5.7.1. GENERAL

All measurements & payments shall be for completed work within the neat lines shown on drawings unless otherwise specifically directed.

Dimensions of length, breadth and thickness shall be measured correct to nearest cm. except for the thickness of slab and partition which shall be measured to nearest 5 mm. Areas shall be worked out to nearest 0.01 sq.m and the cubic contents of consolidated concrete shall be worked out to nearest 0.01 cum. Any work done in excess over the specified dimension or sections shown in the drawing shall be ignored.

Reinforced cement concrete whether cast-in-situ shall be classified and measured separately as follows.

(a) Raft, footing, bases of columns and mass concrete etc. all work up to plinth level, column up to plinth level, plinth beams.

(b) Wall (any thickness) including attached pilasters, buttresses plinth and string course, fillets, column, pillars, piers, abutments, post and struts etc.

(c) Suspended floors, roofs, landings and balconies.

(d) Shelves

(e) Chajjas

(f) Lintel, beams.

(g) Columns, pillars, piers, abutments, posts and struts.

(h) Stair-cases including waist or waist less slab but excluding landing except in (i) below.

(i) Spiral stair-case (including landing).

(j) Arches, arch ribs, domes and vaults.

(k) Chimneys and shafts.

(l) Well steining.

(m) Vertical and horizontal fins individually or forming box, louvers and facias.

(n) Kerbs, steps and the like.

(o) String courses, bands, coping, bed plates, anchor blocks, plain window sills and the like.

(p) Mouldings as in cornices, window sills etc.

(q) Shell, dome and folded plates.

(r) Extra for shuttering in circular work in plan.

5.7.2. CAST-IN-SITU CONCRETE

It shall be measured in stages described in the item of work, such as:

(a) Rafts, footings, bases of columns etc. and mass concrete.

(b) All other items upto floor two level.

(c) From floor two level to floor three level and so on.

(d) R.C.C. above roof level shall be measured along with R.C.C. Work in floor just below.

5.7.3. NO DEDUCTION SHALL BE MADE FOR THE FOLLOWING:

(a) Ends of dissimilar materials for example beams, posts, girders, rafters, purlins, trusses, corbels and steps upto 500 sq cm in cross sections.

(b) Opening upto 0.1 sq metre (1000 sq.cm)

(c) Volume occupied by reinforcement, pipes, conduits, sheathing etc. not exceeding 100 sq cm each in cross sectional areas.

(d) Small voids that do not exceed 40 sq cm each in cross section.

5.7.4. Measurement shall be taken before any rendering is done in concrete members. Measurement will not include rendering. The measurement of R.C.C. work between various units shall be regulated as below:

(a) Slabs shall be taken as running continuously through except when slab is monolithic with the beam. In that case it will be from the face to face of the beam.

(b) Beams shall be measured from face to face of columns and shall be including haunches, if any, between columns and beam. The depth of the beam shall be from the bottom of slab to the bottom of beam if beam and slab are not monolithic. In case of monolithic construction where slabs are integrally connected with beam, the depth of beam shall be from the top of the slab to the bottom of beam.

(c) The columns measurements shall be taken through.

(d) Chajjas along with its bearing on wall shall be measured in cubic metre nearest to two places of decimal. When chajjas is combined with lintel, slab or beam, the projecting portion shall be measured as chajjas, built in bearing shall be measured as per item of lintel, slab or beam in which chajja bears.

(e) Where the band and lintels are of the same height and the band serves as lintel the portion of the band to be measured as lintel shall be for clear length of opening plus twice the over all depth of band.

5.7.5. REINFORCEMENT

No measurement and payment shall be made for the under-mentioned specified works for reinforcement. The cost thereof shall be deemed to have been included in the unit rate of the respective items of the BOQ.

- Providing and installing of chairs, supports, hooks, spacers, binding wires and laps not shown on the Drawings.
- Wastage and rolling margin

Measurement shall be made in tonnes of reinforcing steel acceptably placed on the basis of the lengths of bars installed in accordance with the approved Drawings or bar schedules or as directed by the Engineer-in-Charge. Lengths of each size of bars shall be converted to weights by the use of the unit weights per linear metre for each size as per ASTM A-615 or BS 4449 Standards as approved by the Engineer-in-Charge. Steel in laps indicated on the Drawings and as required by the Engineer-in-Charge will be measured for payment.

5.7.6. COMPOSITE RATE

The measurement and payment for the items of the work of Plain & Reinforced Concrete hereof shall be made corresponding to the applicable CSR items as provided in Contract Agreement and shall constitute full compensation, for procurement, transportation, performance in all respects and completion of work as specified including the site clearance as approved by the Engineer-in-Charge.

5.7.7. LABOUR RATE

The measurement and payment for the items of the work of Plain & Reinforced Concrete hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurement transportation, performance in all respects and completion of work as specified including site clearance, as approved by the Engineer-in-Charge except the cost of materials to be provided by Department at designated location as defined in the Contract Agreement.

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6. PRE-STRESSED CONCRETE

6.1 SCOPE

This work shall consist of pre-stressing, furnishing and placing precast concrete or cast-in-place concrete members/ structures in accordance with details shown on the drawings and as specified in these specifications. The pre-stressing i.e., pre tensioning or post tensioning shall be as per drawings.

This Work shall include the furnishing and installation of all items necessary for the particular pre-stressing system to be used, including but not limited to pre-stressing and reinforcing steel, ducts, anchorage assemblies, bulkheads and grout used for pressure grouting ducts. The Work also includes curing, storing, transportation of pre-stressed members.

6.2 MATERIAL REQUIREMENTS

6.2.1 HIGH TENSILE WIRE

Pre-stressing steel (Cables) shall be high-tensile wire conforming to ASTM Specification A-421 or AASHTO Designation M-204, strand or rope conforming to ASTM Specification A-416 or AASHTO Designation M-203 or high tensile alloy bars as follows:-

Table 6.1 Breaking Strength Requirements as per ASTM A-416

Grade MPa (Ksi)	Strand Designation No.	Dia of strand mm (in)	Min Breaking strength of Strand KN (Lbf)	Steel Area of Strand, mm^2 (in^2)	Weight of Strand kg/1000 m (lb /1000 ft)
1725 (250)	6	6.4 (0.250)	40.0 (9,000)	23.2 (0.036)	182 (122)
	8	7.9 (0.313)	64.5 (14,500)	37.4 (0.058)	294 (197)
	9	9.5 (0.375)	89.0 (20,000)	51.6 (0.080)	405 (272)
	11	11.1 (0.438)	120.1 (27,000)	69.7 (0.108)	548 (367)
	13	12.7 (0.500)	160.1 (36,000)	92.9 (0.144)	730 (490)
	15	15.2 (0.600)	240.2 (54,000)	139.4 (0.216)	1094 (737)
1860 (270)	9	9.53 (0.375)	102.3 (23,000)	54.8 (0.085)	432 (290)
	11	11.11 (0.438)	137.9 (31,000)	74.2 (0.115)	582 (390)
	13	12.70 (0.500)	183.7 (41,300)	98.7 (0.153)	775 (520)
	15	15.24 (0.600)	260.7 (58,600)	140.0 (0.217)	1102 (740)

Table 6.2 Yield Strength Requirements as per ASTM A-416

Grade MPa (Ksi)	Strand Designation No.	Dia of strand mm (in)	Initial Load KN (lbf)	Min Load at 1% Extension KN (lbf)	
				Low Relaxation	Normal Relaxation
1725 (250)	6	6.4 (0.250)	4.0 (900)	36.0 (8100)	34.0 (7650)
	8	7.9 (0.313)	6.5 (1450)	58.1 (13,050)	54.7 (12,300)
	9	9.5 (0.375)	8.9 (2000)	80.1 (18,000)	75.6 (17,000)
	11	11.1 (0.438)	12.0 (2700)	108.1 (24,300)	102.3 (23,000)
	13	12.7 (0.500)	16.0 (3600)	144.1 (32,400)	136.2 (30,600)
	15	15.2 (0.600)	24.0 (5400)	216.2 (48,600)	204.2 (45,900)
1860 (270)	9	9.53 (0.375)	10.2 (2300)	92.1 (20,700)	87.0 (19,550)
	11	11.11 (0.438)	13.8 (3100)	124.1 (27,900)	117.2 (26,350)
	13	12.70 (0.500)	18.4 (4130)	165.3 (37,170)	156.1 (35,100)
	15	15.24 (0.600)	26.1 (5860)	234.6 (52,740)	221.5 (49,800)

The steel shall be free from injurious defects and shall have a smooth surface. Material, which shows injuries defects during or prior to its installation in the work, shall be rejected. Strand shall be supplied in coils of sufficient diameter to ensure that they lie out straight.

The Engineer-in-Charge may call for a relaxation test on pre-stressing steel in case, he is not satisfied with the source of manufacture. Relaxation for pre-stressing steel shall be measured over a period of thousand (1000) hours stressed at seventy (70) percent of its ultimate tensile strength giving less than six (6) percent elongation.

6.2.2 TESTING

Generally all strands, or bars to be transported to the site shall be assigned a lot number and tagged for identification purposes. Anchorage assemblies to be transported shall be likewise identified.

All samples submitted shall be representative of the lot to be furnished. All of the materials specified for testing shall be furnished free of cost and shall be delivered in time for tests to be made well in advance of anticipated time of use. The contractor shall furnish for testing the following samples selected from each lot as ordered by the Engineer-in-Charge. The selection of samples shall be made at the manufacturer's plant by the Engineer-in-Charge or his representative.

a) Pre-tensioning Method

Samples at least 2.1 meter (7 Ft) long shall be furnished of strand size. A sample shall be taken from each and every coil.

b) Post-tensioning Method

Samples of the following lengths shall be furnished.

For wires, sufficient length to make up one parallel lay cable one and half (1.5) M long consisting of the same number of wires as the cable to be furnished. For strands, one and half (1.5) M (5 Ft) length shall be furnished. For bars to be furnished with threaded ends and nuts, one and half (1.5) M (5 Ft) between threads at end.

c) Anchorage Assemblies

Two anchorage assemblies of each size of anchorage to be used shall be furnished, complete with distribution plates. The RCC precast end block where used shall be of reinforced concrete manufactured in accordance with the provisions of Section 5 – Plain & Reinforced Concrete.

All anchorages and couplers for post-tensioning shall be capable of holding the pre-stressing steel at a load producing a stress of not less than ninety-five (95) percent of the specified ultimate tensile strength of the pre-stressing steel. The coupling of tendons shall not reduce the elongation at rupture below the requirements of the tendon itself.

Couplers and coupler components shall be enclosed in housing long enough to permit necessary movements. Couplers shall not be used at points of sharp tendon curvature.

The contractor shall prepare working drawings, backup calculations and material data for the bulk head, anchorages and couplers for pre tensioning to be submitted to the Engineer in Charge for approval unless otherwise directed.

Anchorage devices shall have a **minimum clear concrete or grout coverage of 50** mm in every direction.

Allowance for draw in of the tendon during anchoring shall be in accordance with the Engineers/Designers instructions, and the actual

6.3 CONCRETE

The concrete should of the strength as specified by the designer or as mentioned in BOQ item. The contractor should established the mix design for this purpose from the authorized laboratory of the Government at his own expanse and this will submit to the Engineer in Charge.

6.4 REINFORCEMENT STEEL

Reinforcement steel shall be as specified on drawings shall conform to the provisions of Section 5.4 – Concrete Reinforcement.

6.5 CONSTRUCTION REQUIREMENTS

6.5.1 GENERAL

Unless otherwise ordered by the Engineer-in-Charge, the Contractor shall certify can sublet the work to approved specialized firm approved by the Engineer in Charge for pre-stressing / post-tensioning accompanied by experience certificates for similar projects including list of qualified technicians for completion of pre-stressing operations, equipment for jacking, calibration certificates for equipment to be used and methodology to be adopted for early completion of work

The tensioning process shall be conducted so that the tension being applied and the elongation may be measured at all times.

Safety Precaution during Stressing

During the pre-stressing operations, standing behind or under jack will not be allowed in order to ensure that no one is injured by the flying spindle, tendon or the jack in the event of a break occurring.

6.5.2 PRE-STRESSING SYSTEM

The pre-stressing system shall be as shown on drawings and indicated in the tender. The Contractor may opt for the alternate method of pre-stressing to be used, provided he introduces no change in the position of centroid of the total pre-stressing force over the length of the member and in the magnitude of the final effective pre-stressing force as prescribed in the Drawings.

In case Contractor wants to use alternate systems provided in the drawings, he shall provide details of the system he proposes to use to the Engineer in Charge for his approval

The alternate option shall be subject to all requirements hereinafter specified.

a. The safety of the anchorage of the pre-stressing tendons and their suitability for the transmission of forces to the concrete under all loads whatsoever.
b. That the actual losses due to friction coincide with the calculated ones for the pre-stressing.
c. The suitability of the proposed steel for the chosen pre-stressing system.
d. The length of transmission of the force to the concrete and the minimum strength of the latter necessary for pre-stressing in systems, where the pre-stressing elements are fully or partially anchored to the concrete through bond and friction.
e. The suitability of measures taken to protect pre-stressing tendons from corrosion until the final tensioning is carried out.

The Contractor shall submit well in advance to the Engineer-in-Charge for approval complete details of the methods, materials, and equipment he proposes to use in the pre-stressing operations. Such detail shall outline the method and sequence of stressing, complete specifications and details of the pre-stressing steel and anchoring devices proposed for use, anchoring stresses, type of enclosures, and all other data pertaining to the pre-stressing operation, including the proposed arrangement of the pre-stressing units in the members.

An agreement certificate for the pre-stressing system shall be submitted and approved by the Engineer-in-Charge before any structural member to be pre-stressed may be tensioned, this agreement certificate must be issued by an authorized testing laboratory otherwise the Engineer-in-Charge may order such an agreement certificate from a laboratory of his choice at the cost of the Contractor. All rules referring to this agreement certificate here in after are subject to the approval of the Engineer-in-Charge.

In his submittal, the Contractor will also describe techniques he intends to use for:

- Placing ducts and strands
- Making ducts completely tight against accidental entrance of laitance during concreting.
- Pre-stressing operations and measurement of elongation.
- Injection
- Cutting of tendons surplus, and filling anchorage recesses.

He will also ensure that all precautions will be taken for the protection of pre-stressing steel, ducts, anchorages, jacking and grouting equipments and all miscellaneous items. Protection will be on storage areas, and also at every stage of construction until injection by grouting and concreting of anchorages recesses.

All type of protections will be described in details (methodology and materials) by the Contractor in his submittal. As for the "storage of materials on site" he will follow AASHTO-Standard Specifications-Division II 10.6.

It is ensured that all these precautions will be sufficient to ensure that the friction coefficient of strands/ducts will be included between 0.20 and 0.24 and no oxidation on steel (ducts and strands) will occur

6.5.3 PRE-STRESSING EQUIPMENT

Hydraulic jacks shall be equipped with accurate pressure gauges. The contractor may elect to substitute screw jacks or other types for hydraulic jacks. In that case, proving rings or other approved devices shall be used in connection with the jacks (at least three (3) functional jacks will be provided on the job in good condition). All devices, whether hydraulic jack gauges or otherwise, shall be calibrated so as to permit the stress in the pre-stressing steel to be computed at all times. A certified calibration curve shall accompany each device. Safety measures shall be taken by the Contractor to prevent accidents due to possible breaking of the pre-stressing steel or the slipping of the grips during the pre-stressing process. All equipments shall be thoroughly washed with clean water at least once every three (3) hours during the grouting operations and at the end of use for each day.

Grouting Equipment

Grouting equipment shall be capable at a pressure of at least seven (7) Kg/sq cm (100 psi). Grouting equipment shall be furnished with a pressure gauge having a full scale reading of not more than 20 Kg/sq cm (284.5 psi). Reciprocating pumps or equipment that produces a pulsating flow shall not be used. Grouting equipment shall be thoroughly washed with clean water at least once every three (3) hours during grouting operations and at the end of use each day. Grout injection pipes shall be fitted with positive mechanical shut off valves. Vents and ejection pipes shall be fitted with valves capable of withstanding the pumping pressure.

6.5.4 ENCLOSURES

Enclosures for pre-stressing steel shall be accurately placed at locations shown on the plans or approved by the Engineer-in-Charge.

All enclosures shall be of strong ferrous metallic material and shall be completely mortar-tight with the exception that the contractor, at his option, with the approval of the Engineer-in-Charge, may form the enclosures by means of cores or ducts composed of rubber or other suitable material which can be removed prior to installing the pre-stressing reinforcement. Enclosures shall be strong enough to maintain their shape under such forces as will be imposed upon them. They shall be six (6) mm larger in internal diameter than the bar, cable, strand or group of strands, which they enclose. Where pressure grouting is specified, cores or ducts shall be provided with the pipes or other suitable connection for the injection of grout after the pre-stressing operations have been completed.

When approved by the Engineer in Charge, ducts shall be of the flexible, corrugated type, delivered to the site on large diameter wooden drums.

Ducts shall be protected from rusting, damage, oil or any other deleterious matter. Ducts shall have sufficient strength to maintain their correct alignment during placing of concrete and shall be bent without crimping or flattering. Joints in adjacent ducts shall be staggered by at least 300 mm. Waterproof tape shall be used at the connections.

6.5.5 PLACING STEEL (SPACER)

All steel units shall be accurately placed in the position shown on the Drawings or required by the Engineer-in-Charge and firmly held during the placing and setting of the concrete. Distance from the forms shall be maintained by stays, blocks, ties, or hangers approved by the Engineer-in-Charge. Blocks for holding units from contact with the forms shall be precast mortar blocks of approved shape and dimensions. Layers of units shall be separated by mortar blocks or other equally suitable devices. Wooden blocks shall not be left in the concrete. Suitable horizontal and vertical spacers shall be provided, if required, to hold the wires in place in true position in the enclosure.

Density of supports, their stiffness and accuracy of position are parameters that affect the loss of tension in cables due to wobbling. The Contractor will take all suitable provisions to reduce this "wobbling effect. In particular, the space between two supports will be less than 1m

6.5.6 PLACING CONCRETE

Concrete shall be controlled, mixed, and handled as specified in Section 5 - Plain & Reinforced Concrete unless otherwise specified herein.

Concrete shall not be poured in the forms until the Engineer-in-Charge has inspected the placing of the reinforcement, conduits, anchorages, and pre-stressing steel and has given his approval thereof.

The concrete shall be vibrated internally or externally, or both as ordered by the Engineer-in-Charge. The vibrating shall be done with care in such a manner as to avoid displacement of reinforcement, conduits, or wires.

6.5.7 PRE-TENSIONING

The pre-tensioning elements shall be accurately held in position and stressed by jacks. A record shall be kept of the jacking force and the elongation produced thereby. Several units may be cast in one continuous line and stressed at one time. Sufficient space shall be left between ends of units, if necessary, to permit access for cutting after the concrete has attained the required strength. No bond stress shall be transferred to the concrete, nor end anchorages released, the concrete has attained a compressive strength, as shown by cylinder tests, of at least two hundreds and eighty (280) Kg/sq.cm (4000 psi), and as approved by the Engineer-in-Charge. The elements shall be cut or released in such an order that lateral eccentricity of pre-stress will be minimum. The contractor shall submit design and drawings along with the backup calculations and material data for the bulk head, anchorages and couplers for pre-tensioning of viaduct for Engineer approval.

6.5.8 POST-TENSIONING

Tensioning shall be carried out only in the presence of the Engineer-in-Charge or his representative unless permission has been obtained to contrary. Immediately before tensioning, the contractor shall prove that all tendons are free to move between jacking points and that members are free to accommodate the horizontal and vertical movements due to the applications of pre-stress.

Tensioning of pre-stressing reinforcement shall not be commenced until tests on concrete cylinders, manufactured of the same concrete and cured under the same conditions, indicate that the concrete of the particular member to be pre-stressed has attained a compressive strength of at least 280 Kg/sq.cm (4000 psi) by cylinder tests.

After the concrete has attained the required strength, the pre-stressing reinforcement shall be stressed by means of jacks to the required tension and stress transferred to the end anchorage(s). Stressing shall be from both ends unless otherwise required in the Contract or agreed by the Engineer-in-Charge. The tensioning process shall be so conducted that the tension being applied and the elongation of the pre-stressing elements may be measured at all times. The friction loss in the elements, i.e. the difference between the tension at the jack and the minimum tension in the pre-stressing steel shall be determined by the formula.

$$F\mathrm{T} = 2\left(1 - \frac{a.c.E}{d}\right)$$

Where

F_T	=	total friction loss
F1	=	observed tension at the jack
a	=	cross sectional area of the pre`-stressing element
c	=	observed elongation of the element when the force at the jack is F1.
E	=	secant modules of elasticity of the element for stress F1 as determined from the stress-strain diagram of the element.
D	=	Distance from the jack to the point of lowest tension in the element. Where jacking is done from both ends of the members, the point of minimum tension is the center of the member. Where jacking is done from one end only. D is the distance to the other end of the member.

Any surplus length of tendon shall be cut off by an approved method which will not affect the strength of the stressed tendon, with particular care if the use of spark erosion or oxyacetylene burning methods of cutting are approved by the Engineer-in-Charge.
A record shall be kept of gauge pressures and elongation at all times and submitted to the Engineer-in-Charge for his approval within twenty four (24) hours of each tensioning operation. The tendons shall be maintained in such a condition that they can be re-stressed until the Engineer-in-Charge has given final approval after inspecting the tensioning log.
After cutting surplus length of cables, recess will be filled with concrete having a compressive cylinder strength of 280 Kg/cm^2 (4000 Psi).

6.5.9 GROUTING OF BONDED STEEL

a. <u>Grout</u>

It shall be a mixture of Portland cement, water and approved admixtures. Composition of the mix shall be submitted to the Engineer in Charge for approval, along with the following information:

- The nature, quality and origin of the constituents.
- Measure by weight of each constituent,
- Sequence of mixing
  The cement will be Portland cement that does not exhibit phenomenon of "false setting" (Test of TUSSCHENBROOK), without any sulphur ions S^{--}, with a chloride ions Cl^- less than 0.05%, and without any element susceptible to induce corrosion of steel.

- The water will not contain chloride ions Cl^- more than 500 mg/l, sulphate ions SO_4^{--} more than 400 mg/l, and no detergent.

- Type of admixtures

Admixtures, if used, should impact the properties of low water content, good flow ability, minimum bleed and expansion if desired. Its formulation should contain no chemicals in quantities that may have harmful effect on the prestressing steel or cement. Admixtures containing chlorides (as C1 in excess of 0.5% by weight of admixture), fluorides, sulfites and nitrate shall not be used.

All admixtures should be used in accordance with the instructions of the manufactures.

The submittal will include the chemical composition of the grout and results of laboratory tests for the following features:

- Sweating
- Fluidity
- Mechanical Strength

b. <u>Sweating</u>

The quantity of water due to sweating at the surface of the grout maintained at rest during three (3) hours must be less than 2% of the volume of the grout; this water must be totally re-absorbed twenty-four (24) hours after the mixing.

c. <u>Fluidity</u>

The flow-out time through the MARSH cone with a 10 mm diameter hole, will be included between 13 and 25 seconds during the time foreseen for the grouting, and at least for 1 hour, at a temperature of 32ºC.

d. <u>Portland Cement</u>

Portland cement conforming to ASTM C150

e. <u>Mechanical Strength</u>

- Three days 230Kg/sq cm
- Seven days 300Kg/sq cm
- Twenty-eight days 350Kg/sq cm

f. <u>Grouting Operation</u>

AASHTO-Standard Specifications-Division II -10.6 & 10.9 will be followed.

Note that mixing water will have to be cooled in summer when temperature of concrete will be above 32ºC.

g. **Quality Control:**

i) Laboratory tests

They will be made to verify the suitability of the grout composition to the intended basic features here above specified.

ii) Checking tests on site

Checking for sweating and fluidity will be made 24 hours before beginning of the injections at the conditions that will really prevail at the injection time; same materials and equipments will be used for that purpose.

Results of tests will be transmitted to the Engineer in Charge for approval.

iii) Tests during grouting operations

For each operation, three series of fluidity tests will be made. Each series consists of one test on the grout at the entry vent and one test on the grout at the exit vent. Results of tests will be transmitted to the Engineer in Charge as well as quantities of grout actually consumed for each duct.

6.5.10 HANDLING

Precast pre-stressed concrete members shall be transported in an upright position and the points of support with respect to the member shall be approximately the same during transportation and storage as when the member is in its final position. In the event that the Contractor deems it expedient to transport or store precast girders in other than this position it should be done at his own risk. Care shall be taken during storage, hoisting, and handling of the pre-casting units to prevent cracking or damage. Units shall be lifted and supported at the designated lift points only. Units damaged by improper storing or handling shall be replaced by the Contractor at his expense.

Pre-stressed structural members shall be constructed in conformity with the drawings governing the particular type of structure to be built or as required by the Engineer-in-Charge.

Working Shop Drawings of handling and all operations to the final positioning of girders will be submitted to the Engineer in Charge.

If permanent displacements of the piers/abutments or of the neoprene bearings are induced as a result of Contractor's methodology, these displacements will be calculated by the Contractor and provisions, like jacking, will be provided by him at his own cost to relieve the structure of these displacements.

Calculations notes showing that stability of beams, inclusive lateral buckling, are ensured at every stage until concreting & achieving desired compressive strength of diaphragms and deck slab. This submittal does not relieve the Contractor of his full responsibility during handling, transport, placing, and attached operations like jacking or slinging.

6.5.11 MANUFACTURE OF PRE-STRESSED MEMBERS OFF THE SITE

i) The details of the method of manufacture shall be approved by the Engineer in Charge before work is started. When the method has been approved, no changes shall be made without the consent of the Engineer-in-Charge.

ii) The Contractor shall inform the Engineer-in-Charge in advance of the date of commencement of manufacture and the dates when tensioning of tendons, casting of members and transfer of stress will be undertaken for the first time for each type of beam.

iii) The Contractor shall send to the Engineer-in-Charge not more than seven (7) days after the transfer of stress, a certificate showing the force and strain in the tendons immediately after they were anchored, the strength and age of the test cubes in accordance with specified procedure and the minimum age in hours of the concrete at the time the stress was applied to the member. A copy of all twenty eight (28) days cube or cylinder test results relating to the work shall be sent to the Engineer-in-Charge as these become available. Records shall be kept so that the identity of those who stress the tendons, cast the concrete and transfer the stress on any member or line of members can be traced.

iv) Where the Engineer-in-Charge's Representative requires tests to be carried out, no beams to which the test relate shall be dispatched to the site until the tests have been satisfactorily completed.

6.5.12 COMPOSITE SLAB BRIDGES

a) The manufacturing tolerances for the precast members shall nowhere exceed those given for the length, cross section and straightness in BS Code of Practice CP 116 (1969),"the structural use of precast concrete". In addition, where beams are laid side by side in a deck:

   i. The difference in soffit level between adjacent units before the in situ concrete is placed shall nowhere exceed five (5) mm for units up to five (5) meters nor ten (10) mm for longer units.
   ii. The width of the deck soffit shall be within plus twenty five (+ 25) mm of that described in the Contract.
   iii. In adjacent spans, the continuity of line of the outside beams shall be maintained.
   iv. The width of the gap between individual beams shall not exceed twice the nominal gap described In the Contract.
   v. The alignment of transverse holes shall permit the reinforcement or pre-stressing tendons to be placed without distortion.

b) The in-situ concrete shall be placed in such a sequence that the advancing edge of the freshly deposited concrete over the full width of deck or between longitudinal construction joints is approximately parallel to the deck supports.

c) Beams shall be prevented from moving laterally during the placing of the in-situ concrete.

6.5.13 CURING CONCRETE

a) **General**

For all pre-stressed concrete operations, the curing procedures shall be well established and properly controlled. Curing shall be commenced immediately following initial set or completion of surface finishing Members shall be kept wet during the entire period of curing.

b) The curing shall conform to the procedure referred in Sub-clause 5.3.7 of Section 5 – Plain & Reinforced Concrete and as approved by the Engineer-in-Charge.

6.6 MEASUREMENT AND PAYMENT

6.6.1 COMPOSITE RATE

The measurement and payment for the items of the work of Pre-Stressed Concrete hereof shall be made corresponding to the applicable CSR items as provided in Contract Agreement and shall constitute full compensation, for procurement, transportation, performance in all respects and completion of work as specified including the site clearance as approved by the Engineer-in-Charge.

6.6.2 LABOUR RATE

The measurement and payment for the items of the work of Pre-Stressed Concrete hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurement transportation, performance in all respects and completion of work as specified including site clearance, as approved by the Engineer-in-Charge except the cost of materials to be provided by Department at designated location as defined in the Contract Agreement.

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7. PILE WORKS

7.1. DESCRIPTION

This work shall consist of performing all operations in connection with cast-in-place concrete piles. It will also include exploratory drilling at major structure locations, if required by the Engineer In-charge.

When test piles and load tests are required in conformance with subsection 7.3.6 and 7.3.7 respectively, the data obtained from such test loads will be used in conjunction with other available subsoil information to determine the number and lengths of piles to be furnished. The Engineer In-charge will not prepare the Itemized list of piles for any portion of the foundation area until all loading tests representative of that portion have been completed.

The Contractor shall provide an outline of his proposed method of constructing the piles when submitting his tender; the proposed method of boring being stated and taking due considerations for running water conditions.

PREREQUISITE FOR PILING WORKS

Not less than two weeks before the Contractor proposes to commence piling, detailed proposal for the piling shall be delivered to the Engineer In-charge. These proposals shall include full details of material, equipment and method to be used in the construction of piles.

If it is proposed to use Bentonite slurry, this shall also be described giving full details.

Work on piling shall not commence until the Contractor's proposals have been approved by the Engineer In Charge and communicated to him.

Strict compliance with these requirements will not relieve the Contractor of the responsibility for adopting whatever **additional provisions may be necessary to ensure the successful completion of the work**.

The kind and type of piles shall be as shown on the Drawings and/or as specified. No alternate types or kinds of piling shall be used, except with the written approval of the Engineer In Charge each time.

Where running water is encountered the Contractor shall submit method statement of boring and casting piles in-situ to the Engineer In Charge for approval. It should include type of barge/boat used for making temporary platform to carry out boring, lowering of steel reinforcement cage and piling activity including concreting.

7.2. MATERIAL REQUIREMENTS

7.2.1. REINFORCED CONCRETE CYLINDRICAL PILES

Diameter of reinforced concrete piles shall be as shown on the Drawings and may or may not have permanent lining.

Reinforcing Steel shall conform to the requirements under Section 5 - Steel Reinforcement.

Concrete for piles shall have the minimum 28 days cylindrical compressive strength of 28 MPa (4000 psi).

7.2.2. STEEL LINER

When permanent or temporary steel casing is shown on the Drawings or as directed by the Engineer In-charge, the steel shall conform to the ASTM A36 or equivalent (BS-15).

7.2.2.1. THICKNESS OF PERMANENT AND TEMPORARY LINER

The minimum thickness of permanent steel liner shall be 10 mm (0.4 inch) whereas for temporary casing liner it shall be 6 mm (0.25 inch) unless otherwise shown on the drawing or as directed by the Engineer In-charge.

If the permanent liner is used in the boring operation or if the handling and transport require a stiffness to avoid deformation or buckling, the stiffness shall be provided by the Contractor at his own expense.

The steel casing shall be furnished in appropriate lengths and joints shall be approved by the Engineer In-charge.

7.2.2.2. HANDLING OF CASING

The casing shall be handled and stored in a manner that shall prevent buckling and other deformation as well as accumulation of dirt, oil and paint. When placed in the work it shall be free from dirt, oil grease, paint, mill scale and loose or thick rust.

The outside surface of the permanent casing of piles, for the depth indicated on the Drawings shall receive two coats of anticorrosion, tar type paint. The paint shall be approved by the Engineer In-charge and its application shall follow the manufacturer's instructions at no extra cost.

7.3. CONSTRUCTION REQUIREMENTS

7.3.1. CAST-IN-PLACE PILES

Piles, cast-in-place, shall consist of one of the following two types either shown on the drawing and /or as specified.

a) PILE CAST IN DRILLED-BORE HOLE-STEEL LINED

The pile shall be cast as stated in 7.3.1(b) and shall be steel lined if required. The Contractor shall provide a permanent lining suitably formed of ten (10) mm minimum (0.4 inch) thickness steel plate. The plates shall be cut and rolled to the inner diameter not less than the nominal diameter of the pile or such larger diameter as to allow the requisite pile diameter hole in the unlined length of pile. The rolled plates shall be connected by full penetration butt welds generally complying with B.S.5133.

Not more than three (3) longitudinal seam welds shall be employed in any one cross-section and such welds shall be staggered in position in the cross-section between one length and the next. The dimensional accuracy of the lining shall be as stated on the drawings.

b) PILES CAST IN DRILLED-BOREHOLE

i. Boring Procedure

The method of boring shall be one which maintains stability, verticality and (as shown on the Drawing) prevent the wall and base of borehole by the use of temporary casing and/or bentonite slurry. The variation from alignment shall not exceed plus or minus one half (0.5) degrees.

All holes shall be drilled to the tip elevation shown on the Drawings, unless otherwise specified or approved by the Engineer In Charge. Rejected bore holes shall be filled with sand by Contractor at his expense and allowed to be consolidated for at least 5 days under saturated conditions before allowing bore for adjacent or alternate pile.

Care during Execution:
The method/ procedure used in execution of bore hole and other operations shall not be such as to cause vibrations resulting in damage to completed or partially completed piles or to adjacent structures, services or other property. The procedure shall not be such as to cause harmful loosening or softening of soil outside the pile that has to be filled with concrete. The equipment used for execution of borehole shall be adequate to ensure that each pile penetrates to the required founding level.

Suitable casings shall be furnished and placed when required to prevent caving of the hole before concrete is poured. Casing, if used in drilling operations (as approved by the Engineer In Charge) shall be removed from the hole as concrete is poured unless otherwise specified. The **bottom of the casing** shall be maintained not less than fifty (50) cm (20 inch) below the top of the concrete during withdrawal and pouring operations unless otherwise permitted by the Engineer In-charge. Separation of the concrete during withdrawal operations shall be avoided.

Reinforcement, if called for, shall conform to the requirements under section 5.

ii. Temporary Casing

The temporary casing of appropriate diameter for locating the pile and piloting the borehole shall be pitched at the exact locations as given on the drawings to ensure that the casing when sunk is within the specified tolerances. The casing shall be sunk to sufficient depth by approved methods. The **depth shall be at least** sufficient to prevent the ingress of alluvium or other loose materials into the bore when executed below the bottom level of the casing. In addition, the depth shall be such as the Contractor considers necessary for the stability of the casing and/or temporary works system during construction in general and for the following conditions and operations.

a. Open temporary casing to ensure against blow -in of soil.
b. Concreting of the pile, until temporary casing is extracted.

Measures Regarding Temporary Casing
The Contractor shall take all such measures and provide such strengthening and bracing as is necessary and to the approval of the Engineer In Charge to ensure that the temporary casing is not disturbed, overturned, over-stressed or under-eroded in any condition of temporary casing and shall be such that it will not disturb the freshly cast concrete and/or permanent lining and /or reinforcement.

Water Level in Temporary Casing
Where the use of temporary casing is approved for the purpose of maintaining the stability and over-rapid withdrawal of the boring tools which could lead to excessive removal of soil and water and disturbance of the surrounding ground and when boring through any permeable stratum (including silt), the water level in the boring shall be maintained between one (1) meter (3.28 Ft) and two (2) meters (6.50 Ft) above the external water level, unless the Engineer In Charge directs other-wise.

During Laying Checking
The temporary casing shall be free from distortion and of uniform cross-sections throughout each continuous length. During concreting these shall be free from encrusted concrete or any internal projections which might prevent the proper formation of the pile.

iii. Bentonite Slurry

Purpose
The bentonite slurry is approved for the purpose of maintaining the stability of the walls and base of bore the Contractor's proposals in accordance with 7.1 shall include details of the slurry.

Prerequisites
These shall include inter-alia:

a. The source of the bentonite
b. The constitution of the slurry.
c. Specific gravity, viscosity, shear strength and pH value of slurry.
d. The methods of mixing, storing, placing, removal and recirculating the slurry, and
e. The provision of stand-by equipment.

Quality Check
Tests shall be carried out to ensure that the proposed constitution of the slurry is compatible with the ground water. Proposals for the constitution and physical properties of the slurry shall include average, minimum and maximum values. The specific gravity of the slurry shall not be less than one and three hundredth (1.03) in any case at any time. The Contractor shall use additives where necessary to ensure the satisfactory functioning of the slurry.

A manufacturer's certificate showing the properties of the bentonite powder shall be delivered to the Engineer In Charge for each consignment delivered to site. Independent tests shall be carried out at laboratory approved by the Engineer In Charge on samples of bentonite frequently.

Upon written instructions of the Engineer In Charge the Contractor shall carry out tests at site during the course of the piling to check the physical properties of the bentonite slurry in the works at his own cost. These tests shall include, inter-alia, density, viscosity, shear strength and pH tests. The test apparatus and test methods shall be those given in "Recommended practice" Standard by American Petroleum Institute, New York City, 1957, reference API RP 29,Section -I, II and VI.

The frequency of tests shall be that which the Contractor considers necessary to ensure that the bentonite slurry is in accordance with his proposals and as such other times as the Engineer In-charge may direct.

Should the physical properties of any bentonite slurry deviate outside the agreed limits, such slurry shall be replaced, irrespective of the number of times it has been used by new bentonite slurry of correct physical properties.

Mixing and Quantity Control
Adequate time shall be allowed for proper hydration to take place, consistent with the method of mixing, before using slurry in the works.

The Contractor shall control the bentonite slurry so that it does not cause a nuisance either on the site or adjacent waterway or other areas. After use it shall be disposed in manner to the approval of the Engineer In-charge.

The level of the slurry in the bentonite shall be maintained so that internal fluid pressure always exceeds the external water pressure.

If chiselling is used when boring through hard strata or to overcome obstructions, the stability of the excavation shall be maintained by methods acceptable to the Engineer In-charge.

iv. Excavation From Boreholes
The soil and debris from inside the pile boreholes shall be removed by bucket, auger or circulating fluid provided that no jetting at the foot of the borehole shall be permitted. **Methods of excavation which in the opinion of the Engineer In-charge may damage the permanent lining of the pile shall not be employed.**

The excavation reveal any soil stratum below the bottom of a pile which is, in the opinion of the Engineer In Charge, unsuitable for supporting the loads that will be imposed on it, the Contractor shall remove all such soil stratum to the satisfaction of the Engineer In Charge and shall lengthen the pile to sound acceptable foundation as directed, and cost of any such lengthening shall be paid as per contract at the given BOQ item rate.

Where buried old structures/hard strata is encountered in a pile bore, which does not allow further penetration, a suitable method for bore advancement shall be got approved by the Contractor.

Time Period
Pile boring shall be carried out as rapidly as possible in order to reduce to a minimum the time in which any strata are exposed to the atmosphere, bentonite slurry or water. The time gap between end of boring and start of concreting shall not exceed three (3) hours, in any case. Besides, the concreting of a pile shall be completed within a maximum period of twelve (12) hours following completion of the corresponding borehole or as directed by the Engineer In-charge.

Disposal of Excavated Material
The materials from pile excavation shall be disposed so that the same does not interfere with any part of the permanent works of this project, in neat and workmanlike manner.

v. Samples and Tests

The Contractor shall take soil samples as given below as directed by the Engineer In Charge and shall carry out in-situ Standard Penetration Tests (if required by the Engineer In Charge) within, and ahead of borehole at least 3 meter (10 Ft) depth below the tip elevation, as and when directed by the Engineer In Charge on the line of vertical axis of the pile at these locations at one and half (1.5) meter (5 Ft) interval. Undisturbed and disturbed samples, its type, frequency and testing shall be as directed by the Engineer In-charge. The costs of tests and collection of samples shall be deemed to be included in the unit rates quoted by the Contractor. Each disturbed sample shall, as far as possible, be truly representative of the grading of in situ soil at the point from which it is taken, shall be without contamination by other material. It shall be approximately five (5) Kg. in weight and shall be placed in a strong air tight container immediately after its removal from the sampler. The container shall be sealed as soon as the sample has been placed in and shall be taken to the site laboratory/laboratories approved by the Engineer In-charge. The samples to be tested and the tests to be carried out for each sample shall be as specified by the Engineer In-charge.

The apparatus and procedure for the Standard Penetration Test shall be in accordance with the provisions of **ASTM D 1586 Penetration Test and Split-barrel sampling of soils and/or ASTM D 1587** thin-walled sampling of soils, (except insofar as any such provisions may conflict with other requirements of the contract). No separate payments for the sampling/testing shall be made.

vi. Limitations of Boring Sequence

Piles shall be constructed in such a manner and sequence as to ensure that no damage is sustained by piles already constructed in adjacent positions. The Contractor shall submit to the Engineer In-charge for his approval a programme showing sequence of construction of various piles.

vii. Tolerances

The heads of piles at the designated cut off level shall be within seventy five (75) mm (3 inch) of their position in plan as shown on the drawings and no pile shall deviate from the vertical alignment by more than one half (0.5) degree. Forcible methods of correction of any casing or piles shall not be used.

viii. Inspection

After the borehole has reached its final stipulated position, after the samples have been taken out, as required by the Engineer In Charge and the borehole has been completely cleaned of all loose matter and otherwise made ready to receive the reinforcement and thereafter the concrete, the Contractor shall so inform the Engineer In-charge.

The Engineer In-charge shall inspect the soil samples and test results thereon, check the elevation of the bottom of the borehole and the amount and direction, if any, by which the top of the casing is out of position, or out-of-plumb having satisfied himself on these and on any other points which he may consider relevant, shall sign permission authorizing the Contractor to proceed with the placing of reinforcement. The Contractor shall under no circumstances proceed with the placing of reinforcement or with the subsequent concreting without having first obtained the authority signed separately for each and every borehole by the Engineer In-charge.

ix. Pile Reinforcement

The reinforcement for each pile shall be assembled and securely tied by means of binding wire and by welded/binded reinforcement rings or spirals of such diameter bar as shown on the drawings, in such a manner as to form a rigid cage.

The **required concrete cover** to the reinforcement shall be maintained by suitable spacers securely attached to the reinforcement and of sufficient strength to resist damage during handling of the reinforcement cage into the pile. The distance between the spacers shall be such that the required cover is maintained throughout and that there **is no displacement of the reinforcement cage in the course of the concreting operation.** Spacers maintaining concrete cover shall be located immediately below and above the laps at four points spaced around the cage**.**

x. Steel Cage Lowering

The Contractor prefer to lower the reinforcement cage assembly into the borehole in sections, he may do so provided the same lapping requirements as for assembly on the ground are followed, namely, the longitudinal reinforcement shall be lapped as shown on the drawings and the spiral reinforcement shall be doubled over the lap zones.

7.3.2. CONCRETING OF PILES

In general, section 5 of the Standard Specifications shall be followed, however, the following particular requirements shall be observed.

a) MATERIALS

Concrete in piles shall have Cylinder Compressive Strength of 28 MPa (4000 psi), except as otherwise indicated in drawings/BOQ.

Suitable retarder, plasticizer may be added as approved by the Engineer In-charge.

The Contractor shall submit the detailed proposed additive for approval which shall be approved after laboratory trial mix results.

Retarders Quantity in Piles Concrete

The dosing of retarders shall ensure initial setting time of not less than five (5) hours corresponding to the ambient temperature at which the concreting is proposed to be carried out.

Slump Range

Maximum slump range for pile concrete is 200 mm (8 inch) if approved mix design contains high range water reducer**.**

b) COMMENCEMENT OF CONCRETING

Prior to placing any concrete:

i. Any heavy contaminated bentonite slurry which could impair the free flow of concrete from the tremie pile shall be removed. A sample of bentonite suspension shall be taken from the base of the boring using an approved sampling device. If the specific gravity of the suspension exceeds 1.20, the placing of concrete shall not proceed and the bentonite shall be modified or replaced subject to approval by the Engineer In-charge.

ii. Any loose or soft material/water soil shall be removed from the bottom of the bore by methods acceptable to the Engineer In-charge.
The Contractor shall not proceed with the concreting of the pile until the Engineer In Charge gives specific permit to do so after satisfying himself of the:

- Adequacy of the Contractor's equipment, materials (including reinforcement cages) and arrangement.
- Proficiency of his personnel.
- Cleanliness of the borehole.
- Contractor shall have a suitable lighting arrangements at all times for inspecting the entire length of the shells, pipe or hole before placing the reinforcing steel or concrete.

c) PLACING OF CONCRETE

TREMIE AND ITS ARRANGEMENTS

Dimensions and Supporting Means

The tremie shall be of not less than two hundred and fifty (250) mm (10 inch) diameter unless otherwise accepted by Engineer in Charge made of water-tight construction. The means of supporting the tremie shall be such as to permit the free movement of the discharge end in the concrete in the pile. The tremie pipe shall be fitted with travelling plug, which shall be placed at the top of the pipe before charging the tremie pipe with concrete as barrier between the concrete and water or bentonite slurry, so as to prevent water or bentonite slurry entering the tube and mixing with the concrete.

Lowering of Tremie and Placement

The tremie shall be carefully lowered into the borehole so that the end of the tube shall rest at about one hundred and fifty (150) mm (6 inch) above the bottom of the borehole, with reinforcement in the borehole, and the hopper end of the tremie tube shall be filled with concrete as aforesaid. It shall be slightly raised so that when the concrete reaches the bottom it flows out of the lower end of the tube, and fills the bottom of the borehole.

Concreting

The rate of withdrawal of the tremie shall be gradual so as to ensure the end of the tremie pipe is always one and half (1.5) meters (5 Ft) below the top of the concrete in the borehole. An allowance shall be made for the top upto five hundred (500) mm (1.5 Ft) of concrete in borehole during concreting being unsatisfactory. When the next batch is placed in the hopper the tremie shall be slightly raised but not out of the concrete at the bottom, until the batch discharges to the bottom of the hopper. This operation shall be controlled by calculating the volume of concrete required to fill one linear meter of pile and then by measuring the rate of withdrawal of the tube corresponding to the volume of the batch in the hopper. The flow shall then be retarded by lowering the tube. The depth of the concrete in borehole shall be measured at intervals to keep a constant check that the tremie pipe bottom is immersed in concrete.

Concreting in each pile shall be carried out in a continuous operation without stoppages until the pile has been completed.

Concreting shall continue until the concrete has reached an elevation five hundred (500) mm higher than the designated pile cut off level shown on the drawings, or as otherwise directed by the Engineer in Charge.

The concrete shall be placed in one continuous operation from tip of cut-off elevation and shall be carried out in such a manner as to avoid segregation. The method of placing the concrete and consistency (slump) shall conform to the requirements of Section 5 or to the satisfaction of the Engineer In-charge.

Precautions during Concreting:
If the bottom of the tremie pipe ceases to be immersed in the body of the concrete in the pile and the seal is broken, concreting shall cease immediately and such remedial measures as the Engineer In Charge may accept or direct shall be carried out. The Contractor shall take precautions to ensure that the concrete is free of voids and shall prevent the entry of water and/or collapse of soil into concrete. If any soil or other deleterious or extraneous materials fall into any pile excavation prior to or during concreting, it shall be removed immediately.

7.3.2.1 MEASUREMENT

Concrete Work shall be measured and paid as detailed in Section 5.

7.3.2.2 REINFORCEMENT IN PILES

The provision of reinforcement will depend on nature and magnitude of loads, nature of strata and method of installation. It should be adequate for vertical loads, lateral load and moments acting individually or in combination. It may be curtailed at appropriate depths only under the advice of the structural engineer. However, provision of reinforcement shall be as specified in drawing.

For piles subject to uplift loads, adequate reinforcement shall be provided to take full up lift which shall not be curtailed at any stage.

7.3.2.3 MEASUREMENT

Reinforcement shall be measured and paid as detailed in Section 5.

7.3.3. WITHDRAWAL OF TEMPORARY CASING

If the **method of construction involves partial withdrawal of temporary casing** as concreting proceeds, a sufficient head concrete shall be maintained above the bottom of the temporary casing to ensure that no voids are formed within the pile and to prevent the entry of ground water and to prevent the collapse of soil into the concrete.

If such entry or collapse should occur, the temporary casing shall be re-driven before the concrete has set and all defective concrete shall be removed or the construction of the pile shall be abandoned, in which case the provision of the clause herein which refers to “Defective Piles” shall apply.

The withdrawal of the temporary casing shall be carried out before the adjacent concrete has taken its initial set. The method and timing of withdrawal must be such as to ensure that the space between the pile and the surrounding ground shall be filled with concrete.

7.3.4. CUTTING OF PILES

Tops of piles shall be embedded in the concrete footing as shown on the drawings. Concrete piles shall, when approved by the Engineer In-charge, be cut off at such a level that at least seventy five (75) mm (3 inch) of undamaged pile can be embedded in the structure above. If a pile is damaged below this level, the Contractor shall repair the pile to the satisfaction of the Engineer In-charge. The longitudinal reinforcement of the piles shall be embedded in the structure above to a length as shown on the Drawings.

The distance from the side of any pile to the nearest edge of the footing shall not be less than twenty (20) cm (8 inch). When the cut-off elevation for a cast-in-place concrete pile is below the elevation of the bottom of the pile cap, the pile may be built up from the butt of the pile to the elevation of the bottom of the cap by means of a reinforced concrete construction according to Section 5, if approved by the Engineer In-charge.

7.3.5. DEFECTIVE PILES

Any pile delivered with defects such as damaged during casting, placed out of its proper location, incapable or partially capable of permanently carrying the load which it is intended to carry, driven below the elevation fixed by the Drawing or by the Engineer In Charge, due to the immature setting of the concrete in the pile or due to caving/collapse of the borehole fully or partially, or due to any cause of which Engineer In Charge shall be sole judge to determine shall be corrected at the Contractor’s expense by one of the following methods approved by the Engineer In Charge:-

a. The pile shall be withdrawn and replaced by a new and when necessary, by longer pile.
b. A second pile shall be cast adjacent to the defective pile.
c. The pile shall be built up as otherwise provided herein or the underside of the footing lowered to properly imbed the pile.
d. The Contractor shall undertake such additional tests/works as the Engineer In Charge may specify to provide additional foundations to supplement the defective piles and so modify the structure to be supported as to ensure that load will be transferred safely to the additional foundations of existing pile. The Contractor shall be responsible for the cost of such additional tests and/or of the extra work carried out in such modification to the structure.

A concrete pile shall be considered defective if it has a visible crack or cracks, extending around the four sides of the pile, or any defect which, in the opinion of the Engineer in Charge affects the strength or life of the pile.

When a new pile is cast to replace a rejected one, the Contractor, at his expense, shall enlarge the footing as deemed necessary by the Engineer in Charge.

7.3.6. TEST PILES

Test piles which are shown on the Drawings or ordered by the Engineer in Charge shall conform to the requirements for piling as specified.

Test piles to be load tested in accordance with Item 7.3.7 shall be cast-in-situ at location determined by the Engineer In-charge. The **test pile (Index pile)** subject to a **minimum of 3.0 times of the design load** shall not be utilized in the structure. The **proof load tests** shall however be performed on **the selected working piles to a maximum load of 1.5 times the design load.**

Any pile, which after serving its purpose as a test pile is found unsatisfactory for utilization in the structure, shall be removed if so ordered by the Engineer In-charge, or if approved by the Engineer In-charge it shall be cut-off below the ground line and footings, but such approval does not in any way relieve the Contractor of his responsibilities.

7.3.7. PILE LOAD TESTS

An ultimate load test shall consist of the application of a load equal to a minimum of three (3.0) times the design load or as otherwise provided for herein or as directed by the Engineer In-charge.

A proof load test (to be performed on two working piles) shall however, be taken to a maximum load of 1.5 times the design load of pile. Load tests shall be made where specified and/or where called for by the Engineer In-charge. Unless otherwise permitted by the Engineer In-charge, the load tests shall be completed before any working pile.

Pre-requisite for Load Test

Load tests shall generally be made in line with "**the latest ASTM D1143-M-07"** procedures or by the methods approved by the Engineer In-charge. The Contractor shall submit to the Engineer In-charge detailed plans of the loading system and apparatus he intends to use at least three weeks in advance.

- The apparatus shall be so constructed as to allow the various increments of the load to be placed gradually without causing vibration to the test piles.
- The pressure gauge/ jack assembly and the micrometers to be used shall calibrate afresh from a laboratory approved by the Engineer In Charge.
- The load test shall not be started until the concrete has attained a minimum compressive strength equal to twice the anticipated compressive stress induced by the maximum load during the test. If he so elects, the Contractor may use, "subject to the approval of the Engineer In-charge" high early strength cement in the concrete of the load test pile.
- The test shall not be started earlier than 14 days age, to allow for development of sufficient skin frictional resistance, or as otherwise approved by the Engineer In-charge.

Suitable approved apparatus for determining accurately the load on the pile and the settlement of the pile under each increment of load shall be supplied by the Contractor. The apparatus shall have a working capacity of at least three times the design load for the pile being tested. Reference points for measurement of pile settlement shall be sufficiently away from the test pile to preclude all possibility of disturbance.

All pile load settlements shall be measured by adequate devices, such as gauges, and shall be checked by means of an Engineer In-charge's level. Increments of settlement shall be read just after each load increment is applied and at close intervals thereafter. The safe load from the test shall be determined by the Engineer In-charge

Test Procedure

The first load to be applied to the test pile shall be 25%, of the pile design load or as approved by the Engineer In Charge and the first increment shall be up to the pile design load by applying additional loads in three equal increments. A minimum period of 2 hours shall intervene between the applications of each increment; except that no increment shall be added until a settlement of less than one tenth (0.1) mm is observed for a 15-minute interval under the previously applied increment. If there is a question as to whether the test pile will support the test load, the load increments shall be reduced by fifty (50) percent, at the direction of the Engineer In-charge, in order that a more closely controlled failure curve may be plotted. The full test load shall remain on the test pile not less than forty eight (48) hours. The full test load shall then be removed and the permanent settlement read upto 24 hours period or as approved by the Engineer In-charge.

When directed by the Engineer In-charge ultimate load tests shall be continued beyond the double design load in 10-ton increments to failure or a maximum of three times the design load.

7.3.8. BACKFILLING EMPTY BORING

When each pile has been cast, the empty bores remaining shall not be following the completion of piling work.

7.3.9. PILE RECORDS

The Contractor shall keep records of the piles installed. A copy of the record shall be given to the Engineer In-charge within two (2) days after each pile is cast. The record form to be used during pile construction is enclosed. The following minimum information shall form an essential part of this record.

Cast-in-Place Piles
Pile type and nominal dimensions.
Date of boring commenced, level reached each day and date of casting.
Soil samples taken from pile boring operation and soil test results.
Strata and groundwater encountered with levels, description shall be in accordance with B.S.C.P. 2001.
Length of finished pile and tip elevation.
Dia. of borehole.
Elevation of the bottom of borehole.
Date of placing concrete; theoretical and actual quantities of concrete used in pile.
Lengths and dia. of temporary casing and permanent lining and the elevation of the tip of temporary casing and of permanent lining.
Details of Reinforcement.
Details of penetration during boring operation.
Quality, consistency and other test results of concrete.
Time interval between boring and concreting. Any other relevant information.

A Performa recommended for keeping the pile construction record is attached at the end.

On completion of the piling for each structure, the Contractor shall deliver to the Engineer In-charge a drawing recording the exact location and the final depth (tip elevation) of all piles.

7.4. MEASUREMENT AND PAYMENT

7.4.1. MEASUREMENT

a) PILES

The quantities to be paid for shall be the number of linear meters of piles including boring and concreting for all piles completed and accepted, measured from the pile tip elevation to the bottom of pile caps, footings or bottom of concrete Beams. No allowance shall be made for cut-offs or the required length of concrete or reinforcing steel placed into the concrete structure as called for on the drawings. Any additional pile lengths that may be necessary to suit the Contractor’s method of operation or for any other reason shall not be included in the measurements.

The supply, fabrication of cage and installation of reinforcement in the piles shall be excluded from this Item but will be included in section 5.

b) STEEL LINER

The quantities to be paid shall be the number of linear meters of casing. Steel casing damaged by the Contractor through handling, welding and transportation shall be replaced by him at no additional expense.

c) PILE LOAD TESTS

Pile Load tests shall be paid by the number of complete and accepted load tests as described in the relevant sub section of the section.

PILE CONSTRUCTION REPORT

GENERAL INFORMATION

PROJECT _______________________ JOB NO. __________ CONTRACTOR ____________
LOCATION _____________________ PILE NO. __________ PILE DIA ______________ mm
METHOD OF BORING ___________

ACTIVITY	BORING	CAGE LOWERING	CONCRETING
DATE STARTED			
TIME STARTED			
DATE COMPLETED			
TIME COMPLETED			

SURVEY & LEVELS

BENCH MARK (B.M) = __________ M SOUNDING AFTER BORING _______________M

BACK SIGHT (B.S) = ____________ M SOUNDING BEFORE CAGE LOWERING _____M

H.I * = (B.M + B.S.) = ____________ M SOUNDING BEFORE CONCRETING ________ M

FORE SIGHT (F>S) = ____________ M LENGTH OF CASING ____________________ _M

G.L. ** = (H.I-F.S) = ____________ M LENGTH OF UNCASED HOLE ______________M

CT/RTT *** = (H.I-F.S) = ___________M PILE BATTER ___________________________DEG

PILE TIP ELEVATION (P.T.E) _______M BORE LENGTH (G.L-P.T.E)_________________M

BOREHOLE LOG

DEPTH (M) FROM	TO		DESCRIPTION OF MATERIALS
1.	_________	_________	____
2.	_________	_________	____
3.	_________	_________	____
4.	_________	_________	____

REINFORCEMENT DETAILS

		DIAMETER (mm)	LENGTH (M)	OVERLAP (M)	PITCH (mm)
MAIN BARS	1				
	2				
	3				
SPIRAL	1				
	2				
	3				

* HEIGHT OF INSTRUMENT
** GROUND LEVEL
*** CASING TOP/ROTARY TABLE TOP

TREMIE AND CASING INSTALLATION AND REMOVAL

TOTAL LENGTH OF BORE ______________________________ M

SR. NO.	* LENGTH OF TREMIE PIPE (M)	REQUIRED SOUNDING OF TREMIE PIPE (M)	ANTUAL SOUNDING OF TREMIE PIPE (M)	REQUIRED SOUNDING OF CASING PIPE (M)	ACTUAL SOUNDING OF CASING PIPE (M)
10					
09					
08					
07					
06					
05					
04					
03					
02					
01					

CONCRETING

TYPE OF CEMENT ________________________
CONCRETE MIX RATIO____________________________W/C RATIO __________________

NUMBER OF CYLINDERS / CUBS ___________________

	1	2	3	4	5	6
BATCH NO.						
SLUMP (mm)						
CYLINDER BATCH NO.						

CEMENT BAGS AVAILABLE _________TOP OF CONCRETE ________________________M

CEMENT BAGS WASTED ____________ACTUAL PILE LENGTH _____________________M

CEMENT BAGS CONSUMED _________ NOMINAL CONCRETE VOLUME ___________CU.M

TYPE OF ADMIXTURE ______________ ACTUAL CONCRETE VOLUME _____________CU.M

DOSAGE OF ADMIXTURE ___________OVER CONSUMPTION CONCRETE____________ %

* TO BE INSTALLED IN REVERSE ORDER

CATEGORY OF PILE (TO BE CATAGORISED BY PILING INCHARGE)	EXCELLENT	GOOD	FAIR	POOR

REMARKS (ATTACH ADDITIONAL SHEET IF REQUIRED)

SHIFT DUTIES

SR. NO.	INSPECTOR	DATE	SHIFT FROM	TO	SIGNATURE
1.					
2.					
3.					

SIGNATURE PILING INCHARGE

TABLE OF CONTENTS

8. DAMP PROOF COURSE AND WATER PROOFING

8.1 DAMP PROOF COURSE

8.1.1 SCOPE

The work shall include furnishing all labour, material and equipment and performing all services to provide the damp-proofing in foundations and over plinths of Structures as shown on the drawings and/or as directed by the Engineer-in-Charge.

8.1.2 RELATED WORKS

- Section 5 - Plain and Reinforced Concrete
- Section 9 - Cement Concrete Block Masonry
- Section 11 - Brick Masonry
- Section 13 – Roofing

8.1.3 INSTRUCTIONS

Damp proofing shall not be applied when the ambient temperature is below 4 degree Centigrade. The work shall be done by workmen experienced in the application of damp proofing, and the Contractor shall co-ordinate damp proofing operations with other phases of the work to prevent staining or damaging finished work. The Contractor shall repair or replace damaged finished work to the satisfaction of the Engineer-in-Charge. Damp proofing shall be applied as shown on the Drawings.

8.1.4 DAMP PROOFING MATERIALS

a) Damp Proof Course

Damp Proof Course unless otherwise specified shall be one inch thick 1:2:4 Plain Cement Concrete placed at the specified plinth level in accordance with the provisions of Section 5 – Plain & Reinforced Concrete.

b) Damp Proof Plaster

Damp Proof Plaster is generally for vertical faces and unless otherwise specified is applied with 1:3 Cement Sand Plaster complying with the provisions of Clause 15.1 – Plaster, Finishes.

c) Polythene Sheet

Polythene Sheet shall be used over bitumen painted surface where specified and shall consist of 0.13mm thick polythene sheet (500 gauge) complying with ASTMD 2103,as approved by the Engineer-in-Charge.

d) Water Proofing Agent

The specified water proofing agent or asphaltic materials shall be delivered in sealed containers bearing the Manufacturer's original labels. Bituminized Kraft paper shall be delivered in rolls as per Manufacturer's original packing. All materials shall conform to the Specifications designated and shall be approved by the Engineer-in-Charge. Damp proofing materials shall conform to the requirements shown on the Drawings and given hereafter.

e) Bitumen

Bitumen for damp proofing shall meet the requirements of Clause 13.3.2 under Section 13 – Roofing and as approved by the Engineer-in-Charge.

f) Hessian Cloth

Hessian Cloth impregnated with bitumen shall be as specified for use on plain plinth surfaces.

8.1.5 EXECUTION

8.1.5.1 PREPARATIONOF SURFACES

Surfaces to receive damp proofing shall be smooth, clean and dry. Holes, joints and cracks shall be painted flush with mortar. Before damp proofing, surface shall be swept clean of all foreign matter and shall be inspected and approved by the Engineer-in-Charge. The surface shall be prepared complying with the provision of Clause 13.15.2.

8.1.5.2 PLACEMENT

a) General

The selection and combination of various water proofing and damp- proofing materials for different locations shall be as shown on the Drawings or as directed by the Engineer-in-Charge. Unless otherwise directed or approved by the Engineer-in-Charge, the procedures given in this sub-section shall be adopted.

b) Damp Proofing under Floors and Foundations

A priming coat of the suitable thinned bitumen mixed with kerosene oil shall be applied to all parts of the surfaces to be damp proofed before the application of bitumen coating. The bitumen coat shall be applied uniformly in such a manner as to cover pores completely and to thoroughly bond with the surface, using not less than 1.71 Kg per square meter for each coat and laying single layer of polythene sheet 0.13mm thick (500 gauge) on damp proof course or as specified. The bitumen coat shall be applied after it is heated upto 350ºF – 375ºF. The polythene Sheet shall be placed in such a way as to ensure proper bond with the asphalt layer.

c) Damp Proofing under Masonry Walls

i. A layer of 1:2:4 plain cement concrete or as specified of thickness as shown on the drawings will be placed over the area to be damp-proof under brick masonry, cement concrete block masonry or stone masonry walls.

   A priming coat of suitable thinned bitumen shall be applied before the application of bitumen coating.

   The bitumen coat, using not less than 1.71 Kg per square metre, shall be applied and laying single layer of polythene sheet 0.13mm thick (500 gauge) on damp proof course..

ii. Alternatively Damp Proofing with Hessian Cloth Impregnated with bitumen where specified at 1.25 kgs of bitumen per square metre shall be applied on smooth DPC or plastered surface. The coating of bitumen and sand blending shall be carried out as specified.

iii. *Where specified add water proofing chemical with 1:2:4 concrete mixed with specified quantity with no addition of admixture. Prior adding the chemicals the contractor submit the samples along-with its technical data of different chemicals manufacturers to Engineer in Charge. The manufacturer should give minimum warranty of the chemical up to 20 years.*

d) Damp Proofing Vertical Surfaces

For brick masonry surfaces, a cement plaster of ¾ inches (19mm) thickness shall be applied to the surface. A priming coat of thinned bitumen shall then be applied to the cement coating or concrete surface before the application of bitumen coating.

The bitumen coat, using not less than 1.71 Kg per square metre as specified shall be applied.

8.1.6 MEASUREMENT

Length and breadth shall be measured along the finished surface correct to a cm and the area shall be worked out to nearest 0.01 sqm. No payment however shall be made for the 100 mm or less overlap of PVC Sheet.

8.2 WATER PROOFING ROOFS

8.2.1 SCOPE

The work of insulation, water proofing and roofing of the flat or sloped roofs shall consist of provision of all labour, material and equipment for installing the insulation, water proofing and roofing whichever required in accordance with the Drawings, specified or as directed by the Engineer-in-Charge.

8.2.2 CODES AND STANDARDS

The work shall conform to the requirements of the following Codes and Standards, unless otherwise specified:

ASTM D41-78	Primer for use with asphalt in damp proofing and water proofing.
ASTM D2103-81	Polyethylene film and sheeting.
BS 747-77	Specifications for roofing felt.
BS 1521-72	Water proof building papers.
BS 4016-72	Building paper (breather type).

8.2.3 WATER PROOFING MATERIALS

8.2.3.1 ASPHALT/BITUMEN

Special industrial asphalt shall be of 10/20 penetration, or any other type approved by the Engineer-in-Charge conforming to the following minimum and maximum limits:

Specific gravity	1.02/1.04 at 25ºC
Penetration, 100 gm	10/20 at 25ºC
Ductility (Cms)	417 at 25ºC
Softening Point	77ºC / 93ºC
Working temperature	150ºC /175ºC

Asphalt/bitumen primer shall be bitumen of 10/20 penetration grade 1420 from an approved manufacturer or any other type approved by the Engineer-in-Charge conforming to ASTM D 41.

8.2.3.2 FELT

The felt shall be an asphalt impregnated type 1C fibre base. The number of plys thickness shall be as specified in the Drawings. The felt shall be smooth and stout building paper having safe water proofing qualities. Weight of 3 ply standard roll of 20 x 1 metre should not be less than 54 Kilograms.The brand/make of felt shall be as specified and approved by the Engineer-in-Charge.

8.2.3.3 ISOLATION MEMBRANCE/FELT/POLYETHYLENE SHEET

Isolation membrance/felt shall be polyethylene sheet 0.13mm thick (500 guage). The contractor shall provide sample of the sheet for approval by the Engineer-in-Charge.

a) MEASUREMENT

No payment however shall be made for the 100 mm overlap of PVC Sheet over the roof slab.

8.2.3.4 JUTOID WATER PROOF MATTING

The jutoid matting shall be asphalt impregnated jute base matting as approved by the Engineer-in-Charge. The matting shall be stout jute matting having safe water proofing qualities. The thickness of the matting shall be as specified.

8.2.3.5 RUBEROID WATER PROOFING MEMBRANCE/FELT

Ruberoid water proofing membrance/felt shall be applied alongwith asphalt felt where specified. The thickness of the membrance/felt shall be 4mm weighing 4 kgs per square meter. The physical properties of membrance/felt when tested according to ASTMD5147 shall be as follows:

Property	Test Method	Values
Tensile Strength @ (nom.), lbf/in	ASTM D5147	90
Elongation @ (nom.), %	ASTM D5147	45
Low Temperature Flexibility (max.), F	ASTM D5147	7
Tear Strength (nom.), lbf	ASTM D5147	98
Dimensional Stability, %	ASTM D5147	<1

8.2.3.6 BLANCO FELT FOR WATER PROOFING

Blanco felt for water proofing shall be of standard manufacturer approved by the Engineer-in-Charge.

8.2.4 EXECUTION

8.2.4.1 ROOFING

a) GRADING ROOF WITH CEMENT CONCRETE 1:2:4

i. Materials

Cement, coarse sand and graded stone aggregate 20 mm nominal size, shall be used as specified in the item.

The specifications for the materials and method of preparation of concrete shall conform in general to the specification described in Section 5 – Plain & Reinforced Concrete. The grading of aggregates shall be limited between 3/4 inches maximum and 3/16 inches minimum.

ii. Laying

Before laying cement concrete for grading, the level markings to the required slope/gradient shall be made only with cement concrete on the surface of the slab at suitable spacing with the help of string and steel tape (Measuring tape) so that the mason can lay the concrete to the required thickness, slope / gradient easily in between the two level markings.

On getting the level marking approved, the surface should be sprinkled with thick cement slurry and the concrete should be laid carefully, without throwing from height, in predetermined strips.

The concrete should be consolidated by specially made wooden tamping. After the tamping is done the surface should be finished to required slope/gradient with wooden trowels without leaving any spots of loose aggregates etc.

The mixed cement concrete must be laid in position, within half an hour of its mixing. In case any quantity of concrete remains unused for more than half an hour the same should be rejected and removed from the site.

iii. Finishing

The slope of finished terrace shall not be more than 1 in 120 unless a steeper slope is ordered by the Engineer-in-Charge. The minimum thickness of the concrete at its junction with Khurra or parapets shall be 5 cm. The concrete shall be rounded at the junction of roof slab and parapet. It is desirable to provide a haunch/gola/filler at the junction of the parapet wall and the roof slab.

The finished concrete surface shall present a smooth surface with correct slopes and uniform rounding. The concrete should be free from cracks. Excess trowelling shall be avoided.

iv. Thickness

Average thickness shall be 1-1/2 inches to 3 inches and as specified.

v. Curing

Curing shall be done either by spreading straw/Hessian cloth over the graded surface, keeping the same wet for full 10 days or flooding the graded area with water by making kiaries with weak cement mortar, for 10 days. Occasional curing by simply spraying water now and then shall not be permitted.

b) GRADING ROOF WITH CEMENT MORTAR

i. Materials

Cement and coarse sand shall be as specified in Section 5 – Plain & Reinforced Concrete.

ii. Cement mortar

Cement mortar 1:3 (1 cement: 3 coarse sand) /1:4(1 cement: 4 coarse sand) specified in the item of work shall conform to the specification described in Section 11 - Brickwork.

iii. Preparation of the surface

The surface shall be cleaned properly with brooms brush and cloth to remove all dirts, dust, mortar droppings.

Laying

Same as described under Clause 8.2.4.1(i) (b) above for concrete, except that cement mortar shall be tamped with wooden and steel trowels and surface finished with steel trowel.

iv. Finishing

1. The slope of finished surface shall not be more than 1 in 120 unless a steeper slope is specified.
2. The finished surface of the grading shall present a smooth surface with correct slopes and uniform rounding wherever they are provided. The mortar surface shall be free of cracks. Excess trowel-ling shall be avoided.

v. Thickness

The minimum thickness of cement mortar grading at the junction with khurra or parapet wall shall be 20 mm. The cement mortar shall be rounded at the junction of roof slab and parapet. It is desirable to provide a haunch/gola/filler at the junction of parapet wall and the roof slab. The maximum thickness that shall be adopted for grading with cement mortar shall be 50 mm. It is not at all desirable to lay the cement mortar grading for greater thickness and in that case it is advised to go in for grading with Cement Concrete.

vi. Curing

Curing for the grading with cement mortar shall be done exactly as described under Clause 8.2.4.1(i) above for concrete.

c) PREPARATION OF SURFACE

i. Flat Roofs

All surfaces to receive roofing and water proofing treatment shall be sound, clean, smooth, dry and free of debris, loose material or defects which would have an adverse effect on the water proofing application or performance. The work shall not start until the preparatory work has been inspected and approved by the Engineer-in-Charge.

ii. Sloped Roofs

Treated wood nailing strips 254 x 50 mm size shall be embedded in the roof with top of strip flush with the deck at 900 mm on centres or as shown an the drawings and/or directed by the Engineer-in-Charge. Metal gravel strips, scuppers and roof drains shall be placed and metal flashing, flanges etc., shall be provided and installed in time. Cant strips shall be installed at the angle formed by the roof deck and the vertical surfaces.

d) INSTALLATION OF ROOF FELT / MATTING

i. Bitumen for built-up roofing shall not be applied when it is above 205^{o}C, (400^{o}F) nor shall it be heated above 245^{o}C (475^{o}F).

ii. The terms Felt/Matting used are synonymous. Felt shall be stacked in properly protected piles. Felt surfacing material shall always be dry and the several layers of felt shall be laid free from wrinkles.

iii. Roofing shall not be applied during rain or while surfaces are damp; it shall be applied only to surfaces that are clean and dry.

iv. Method of laying the different layers of built-up roofing shall be strictly in accordance with the recommendations of the manufacturer and the method proposed by the Contractor and approved by the Engineer-in-Charge.

v. Built-up roofing shall not be laid when the temperature at the location of the work is below 5^{o}C (40^{o}F).

vi. Heating of asphalt/bitumen shall be strictly regulated by means of an accurate thermometer of approved type, kept constantly suspended in the heating kettle while the work is in progress.

vii. Entire deck surface and parapet walls shall be painted with asphalt primer or as specified and allowed to dry thoroughly. Primer shall be kept several centimetres back from joints of pre-cast panels.

viii. Mopping of surface with asphalt/bitumen shall be performed so that the surface shall be completely covered. Bond coats of asphalt shall be at the rate of 1.25 Kg per square metre or as specified. At no point shall felt touch the underlying concrete and the rate of application shall be such that the asphalt mopping shall not be more than one metre ahead of the roll of felt. All asphalt shall be applied with mops except that the hot surfacing application shall be poured from a dipper.

Felt shall be laid with each sheet lapping the preceding one. Each sheet shall be lapped with an exposed lap of 300 mm. All end laps shall be 100 mm minimum. The laying of felt shall, in general, be started at low points working upwards to high points of the surface. The roofing felt shall be rolled while mopping, rubbing and pressing the felt sheets as it spreads on to the surface, so as to ensure thorough sticking and a smooth firm surface, free from wrinkles or bubbles. Roofing felt shall be extended to points and position as shown on the drawings.

MEASUREMENT

Length and breadth shall be measured along the finished surface correct to a cm and area shall be worked out to nearest 0.01 sqm.

e) DAMP PROOFING OF THE ROOF WITHOUT FELT / MATTING

i. The damp proofing of the roof with bitumen coating without Felt/matting shall be carried out in accordance with the applicable items of preparation under Clause 8.2.4.1(iii) (a) above.

ii. The bitumen at the specified rate and the layers shall be applied by mopping of surface in accordance with the procedure according to the items (a), (c),(e),(f), & (h) of Clause 8.2.4.1(iv) above.

iii. Blinding with Coarse, Sand/Washed Shingle as specified shall be sprinkled and penetrated into bitumen coat to seal the surface properly.

iv. Where specified, 0.13mm thick (500 garage) polyethylene sheet shall be spread over final coat of bitumen and rammed with minimum 75mm side laps and 100mm end laps staggered with layers bonded to gather with asphalt. The surface shall be broomed to ensure that it is free of wrinkles.

v. The Contractor shall take care to maintain the slopes, levels and protect the work from any damage during the construction and maintenance period. The Contractor shall have to remove, replace and rectify such damaged work.

MEASUREMENT

Length and breadth shall be measured along the finished surface correct to a cm and area shall be worked out to nearest 0.01 sqm.

f) WATER PROOFING

The following shall be sequence of operation for laying Ruberoid water proofing:

- Asphalt Saturated Felt
- Water Proofing Compound
- Membrane/felt (of the specified ply)
- Washed Gravel

The roof surface shall be prepared as per (iii) above the work shall be performed according to the instructions of the manufacturer.

Two or three underlay sheets will be unrolled and placed in position on the roof. Each sheet overlapping the adjoining one by 2 inches. Where the sheets meet the parapet or other roof obstructions they should be turned up 6 inches and bonded with Ruberoid Compound to the concrete for a width of about 15 inches.

The first spread of the underlay should be 18 inches wide so that the laps of the Approved water proofing membrane/felt break joints with those of the underlay. Each length of the membrane/felt is in turn fitted in position and rolled back half way so that when unrolled it will resume its former position. The compound heated to the fusing point will then be poured from a suitable container such as watering can without a rose or a bucket and dipper at the rate of 30 lbs per hundred sft. on the underlay. As membrane/felt is rolled out pressure is applied so as to ensure adhesion while the compound is still hot. The other half of the length is then rolled up and the process repeated. The joints of the membrane/felt should overlap 2 inches and care should be taken to see that ample compound is applied so that it flows out along-with edges. The length of the membrane/felt should not exceed 15 feet. It is advisable that the laying operation for

underlay and membrane/felt should follow each other in such a way that a minimum of incomplete work is exposed to weather.
The membrane/felt should be inserted for a depth of about 2 inches in the parapet wall by cutting chases in the first convenient course of parapet and covering these with cement plaster. It should be clearly understood that the underlay is not bonded with compound to the concrete substructure except at vertical abutments etc.

Over this surface of the membrane a bitumen compound will be spread at the rate of 30 lbs per hundred sft. in the same manner as described above washed gravel graded from 3/8 inch downward will be spread at the rate of 3 Cu.ft. per hundred Sq.ft. over the bitumen compound and pressed to the surface by means of wooden thappies so that it adheres well to the bitumen compound.

MEASUREMENT

Length and breadth shall be measured along the finished surface correct to a cm and area shall be worked out to nearest 0.01 sqm.

g) PROVIDING ROOFING FELT

The following will be the sequence of operation for laying roofing felt:

1. Sticking layer of bitumen
2. Layer of 2 ply felt
3. Flood coat of bitumen
4. Washed gravel

The roof surface shall be prepared as per (iii) above shall be filled in with 1:3 cement mortar. The work shall be carried out according to the instructions of the manufacturer.
Over the surface thus prepared a layer of bitumen heated to the fusing point will be spread from a suitable container such as watering cans without a rose or a bucket and dipper at the rate of 30 lbs per hundred Sq,ft.
Over this the felt roofing will be laid and the same will be pressed hard on the surface so that it may adequately adhere to it. Where the felt meets the parapet or other roofing obstruction they should be turned up 6 inches and bonded with bitumen to the concrete for a width of about 15 inches. The length of the roofing felt should not exceed 15 feet. The joints of the felt should overlap 2 inches.
Over this surface of roofing felt bitumen will be spread at the rate of 30 lbs. per hundred sft. in the same manner as described above. Washed gravel graded from 3/8 inch downward will be spread at the rate of 3 Cu.ft. per hundred Sq.ft. over bitumen compound and pressed to the surface by means of wooden thappies so that it stick well to the bitumen.

MEASUREMENT

Length and breadth shall be measured along the finished surface correct to a cm and area shall be worked out to nearest 0.01 sqm.

h) WATER PROOF MATTING

Water Proof Matting can be nailed into position over a wooden surface or can be fixed on a concrete base. If the area to be covered is more than 40 inches in width or 28 yards in length then another roll of similar dimension can be joined together by allowing an overlapping of about 4 inches in such a manner that the overlapping piece is on the higher level in case of a slope and the piece inserted below as the joint comes from the lower level of the slope. This allows the water to smoothly flow over the joint without striking it or penetrating inside to effect the water proofing. The overlap would have to be fixed with a special adhesive. This adhesive is heated, mixed with kerosene oil in specified quantities and applied hot at the joints and at the outer edges of the structure.

MEASUREMENT

Length and breadth shall be measured along the finished surface correct to a cm and area shall be worked out to nearest 0.01 sqm.

i) FLASHINGS

Roofing joints and parapets shall be provided base flashings as shown on the Drawings or directed by the Engineer-in-Charge. The base flashings can be either of the following types:

Where built-up base flashings are required, they shall be made by continuing the built-up roofing upon the cant and over the tip and securing the edge with galvanized roofing nail used with metal discs. The nails shall be spaced not over 100 mm apart.

Where metal base flashings are required, 3 layers of felt shall be applied extending up 150 mm on the vertical surface and out on the roof surfaces 100 to 150 mm respectively cementing the same in place with asphalt plastic, troweled on. These flashing strips shall be applied over the top ply of roofing and under the metal base flashing. The portion of metal flashing extending out over roof surfaces shall be covered with two additional plies of felt, 400 mm and 450 mm wide respectively and both cemented in place with bitumen.

8.2.5 WATER PROOFING OF BASEMENT

Basements are typically the area of a structure most at risk for water damage because they are located below grade and surrounded by soil. Soil releases water it has absorbed during rain or when snow melts, and the water can end up in the basement through leaks or cracks.

Water can even migrate through solid concrete walls via capillary action, which is a phenomenon whereby liquid spontaneously rises in a narrow space, such as a thin tube, or via porous materials. Wet basements can cause problems that include peeling paint, toxic mild contamination, building rot, foundation collapse, and termite damage. Even interior air quality can be affected if naturally occurring gasses released by the soil are being transmitted into the basement.

Prevent Water Entry By Diverting It Away From The Foundation.

Preventing water from entering the basement by ensuring it is diverted away from the foundation is of primary concern. Poor roof drainage and surface runoff due to gutter defects and improper site grading may be the most common causes of wet basements. Addressing these issues will go a long way toward ensuring that water does not penetrate the basement.

Measures to Divert Water from Foundation

- Install and maintain gutters and downspouts so that they route all rainwater and snow melt far enough away from the foundation of the building to ensure that pooling does not occur near the walls of the structure. At least 10 feet from the building is best, and at the point where water leaves the downspout, it should be able to flow freely away from the foundation instead of back toward it, and should not be collecting in pools.

- The finish grade should be sloped away from the building for 10 to 15 feet. Low spots that may lead to water pooling should be evened out to prevent the possibility of standing water near the foundation.

- **Shallow ditches called swales** should be used in conditions where one or more sides of the building face an upward slope. A swale should slope away from the building for 10 to 15 feet, at which point it can empty into another swale that directs water around to the downhill-side of the building, leading it away from the foundation.

- **Plinth Protection Works:** The buildings shall be provided with plinth protection of at least 900 mm (3 Ft) width excluding platform portion around the structure and shall have minimum outward slope of 1 in 48 for satisfactory drainage of rain water. The plinth protection may consist of a layer of 115 mm (4.5 in) thick brick or stone ballast, consolidated dry to the required slope, the surface shall be grouted evenly with fine sand 0.06 m^3 /10 m^2 (2 ft^3/100 ft^2) and slightly sprinkled with water and rammed. A topping of 50 mm (2 in) thick cement concrete (1: 3: 6) may be laid in alternate panel slabs over a well-rammed brick or stone ballast and finished smooth at top. The finished surface may have a minimum outward slope of 1 in 48. Any other mode of the plinth protection may be adopted depending upon the site condition and economy of the materials for a particular locality. If vehicular traffic is likely to come on the plinth protection, the same should be suitably designed as a pavement in such portions

REPAIR all CRACKS & HOLES.

If leaks or seepage is occurring in the basement's interior, water and moisture are most likely entering through small cracks or holes. The cracks or holes could be the result of several things. Poor workmanship during the construction is the main cause of cracks or holes. Hydrostatic pressure from the outside, forcing water through walls. The building may have settled, causing cracks in the floor or walls. Repairing all cracks and small holes will help prevent leaks and floods.

Following are the points which should be encountered if the water is coming from the holes of the basement:

- Identify areas where water may be entering through cracks or holes by checking for moisture, leaking or discoloration. Every square inch of the basement should be examined, especially in cases where leaking or flooding has not been obvious, but moisture build up is readily apparent.

- A mixture of epoxy and latex cement can be used to fill small hairline cracks and holes. This is a waterproof formula that can help ensure that moisture and water do not penetrate basement walls. It is effective primarily for very small cracks and holes.

- Any cracks larger than about 1/8-inch should be filled with mortar made from one part cement and two parts fine sand (1:2), with just enough water to make a fairly stiff mortar. It should be pressed firmly into all parts of the larger cracks and holes to be sure that no air bubbles or pockets remain. As long as water is not being forced through basement walls due to outside pressure, the application of mortar with a standard trowel will be sufficient if special care is taken to fill all cracks completely.

- If water is being forced through by outside pressure, a slightly different method of patching with mortar can be used. Surface areas of walls or floors with cracks should first be chiselled out a bit at the mouth of the crack and all along its length. Using a chipping chisel and hammer or a cold chisel, cut a dovetail groove along the mouth of each crack to be filled, and then apply the mortar thoroughly. The dovetail groove, once filled, should be strong enough to resist the force of pressure that was pushing water through the crack.

- Apply sodium-silicate sealant to the walls and floor.

Once all runoff has been thoroughly diverted away from the foundation, and all cracks and holes have been repaired and no leaking is occurring, a waterproof sealant can be applied as a final measure.

Sodium silicate is a water-based mixture that will actually penetrate the substrate by up to 4 inches. Concrete, concrete block and masonry have lime as a natural component of their composition, which reacts with the sodium silicate to produce a solid, crystalline structure which fills in all the microscopic cracks, holes and pores of the substrate. No water vapour or gas will be able penetrate via capillary action because the concrete and masonry have now become harder and denser from the sodium silicate.

Application Procedure:

Special care should be taken when applying sodium silicate. It is an alkaline substance and, as such, can burn skin and eyes if it comes into contact with them. Inhalation can also cause irritation to the respiratory tract.

Sodium silicate must be applied only to bare concrete, concrete block or masonry that has been cleaned thoroughly and is free of any dirt, oil, adhesives, paint and grease. This will ensure that it penetrates the substrate properly and fills in all microscopic cracks. It can be applied using a garden sprayer, roller or brush to a surface that has first been lightly dampened with a mop or brush. Apply two to three coats to the concrete, waiting 10 to 20 minutes between each application. Concrete block and masonry will take three to four coats, with the same 10 to 20 minutes between applications. Any excess should then be wiped away. Sodium silicate should not be over-applied or it will not be completely absorbed by the substrate, leaving a white residue.

Paint can then be applied without fear of water vapour getting trapped between the paint and the wall, which could eventually cause blistering and peeling. Adhesives for tile or floor covering can also be used more effectively, once the substrate has been sealed.

Conclusion:-

Diverting water away from foundations so that it does not collect outside basement walls and floors is a key element in preventing flooding and water damage. Ensuring that any water that does end up near basement exteriors cannot enter through holes or cracks is also important, and sealing with a waterproof compound will help prevent water vapour or gas from penetrating, as well. By following these procedures, the risk of water-related issues in basement interiors can be greatly reduced, protecting the building from damage such as foundation rotting and peeling paint, as well as improving the interior air quality by blocking the transmission of gasses from the soil outside.

Properly waterproofing a basement will lessen the risk of damage caused by moisture or water. Homeowners will want to be aware of what they can do to keep their basements dry and safe from damage. Inspectors can also benefit from being aware of these basic strategies for preventing leaks and floods.

8.3 MEASUREMENT AND PAYMENT

Length and breadth shall be measured along the finished surface correct to a cm and area shall be worked out to nearest 0.01 sqm. Overlaps and tucking in a flashing grooves shall not be measured.

No deductions shall be made for openings or recess or chimney stack, roof lights or Khurras of area upto 0.40 sqm, nor anything extra shall be paid for forming such openings, recess etc. For area exceeding 0.40 sqm. deduction will be made in the measurement for the full opening and nothing extra shall be paid for making such opening.

Measurements shall be taken over the entire exposed area of roofing and flashing treatment including flashing over low parapet walls, low dividing walls and expansion joints and at pipe projections etc. Overlaps and tucking into flashing grooves shall not be measured.

Primer or saturated felt underlay, where provided, shall also be measured in the same manner as the water proofing treatment and paid for separately.

For similar areas exceeding 40 sq. decimetre deductions will be made in measurements for full opening and nothing extra shall be paid for forming such openings.

8.3.1 COMPOSITE RATE

The measurement and payment for the items of the work of D.P.C. & Water Proofing hereof shall be made corresponding to the applicable CSR items as provided in Contract Agreement and shall constitute full compensation, for procurement, transportation, performance in all respects and completion of work as specified including the site clearance as approved by the Engineer-in-Charge.

8.3.2 LABOUR RATE

The measurement and payment for the items of the work of D.P.C. & Water Proofing hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurement transportation, performance in all respects and completion of work as specified including site clearance, as approved by the Engineer-in-Charge except the cost of materials to be provided by Department at designated location as defined in the Contract Agreement.

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9. SOLID CONCRETE BLOCK MASONRY

9.1 SCOPE

The work under this section of the specifications consists of furnishing all plant, labour, equipment, appliances and materials and performing all operations in any floor and at any height in connection with the supply and installation of ordinary cement concrete Solid block masonry work including wall ties, anchors, damp-proof courses, complete in strict accordance with this section of the Specifications and applicable drawings, and subject to the terms and conditions of the Contract.

9.2 MATERIALS

9.2.1 FOR BLOCK

Cement, aggregates and water for concrete blocks shall conform to the requirements as specified in Section 5 for Plain and Reinforced Concrete.

9.2.2 FOR MORTAR

The cement and sand mortar for concrete block masonry shall specified.

9.2.2.1 SAND

Sand for mortar shall comply with the requirements for BS-1200. It shall be graded in accordance with the following table and the various sizes of particles shall be uniformly distributed. Sand that has been in contact with seawater shall not be used unless it has been thoroughly washed to the satisfaction of the Engineer-in-Charge.

Table 9.2.2(a)
Grading of Sand

Sieve Size Number	Percent Passing by Weight	
	Min.	Max.
# 4	100	Not Applicable
# 8	95	100
# 16	70	100
# 30	40	75
# 50	10	35
# 100	2	15
# 200	0	0

The sand shall conform to the provisions of 5.3.1.3 – Plain & Reinforced Concrete for limits of deleterious material.

9.2.2.2 CEMENT

Cement shall be Ordinary Portland Cement conforming to BS-12.

9.2.2.3 WATER

Water shall be clean and free from any harmful impurity. Where the quality of the water is doubtful, it shall be tested in accordance with BS- 3148.The water shall comply with the provisions of Clause 5.3.1.6 - Plain & Reinforced concrete.

9.2.2.4 ADDITIVES

Additives where used, shall be proprietary products used in the proportions and manner recommended by the manufacturer. The additives shall in no way adversely affect the mortar strength or contain chemicals, which may be harmful to other building materials. To add gypsum to cement is strictly forbidden.

9.2.2.5 MORTARS AND GROUT

Materials for mortar, sand and binding agent and water, shall be mixed by volume or by weight as specified for at least 3 minutes with the minimum amount of water to produce a correctly mixed mortar or grout of workable consistency in a mechanical batch mixer. For small jobs, hand mixing may be permitted, the ingredients being mixed with sufficient water to produce a correctly mixed workable mortar.

Mortar shall be as strong, but no stronger than the materials it bonds together. Mortars shall be mixed in batches, which can be used within a period before the setting process commences. Once a mix begins drying off, it shall be rejected. No ingredients shall be added to it once the setting process has begun.

9.3 CONCRETE BLOCK MAKING

The Solid blocks shall be factory manufactured/fabricated and be machine moulded. The block making machines shall be of the standard approved by the Engineer-in-Charge. They shall be operated according to the instructions laid down by the manufacturers. The contractor shall submit samples/literature of various manufacturers for Engineer-in-Charge's approval. The contractor should note that only blocks supplied by the approved manufacturer(s) shall be allowed to be used in the work.

The blocks shall be continuously water cured by sprinkling water for a minimum of 10 days and covered between sprinkling operations with 4 mils thick polyethylene sheeting. After 10 days water curing period the blocks shall be air-dried. Under no circumstances blocks will be used in the work until they are completely dry. During curing period no surfaces of the block will be allowed to dry.

Cured concrete blocks shall be stored off the ground, stacked on level platforms which allow air circulation under stacked units. Units shall be covered and protected against wetting.

Care shall be exercised in the handling of all concrete blocks. No damaged blocks shall be used in the work.

The hollow blocks shall be manufactured as per pattern shown on the drawing. These block units shall be provided by the Contractor for use where required in building structures from approved type of materials. Units shall have uniformly fine smooth surfaces of uniform colour. These shall be free of any honey combing or other imperfections or deformations, all edges true and straight, and at right angles with each other and without any chipped or otherwise broken edges.

The blocks cast on different dates shall be stacked separately and must be labelled showing the date on which they were cast.

Reinforced cement concrete hollow block masonry shall be provided where shown on the drawings. Hollow block manufactured by moulding machine shall have well formed cavities, sharp and well defined edges and corners, smooth surfaces without any imperfections or deformations.

9.4 PROPERTIES OF BLOCKS

All blocks shall be of the size and shape required to complete the work shown in the Drawings or as instructed by the Engineer-in-Charge.

The cement, sand and coarse aggregate shall be volume batched and their proportion may be adjusted so as to provide the concrete of the required strength when tested and shall be mixed in a concrete mixer in accordance with the provisions of Section 5 - 'Plain and Reinforced Concrete.

All blocks shall comply with ASTM C-55-03 edition. The compressive strength of various Solid blocks shall be as follows:

Sr. #	Type of Concrete Masonry	Compressive Strength (Psi)		Location
		Average of 3 Units	Individual Unit	
1.	Solid load bearing Masonry units (ASTM-C-145-85)	2000 psi minimum	2000	Exposed to frost action
2.	Solid/Hollow non-load bearing Masonry units	600	500	Not exposed to moisture& weather
3.	(ASTM-C-90-85)	700	600	Not exposed to moisture & weather

Normally 1:3:6 concrete mix should meet the above strength requirement as per Clause 5.3.2.2 Section 5 – Plain & Reinforced Concrete. The specific gravity should be between 2.3 to 2.4.

The proportion shall however be confirmed by contractor by trial mix and approved by Engineer-in-Charge for actual site conditions.

The Contractor shall provide test certificates providing the average minimum crushing strength of the blocks prior to the commencement of the construction. Further test certificates shall be provided as required by the Engineer-in-Charge to ensure that all batches of blocks have the minimum specified crushing strength.

A laboratory approved by the Engineer-in-Charge shall carry out the test. Evidence shall be produced that the block manufacturer has an efficient method of quality control. The Engineer-in-Charge will require to test samples of blocks periodically and the Contractor shall make necessary arrangements accordingly. The method of sampling for all tests shall be in accordance with ASTM standards referred in Section 9.4.3.

9.5 SUCTION RATE

The Contractor shall, at his own cost, satisfy the Engineer-in-Charge that the suction rate of the block when determined in accordance with Appendix "A" of BS 3921 does not exceed 20 g/dm^2/ min. or that the Contractor is able to adjust it so that it does not exceed this value on site.

9.6 SOLUBLE SALT CONTENT

For exposed blockwork, the contents by weight percent of soluble sulphate, calcium, magnesium, potassium and sodium radicals, shall not exceed 0.30, 0.10, 0.30, 0.03 and0.03, percent respectively when ascertained in accordance with BS 3921, at the cost of the Contractor.

9.7 REINFORCING AND ANCHORS OF BLOCK MASONRY

Unless otherwise stated reinforcing and anchors shall conform to under-mentioned sizes:

Joint reinforcing shall be 1.32mm (0.05-inch) diameter mild steel wire mesh design, galvanized after fabrication. Steel wire woven into 12mm mesh 75mm wide. Reinforcing bar anchors shall be 25 mm dia. deformed bar minimum 10 inch long.

Two 6mm dia bar shall be provided at every fourth course for anchoring of block masonry to columns. Two 10 mm bars at every fourth horizontal course shall be provided for anchoring masonry walls to plinth beam/floor beam, as shown on the drawings.

Dovetail anchors and slots (if used as an alternate anchorage) shall be not less than 18 gauge galvanized steel.

9.8 ERECTION

Blocks shall be laid true to line, level and laid in accurately spaced courses in stretcher bond with vertical joints of each course located at centre of units in alternate courses below. Vertical joints shall be buttered in the entire height of blocks. Each course shall be bonded at corners and at intersections of walls and shall be properly bonded. Courses of block shall be kept plumb throughout and corner reveals shall be true and in plumb.

Standard width of mortar joints for both horizontal and vertical joints shall be 10mm (maximum). Mortar joints in walls shall have full mortar coverage on vertical and horizontal faces between the blocks. Mortar joints on wall including struck joints, shall be thoroughly compacted and pressed tight against the edges of the blocks with proper tools. Blocks terminating against soffits of beam or slab construction shall be wedged tight with wedges and the joints shall be packed solidly with mortar between the top of the block and the bottom of slab or beam. Control expansion joints shall be kept free from mortar or other debris.

Unless otherwise shown on the drawings or specified by the Engineer-in-Charge, the spaces around doorframes and other material or built in items shall be solidly filled with mortar. Spaces around the door and window holdfasts shall be filled in with 1:3:6 concrete. Work required to be built in with masonry including doorframe anchors, wall plugs, and dovetail anchors and accessories shall be built in as the erection progresses.

The block work shall be carried up in a uniform manner and no portion shall be carried more than one metre above the adjoining one at any time. All masonry shall be kept strictly true and square and the whole properly bonded together and levelled round each floor.

Sleeves, Chases, holes, sinking and mortices for other trades shall be correctly located and formed to the sizes as required by the relevant trades. Chiselling of completed walls or the formation of holes shall only be carried out as per design drawings with the approval of the Engineer-in-Charge.

Walls of blocks indicated, as being non-load bearing shall be constructed on the insitu concrete floor slab unit after the floor formwork is struck and the concrete has obtained sufficient strength to support their-weight. Toothing into load-bearing walls shall not be permitted.

All bolts, anchors, ties, pipe sleeves, flushing metal attachments, lintels and the like required to be built into the work shall be correctly inserted and executed as the work proceeds.

Walls or partitions abutting concrete columns or walls shall be securely anchored and tied with metal anchors or ties at not more than 450mm vertical centres. Wall ties cast in with concrete shall be bent down after the removal of formwork and shall be securely jointed into the mortar beds of walling.

Care shall be taken during construction of cavity walls so as to avoid the filling up of cavity with mortar. G.I. flashing and weep holes shall be provided wherever specified on the drawings or as per the instructions of the Engineer-in-Charge. Weep holes will be formed by oiled rods, removed after the mortar is set, at specified locations.

9.9 SCAFFOLDING

Contractor shall provide safe scaffolding of adequate strength for use of workmen at all levels and heights at his own expense. Scaffolding which is unsafe in the opinion of the Engineer-in-Charge shall not be used until it has been strengthened and made safe for use of workmen. Cost of scaffolding etc. shall be included by the Contractor in the unit rate for masonry items.

Damage to masonry from scaffolding or from any other object shall be repaired by the Contractor at his own cost.

9.10 JOINTING

Jointing is the forming of joints as work proceeds. Joints shall be as follows:

- Exterior exposed joints shall be tightly formed to a weather joint with the point of the trowel.
- Interior exposed joints shall be tightly formed to a concave joint.
- Joints which are subsequently covered with plaster or other finish materials shall be struck flush.

9.11 TOLERANCES

All block work shall be erected plumb and true to line and level with the maximum variation in any storey height or any length of wall being one mm in one metre. The maximum tolerance in the length, height or width of any single masonry unit shall be $\pm$ 3mm.

9.12 DAMP PROOF COURSE

Damp-proof course shall be laid on an even mortar bed, free from projections, which may puncture the material. Where the damp-proof course is to be stepped, only flexible membrane shall be used. All damp proof course, unless otherwise specified, shall consist of 1:2:4 cement concrete 50mm thick, mixed with 2.5 kg of pudlo per bag of cement or other approved quality water proofing compound as per manufacturer's specifications and shall be laid at required levels as per drawings and instructions of the Engineer-in-Charge. The D.P.C shall be tamped consolidated, levelled, edges and corners made to the requirements of concerned drawings including finishing and curing complete.

9.13 SOLID BLOCK WORK AROUND OPENING OF HOLLOW MASONRY

Around all openings in hollow block masonry, the Contractor shall provide solid block work of same thickness as that of hollow block masonry wall and of width as indicated on the Drawings. Solid block shall be laid around openings in such a manner that these are bonded integrally with hollow block masonry.

Reinforced pocket cavity masonry wall construction is shown on Figure 9.1

9.14 CURING AND REPAIRS

All block masonry shall be water cured and shall be kept wet for at least seven days, by an approved method, which will keep all surfaces to be cured continuously wet. Water used for curing shall meet the requirements of the specifications for water used in the manufacture of blocks.

If, after the completion of any block masonry, the work is not in alignment or level, or does not, conform to the lines and grades shown on the Drawings or shows a defective surface, it shall be removed and replaced by the Contractor at his expense unless the Engineer-in-Charge grants permission, in writing, to patch or replace the defective area.

9.15 MASONRY SHORT OF HEIGHT

In case of different thickness of slab in different areas or rooms or for any other reasons, whatsoever if chiselling of masonry is required, the Contractor shall do so at his own cost. Where for any reason whatsoever, the height of the wall is short of ceiling height, the actual height shall be made good with 1:3:6 nominal mix concrete. This concrete shall neither be measured nor be paid under item of concrete but will be paid for under the item of wall masonry. Similarly where the lintel heights are such that the Contractor has to chisel the masonry or provide cast-in-place concrete to make up the height of the course, no payment will be made for chiselling, but where such cast-in-place concrete is provided, payment for the same will be made at the unit rate of masonry.

9.16 MEASUREMENT AND PAYMENT

Solid Concrete Block Masonry work shall be measured in cubic metres unless otherwise specified. Any extra work over the specified dimensions shall be ignored. Dimensions shall be measured correct to the nearest 0.01 m i.e. 1 cm. Areas shall be calculated to the nearest 0.01 sq. mtrs and the cubic contents shall be worked out to the nearest 0.01 cubic metres. Block Masonry Work shall be measured separately in the following stages:

(a) From foundation to floor one level (Plinth level)

(b) Plinth (floor one) level to floor two level

(c) Between two specified floor levels above floor two level

Note : (i) Work in parapet walls, mumty, lift machine room and water tanks constructed on the roof upto 1.2 m height above roof shall be measured together with the corresponding work of the floor next below.

No deductions or additions shall be done and no extra payment made for the following:

Note : Where minimum area is defined for deduction of an opening, void or both, such areas shall refer only to opening or void within the space measured.

(a) Ends of dissimilar materials (that is, joists, beams, lintels, posts, girders, rafters, purlins, trusses, corbels, steps, etc.); up to 0.1 m^2 in section;

(b) Opening up to 0.1 m^2 in area (see Note);

(c) Wall plates, bed plates, and bearing of slabs, and the like, where thickness does not exceed 10 cm and bearing does not extend over the full thickness of wall;

(d) Cement concrete blocks as for hold fasts and holding down bolts;

(e) Iron fixtures, such as wall ties, pipes upto 300 mm diameter and hold fasts for doors and windows; and

(f) Chases of section not exceeding 50 cm in girth.

(g) Bearing portion of drip course, bearing of moulding and cornice.

Note : In calculating area of an opening, any separate lintel or sills shall be included with the size of the opening but end portions of lintel shall be excluded. Extra width of rebated reveals, if any, shall also be excluded.

Walls half Block and less shall each be measured separately in square metres stating thickness. Walls beyond half block thickness shall be measured in multiples of half block which shall be deemed to be inclusive of mortar joints. String courses, projecting pilasters, aprons, sills and other projections shall be fully described and measured separately in running metres stating dimensions of each projection.

Square or rectangular pillars shall be measured separately in cubic metres in multiple of half brick.
Circular pillars shall be measured separately in cubic metres as per actual dimensions.

Solid Block Masonry work curved on plan shall be measured like the block work in straight walls and shall include all cutting and wastage of blocks, tapered vertical joints and use of extra mortar, if any. Block work curved on plan to a mean radius not exceeding six metres shall be measured separately and extra shall be payable over the rates for Block work in straight walls. Nothing extra shall be payable if the mean radius of the Block work curved in plan exceeds six metres.

Tapered walls shall be measured net as walls and extra payment shall be allowed for making tapered surface for Block work in walls.

9.18.1 COMPOSITE RATE

The measurement and payment for the items of the work of Solid Cement Concrete Block Masonry hereof shall be made corresponding to the applicable CSR items as provided in Contract Agreement and shall constitute full compensation, for procurement, transportation, performance in all respects and completion of work as specified including the site clearance as approved by the Engineer-in-Charge. Furthermore,

The rate shall include the cost of materials and labour required for all the operations described above except the vertical reinforcement and its encasement in cement mortar or cement concrete. The rate shall also include the following:

(a) Raking out joints or finishing joints flush as the work proceeds;

(b) Preparing tops of existing walls and the like for raising further brick work.

(c) Rough cutting and waste for forming gables, splays at eaves and the like.

(d) Leaving holes for pipes upto 150 mm dia. and encasing hold fasts etc.

(e) Rough cutting and waste for block work curved in plan and for backing to stone or other types of facing.

(f) Embedding in ends of beams, joists, slabs, lintels, sills, trusses etc.

(g) Bedding wall plates, lintels, sills, roof tiles, corrugated sheets, etc. in or on walls if not covered in respective items and

(h) Leaving chases of section not exceeding 50 cm in girth or 350 sq cm in cross-section.

(i) Cut brick corners, splays reveals, cavity walls, block works curved on plan to a mean radius exceeding six metres.

9.18.2 LABOUR RATE

The measurement and payment for the items of the work of Cement Concrete Block Masonry hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurement transportation, performance in all respects and completion of work as specified including site clearance, as approved by the Engineer-in-Charge except the cost of materials to be provided by Department at designated location as defined in the Contract Agreement.

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10. CONCRETE BLOCK MASONRY

10.1 SCOPE

The work under this section of the specifications consists of furnishing all plant, labour, equipment, appliances and materials and performing all operations in any floor and at any height in connection with the supply and installation of ordinary cement concrete Hollow block masonry work including wall ties, anchors, damp-proof courses, complete in strict accordance with this section of the Specifications and applicable drawings, and subject to the terms and conditions of the Contract.

10.2 MATERIALS

10.2.1 FOR BLOCK

Cement, aggregates and water for concrete blocks shall conform to the requirements as specified in Section 5 for Plain and Reinforced Concrete.

10.2.2 FOR MORTAR

The cement and sand mortar for concrete block masonry shall specified.

10.2.2.1 SAND

Sand for mortar shall comply with the requirements for BS-1200. It shall be graded in accordance with the following table and the various sizes of particles shall be uniformly distributed. Sand that has been in contact with seawater shall not be used unless it has been thoroughly washed to the satisfaction of the Engineer-in-Charge.

Table 9.2.2(a)
Grading of Sand

Sieve Size Number	Percent Passing by Weight	
	Min.	Max.
# 4	100	Not Applicable
# 8	95	100
# 16	70	100
# 30	40	75
# 50	10	35
# 100	2	15
# 200	0	0

The sand shall conform to the provisions of 5.3.1.3 – Plain & Reinforced Concrete for limits of deleterious material.

CEMENT

Cement shall be Ordinary Portland Cement conforming to BS-12.

WATER

Water shall be clean and free from any harmful impurity. Where the quality of the water is doubtful, it shall be tested in accordance with BS- 3148.The water shall comply with the provisions of Clause 5.3.1.6 - Plain & Reinforced concrete.

ADDITIVES

Additives where used, shall be proprietary products used in the proportions and manner recommended by the manufacturer. The additives shall in no way adversely affect the mortar strength or contain chemicals, which may be harmful to other building materials. To add gypsum to cement is strictly forbidden.

MORTARS AND GROUT

Materials for mortar, sand and binding agent and water, shall be mixed by volume or by weight as specified for at least 3 minutes with the minimum amount of water to produce a correctly mixed mortar or grout of workable consistency in a mechanical batch mixer. For small jobs, hand mixing may be permitted, the ingredients being mixed with sufficient water to produce a correctly mixed workable mortar.

Mortar shall be as strong, but no stronger than the materials it bonds together. Mortars shall be mixed in batches, which can be used within a period before the setting process commences. Once a mix begins drying off, it shall be rejected. No ingredients shall be added to it once the setting process has begun.

10.3 CONCRETE BLOCK MAKING

The Hollow blocks shall be factory manufactured/fabricated and be machine moulded. The block making machines shall be of the standard approved by the Engineer-in-Charge. They shall be operated according to the instructions laid down by the manufacturers. The contractor shall submit samples/literature of various manufacturers for Engineer-in-Charge’s approval. The contractor should note that only blocks supplied by the approved manufacturer(s) shall be allowed to be used in the work.

The blocks shall be continuously water cured by sprinkling water for a minimum of 10 days and covered between sprinkling operations with 4 mils thick polyethylene sheeting. After 10 days water curing period the blocks shall be air-dried. Under no circumstances blocks will be used in the work until they are completely dry. During curing period no surfaces of the block will be allowed to dry.

Cured concrete blocks shall be stored off the ground, stacked on level platforms which allow air circulation under stacked units. Units shall be covered and protected against wetting.

Care shall be exercised in the handling of all concrete blocks. No damaged blocks shall be used in the work.

The hollow blocks shall be manufactured as per pattern shown on the drawing. These block units shall be provided by the Contractor for use where required in building structures from approved type of materials. Units shall have uniformly fine smooth surfaces of uniform colour. These shall be free of any honey combing or other imperfections or deformations, all edges true and straight, and at right angles with each other and without any chipped or otherwise broken edges.

The blocks cast on different dates shall be stacked separately and must be labelled showing the date on which they were cast.

Reinforced cement concrete hollow block masonry shall be provided where shown on the drawings. Hollow block manufactured by moulding machine shall have well formed cavities, sharp and well defined edges and corners, smooth surfaces without any imperfections or deformations.

10.4 PROPERTIES OF BLOCKS

All blocks shall be of the size and shape required to complete the work shown in the Drawings or as instructed by the Engineer-in-Charge.

The cement, sand and coarse aggregate shall be volume batched and their proportion may be adjusted so as to provide the concrete of the required strength when tested and shall be mixed in a concrete mixer in accordance with the provisions of Section 5 - 'Plain and Reinforced Concrete.

All blocks shall comply with ASTM C-55-03 edition. The compressive strength of various Hollow blocks shall be as follows:

Sr. #	Type of Concrete Masonry	Compressive Strength (Psi)		Location
		Average of 3 Units	Individual Unit	
1.	(ASTM-C-90-85)	700	600	Not exposed to moisture & weather

Normally 1:3:6 concrete mix should meet the above strength requirement as per Clause 5.3.2.2 Section 5 – Plain & Reinforced Concrete. The specific gravity should be between 2.3 to 2.4.

The proportion shall however be confirmed by contractor by trial mix and approved by Engineer-in-Charge for actual site conditions.

The Contractor shall provide test certificates providing the average minimum crushing strength of the blocks prior to the commencement of the construction. Further test certificates shall be provided as required by the Engineer-in-Charge to ensure that all batches of blocks have the minimum specified crushing strength.

A laboratory approved by the Engineer-in-Charge shall carry out the test. Evidence shall be produced that the block manufacturer has an efficient method of quality control. The Engineer-in-Charge will require to test samples of blocks periodically and the Contractor shall make necessary arrangements accordingly. The method of sampling for all tests shall be in accordance with ASTM standards referred in Section 9.4.3.

10.5 SUCTION RATE

The Contractor shall, at his own cost, satisfy the Engineer-in-Charge that the suction rate of the block when determined in accordance with Appendix "A" of BS 3921 does not exceed 20 g/dm^2/ min. or that the Contractor is able to adjust it so that it does not exceed this value on site.

10.6 SOLUBLE SALT CONTENT

For exposed blockwork, the contents by weight percent of soluble sulphate, calcium, magnesium, potassium and sodium radicals, shall not exceed 0.30, 0.10, 0.30, 0.03 and0.03, percent respectively when ascertained in accordance with BS 3921, at the cost of the Contractor.

10.7 REINFORCING AND ANCHORS OF BLOCK MASONRY

Unless otherwise stated reinforcing and anchors shall conform to under-mentioned sizes:

Joint reinforcing shall be 1.32mm (0.05-inch) diameter mild steel wire mesh design, galvanized after fabrication. Steel wire woven into 12mm mesh 75mm wide. Reinforcing bar anchors shall be 25 mm dia. deformed bar minimum 10 inch long.

Two 6mm dia bar shall be provided at every fourth course for anchoring of block masonry to columns. Two 10 mm bars at every fourth horizontal course shall be provided for anchoring masonry walls to plinth beam/floor beam, as shown on the drawings.

Dovetail anchors and slots (if used as an alternate anchorage) shall be not less than 18 gauge galvanized steel.

10.8 ERECTION

Blocks shall be laid true to line, level and laid in accurately spaced courses in stretcher bond with vertical joints of each course located at centre of units in alternate courses below. Vertical joints shall be buttered in the entire height of blocks. Each course shall be bonded at corners and at intersections of walls and shall be properly bonded. Courses of block shall be kept plumb throughout and corner reveals shall be true and in plumb.

Standard width of mortar joints for both horizontal and vertical joints shall be 10mm (maximum). Mortar joints in walls shall have full mortar coverage on vertical and horizontal faces between the blocks. Mortar joints on wall including struck joints, shall be thoroughly compacted and pressed tight against the edges of the blocks with proper tools. Blocks terminating against soffits of beam or slab construction shall be wedged tight with wedges and the joints shall be packed solidly with mortar between the top of the block and the bottom of slab or beam. Control expansion joints shall be kept free from mortar or other debris.

Unless otherwise shown on the drawings or specified by the Engineer-in-Charge, the spaces around doorframes and other material or built in items shall be solidly filled with mortar. Spaces around the door and window holdfasts shall be filled in with 1:3:6 concrete. Work required to be built in with masonry including doorframe anchors, wall plugs, and dovetail anchors and accessories shall be built in as the erection progresses.

The block work shall be carried up in a uniform manner and no portion shall be carried more than one metre above the adjoining one at any time. All masonry shall be kept strictly true and square and the whole properly bonded together and levelled round each floor.

Sleeves, Chases, holes, sinking and mortices for other trades shall be correctly located and formed to the sizes as required by the relevant trades. Chiselling of completed walls or the formation of holes shall only be carried out as per design drawings with the approval of the Engineer-in-Charge.

Walls of blocks indicated, as being non-load bearing shall be constructed on the insitu concrete floor slab unit after the floor formwork is struck and the concrete has obtained sufficient strength to support their-weight. Toothing into load-bearing walls shall not be permitted.

All bolts, anchors, ties, pipe sleeves, flushing metal attachments, lintels and the like required to be built into the work shall be correctly inserted and executed as the work proceeds.

Walls or partitions abutting concrete columns or walls shall be securely anchored and tied with metal anchors or ties at not more than 450mm vertical centres. Wall ties cast in with concrete shall be bent down after the removal of formwork and shall be securely jointed into the mortar beds of walling.

Care shall be taken during construction of cavity walls so as to avoid the filling up of cavity with mortar. G.I. flashing and weep holes shall be provided wherever specified on the drawings or as per the instructions of the Engineer-in-Charge. Weep holes will be formed by oiled rods, removed after the mortar is set, at specified locations.

10.9 SCAFFOLDING

Contractor shall provide safe scaffolding of adequate strength for use of workmen at all levels and heights at his own expense. Scaffolding which is unsafe in the opinion of the Engineer-in-Charge shall not be used until it has been strengthened and made safe for use of workmen. Cost of scaffolding etc. shall be included by the Contractor in the unit rate for masonry items. Damage to masonry from scaffolding or from any other object shall be repaired by the Contractor at his own cost.

10.10 JOINTING

Jointing is the forming of joints as work proceeds. Joints shall be as follows:

- Exterior exposed joints shall be tightly formed to a weather joint with the point of the trowel.
- Interior exposed joints shall be tightly formed to a concave joint.
- Joints which are subsequently covered with plaster or other finish materials shall be struck flush.

10.11 TOLERANCES

All block work shall be erected plumb and true to line and level with the maximum variation in any storey height or any length of wall being one mm in one metre. The maximum tolerance in the length, height or width of any single masonry unit shall be ± 3mm.

10.12 DAMP PROOF COURSE

Damp-proof course shall be laid on an even mortar bed, free from projections, which may puncture the material. Where the damp-proof course is to be stepped, only flexible membrane shall be used. All damp proof course, unless otherwise specified, shall consist of 1:2:4 cement concrete 50mm thick, mixed with 2.5 kg of pudlo per bag of cement or other approved quality water proofing compound as per manufacturer's specifications and shall be laid at required levels as per drawings and instructions of the Engineer-in-Charge. The D.P.C shall be tamped consolidated, levelled, edges and corners made to the requirements of concerned drawings including finishing and curing complete.

10.13 REINFORCED HOLLOW BLOCK MASONRY

Where specified on the Drawings, reinforced hollow block masonry shall be provided. Horizontal and vertical reinforcement shall be cold worked deformed bar. Two bars of (8mm) diameter shall be provided at every third horizontal course at 600 mm centres, while the vertical reinforcement shall be two bars of (12mm) diameter at 800mm centres. Bars shall be anchored and held firmly vertical in respective beams and columns in the manner shown in shop Drawings. The reinforced hollow part of the block wall shall be solidly filled with Class 'D' concrete at intervals of one meter maximum height as the laying of block masonry work proceeds. The filled concrete shall be consolidated thoroughly by rodding to avoid formation of voids. Contractor shall submit shop drawings of anchoring and placing of reinforcement in hollow block masonry for approval of the Engineer-in-Charge.

10.14 CURING AND REPAIRS

All block masonry shall be water cured and shall be kept wet for at least seven days, by an approved method, which will keep all surfaces to be cured continuously wet. Water used for curing shall meet the requirements of the specifications for water used in the manufacture of blocks.

If, after the completion of any block masonry, the work is not in alignment or level, or does not, conform to the lines and grades shown on the Drawings or shows a defective surface, it shall be removed and replaced by the Contractor at his expense unless the Engineer-in-Charge grants permission, in writing, to patch or replace the defective area.

10.15 MASONRY SHORT OF HEIGHT

In case of different thickness of slab in different areas or rooms or for any other reasons, whatsoever if chiselling of masonry is required, the Contractor shall do so at his own cost. Where for any reason whatsoever, the height of the wall is short of ceiling height, the actual height shall be made good with 1:3:6 nominal mix concrete. This concrete shall neither be measured nor be paid under item of concrete but will be paid for under the item of wall masonry. Similarly where the lintel heights are such that the Contractor has to chisel the masonry or provide cast-in-place concrete to make up the height of the course, no payment will be made for chiselling, but where such cast-in-place concrete is provided, payment for the same will be made at the unit rate of masonry.

10.16 MEASUREMENT AND PAYMENT

Hollow Concrete Block Masonry work shall be measured in cubic metres unless otherwise specified. Any extra work over the specified dimensions shall be ignored. Dimensions shall be measured correct to the nearest 0.01 m i.e. 1 cm. Areas shall be calculated to the nearest 0.01 sq. mtrs and the cubic contents shall be worked out to the nearest 0.01 cubic metres. Block Masonry Work shall be measured separately in the following stages:

(a) From foundation to floor one level (Plinth level)

(b) Plinth (floor one) level to floor two level

(c) Between two specified floor levels above floor two level

Note : Work in parapet walls, mumty, lift machine room and water tanks constructed on the roof upto 1.2 m height above roof shall be measured together with the corresponding work of the floor next below.

No deductions or additions shall be done and no extra payment made for the following:

Note : Where minimum area is defined for deduction of an opening, void or both, such areas shall refer only to opening or void within the space measured.

(a) Ends of dissimilar materials (that is, joists, beams, lintels, posts, girders, rafters, purlins, trusses, corbels, steps, etc.); up to 0.1 m^2 in section;

(b) Opening up to 0.1 m^2 in area (see Note);

(c) Wall plates, bed plates, and bearing of slabs, and the like, where thickness does not exceed 10 cm and bearing does not extend over the full thickness of wall;

(d) Cement concrete blocks as for hold fasts and holding down bolts;

(e) Iron fixtures, such as wall ties, pipes upto 300 mm diameter and hold fasts for doors and windows; and

(f) Chases of section not exceeding 50 cm in girth.

(g) Bearing portion of drip course, bearing of moulding and cornice.

Note : In calculating area of an opening, any separate lintel or sills shall be included with the size of the opening but end portions of lintel shall be excluded. Extra width of rebated reveals, if any, shall also be excluded.

Walls half Block and less shall each be measured separately in square metres stating thickness. Walls beyond half block thickness shall be measured in multiples of half block which shall be deemed to be inclusive of mortar joints. String courses, projecting pilasters, aprons, sills and other projections shall be fully described and measured separately in running metres stating dimensions of each projection. Square or rectangular pillars shall be measured separately in cubic metres in multiple of half brick. Circular pillars shall be measured separately in cubic metres as per actual dimensions.

Hollow Block Masonry work curved on plan shall be measured like the block work in straight walls and shall include all cutting and wastage of blocks, tapered vertical joints and use of extra mortar, if any. Block work curved on plan to a mean radius not exceeding six metres shall be measured separately and extra shall be payable over the rates for Block work in straight walls. Nothing extra shall be payable if the mean radius of the Block work curved in plan exceeds six metres.

Tapered walls shall be measured net as walls and extra payment shall be allowed for making tapered surface for Block work in walls.

10.16.1 COMPOSITE RATE

The measurement and payment for the items of the work of Cement Concrete Block Masonry hereof shall be made corresponding to the applicable CSR items as provided in Contract Agreement and shall constitute full compensation, for procurement, transportation, performance in all respects and completion of work as specified including the site clearance as approved by the Engineer-in-Charge.

The measurement and payment for the items of the work of Hollow Cement Concrete Block Masonry hereof shall be made corresponding to the applicable CSR items as provided in Contract Agreement and shall constitute full compensation, for procurement, transportation, performance in all respects and completion of work as specified including the site clearance as approved by the Engineer-in-Charge. Furthermore,

The rate shall include the cost of materials and labour required for all the operations described above except the vertical reinforcement and its encasement in cement mortar or cement concrete. The rate shall also include the following:

(a) Raking out joints or finishing joints flush as the work proceeds;

(b) Preparing tops of existing walls and the like for raising further brick work.

(c) Rough cutting and waste for forming gables, splays at eaves and the like.

(d) Leaving holes for pipes upto 150 mm dia. and encasing hold fasts etc.

(e) Rough cutting and waste for block work curved in plan and for backing to stone or other types of facing.

(f) Embedding in ends of beams, joists, slabs, lintels, sills, trusses etc.

(g) Bedding wall plates, lintels, sills, roof tiles, corrugated sheets, etc. in or on walls if not covered in respective items and

(h) Leaving chases of section not exceeding 50 cm in girth or 350 sq cm in cross-section.

(i) Cut brick corners, splays reveals, cavity walls, block works curved on plan to a mean radius exceeding six metres.

10.17.1 LABOUR RATE

The measurement and payment for the items of the work of Cement Concrete Block Masonry hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurement transportation, performance in all respects and completion of work as specified including site clearance, as approved by the Engineer-in-Charge except the cost of materials to be provided by Department at designated location as defined in the Contract Agreement.

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11. BRICKWORK

11.1 SCOPE

All brick masonry required to be constructed under these specifications for masonry buildings, structures, piers, abutments, and perforated as directed by the Engineer-in-Charge, shall consist of the materials herein specified and cement sand mortar shall be proportioned, mixed, and bricks placed in accordance with the requirements stated herein. The requirements set forth herein shall apply to all brickwork, except when such requirements are specifically modified by the Engineer-in-Charge for any particular item of work.

11.2 APPROVAL OF SUPPLY SOURCE

All products supplied under this section must be obtained from an approved source with respect to strength and quality. The contractor will not be permitted to change the source of supply without the permission of the Engineer-in-Charge.

11.3 CLAY MASONRY UNITS (BRICKS)

The clay bricks shall be manufactured from good firm loam with a clay content ranging from 10 to 20 percent as per BS 6669, which will give plasticity index of 7. The earth shall be free from objectionable quantities of lime, gravel, coarse sand and roots or other organic matter. Salts and calcium silicates in the earth shall not exceed 0.5% and 2.0% respectively as given in BS 187.

The common burnt clay bricks shall be hand moulded or machine moulded. They shall be free from nodules of free lime, visible cracks, flaws warp age and organic matter, have a frog 100 mm in length 40 mm in width and 10 mm to 20 mm deep on one of its flat sides as per BS 4729. Bricks made by extrusion process and brick tiles may not be provided with frogs. Each brick shall be marked (in the frog where provided) with the manufacturer's identification mark or initials.

11.3.1 DIMENSIONS

Nominal size of bricks/tiles shall be as follows as per BS 4729:

Bricks	9 inches x 4-1/2 inches x 3 inches (225x113x75mm)
Tiles	12 x 6 x 2 inches (300x150x50mm)
	12 x 6 x 1-1/4 inches
	9 x 4-1/2 x 2 inches

The bricks shall have smooth rectangular faces with sharp corners and shall be uniform in colour and emit clear ringing sound when struck. Bricks required for construction works usually measure 225x113x75 mm as nominal size. However, Bricks/Tiles used for special works shall measure according to the special needs.

11.4 CLASSIFICATIONS

Bricks as they come from the kiln are stored and stacked in stacks of one or two thousands separately, accordingly as they are First Class, Second Class, Third Class (under burnt or *pilla*) Fourth Class (over-burnt or *Jhama*) and Fifth Class (Sundried) Bricks.

11.4.1 FIRST CLASS BRICKS

The size of bricks shall be as specified. They shall be well burnt without being vitrified. They shall be of uniform colour, regular in shape and size, with sharp and square corners and parallel faces. They must be homogeneous in texture and emit a clear ringing sound when struck. They shall be free from flaws and cracks. They shall not absorb more than 1/6th of their weight of water after being soaked for one hour at a temperature of 24 to 26^{o}C, and shall show no signs of efflorescence on subsequent drying. The average compressive strength of five representative bricks shall not be less than 1800-2000 pounds per square inch. When tested in accordance with ASTM Designation: C-67.

If 10 bricks per thousand are defective or if the average weight of nominal 9 inches' x 4-1/2 inches' x 3 inches (with tolerance of 0.11 inches only) brick is less than 5.5 lbs (2.5 Kg) or brick are out of dimension, the whole lot shall be rejected and the contractor shall remove the rejected lots from the site free of cost.

In addition to above, for bricks required in connection with lining of Canals, salt content in the earth shall not be more than 0.3%. perforated bricks shall be manufactured as per specified design and perforations.

11.4.2 SECOND CLASS BRICKS

Second class bricks shall be as well burnt as first class, or slightly over-burnt but not vitrified in any part and must give a clear ringing sound when struck. In this class of bricks slight irregularities in size, shape, or colour will be accepted but not such as to give irregular or uneven courses when used. Second class bricks may have slight chips or flaws. They shall not absorb more than 1/4th their weight of water after one hour's immersion in water of 24 to 26^{o}C. Their compressive strength shall not be less than 1500 pounds per square inch. The average weight of bricks shall not be less than 5.5 lbs. (2.5 kgs).

11.4.3 THIRD CLASS BRICKS OR UNDER-BURNT OR PILLA BRICKS

These bricks are not as fully burnt as first or second class bricks. Any defects in uniformity or shape must not be such as to cause difficulty in obtaining uniform courses with their use. Their compressive strength shall not be less than 1000 lbs. per square inch. The use of third class bricks is prohibited except as substitutes for sundried bricks. These bricks shall not be allowed for face work. Joints in third class bricks shall be ½ inch, but shall in no case exceed 5/8 inch. The height of four courses laid according to the above specifications with 4 horizontal joints shall not exceed 2 inches the eight of 4 bricks piled dry, one upon another.

11.4.4 FOURTH CLASS JHAMA BRICKS

Jhama bricks are bricks so over-burnt as to get vitrified or distorted and are useless for exact work. Their compressive strength shall not be less than 725 lbs. per square inch. They may be broken up for ballast provided the vitrified mass has not become porous or spongy in the process of being over-burnt.

11.4.5 FIFTH CLASS OR SUNDRIED BRICKS

Sundried bricks shall be un-burnt bricks. Any defects in uniformity or shape must not be such as to cause difficulty in obtaining uniform courses with their use. Their compressive strength shall not be less than 500 lbs. per square inch.

11.5 STACKING, SAMPLING AND TESTS

STACKING: The bricks shall be sorted and arranged in stacks of one or two thousands as specified. Each stack shall be 10 courses high and two bricks thick so that at least one ends of every brick are visible. At least two feet space between the stacks shall be left for the purpose of inspection. Each class of bricks shall be stacked separately.

Samples of bricks shall be subjected to the following tests:

(a) Dimensional tolerance.
(b) Water absorption.
(c) Efflorescence.
(d) Compressive strength.

11.5.1 SAMPLING

For carrying out compressive strength, water absorption, efflorescence and dimensional tests, the samples of bricks shall be taken by one of the methods given below:-

Sampling Bricks or Tiles from a Motion:

Whenever practicable samples shall be taken whilst the bricks or tiles are being moved; for example, during loading or unloading, in this case the bricks or tiles shall be taken at random from each of a number of convenient portions of the consignment or batch. The portion chosen should be small enough in relation to the whole to provide the minimum number of samples specified below.

Sampling Bricks or Tiles from a Stack:

Samples shall be taken each at random from a stack of bricks or tiles. The number of bricks required for the tests shall be taken from across the top of the stack, the sides accessible and from the interior of the stack by opening the trenches from the top.

Whichever method is employed, a sample of 50 bricks/tiles shall be taken at random from every consignment of 50,000 bricks/tiles or part thereof.

The samples thus taken shall be stored in a dry place not in contact with the ground until the tests are made. The bricks for tests shall be taken at random from the sample.

11.5.2 TESTING OF SAMPLES

Visual & Dimensional Characteristics

The Visual & Dimensional Characteristics of bricks/tiles as specified under 11.4.1, 11.4.2 & 11.4.6 shall be checked on a sample of 20 first class & 2nd class bricks.

11.5.3 COMPRESSIVE STRENGTH

The average compressive strength of five representative bricks, when tested according to ASTM Designation C-67 shall have a minimum average compressive strength for various classes as given in Sub-Section 11.5. The compressive strength of any individual brick tested shall not fall below the min. average compressive strength specified for the corresponding class of brick by more than 20%.

Designation	Average compressive strength (lbs/Sq.inch)
First Class	2000
Second Class	1500
Third Class	1000
Fourth Class	725

11.5.4 WATER ABSORPTION

This test is significant as it gives as index of the durability of brick. The average water absorption of first class & second class bricks for a sample of five bricks when tested shall be not more than as specified in Clause 11.4.1 and 11.4.2.

11.5.5 EFFLORESCENCE

The bricks checked for water absorption as per Clause 11.5.4 shall show no signs of efflorescence in drying.

11.5.6 CRITERIA OF ACCEPTANCE

If more than 10% bricks in the stacks do not conform to any of the specification requirements, than the whole consignment shall be rejected.

11.6 BRICK WORK

11.6.1 CLASSIFICATION

The brick work shall be classified according to the class designation of bricks used. The specifications stated hereof are for First class brick masonry in cement sand mortar except specified otherwise.

11.6.2 MORTAR

The cement sand mortar for the brick work shall be as specified. For sundried brick mud mortar shall be used.

A. Mud Mortar

1. Composition

Mud mortar for brickwork and masonry shall be prepared from good earth and water, Sand or shopped straw shall be added to the earth that is too clayey. Mud mortar for plastering shall be prepared from earth, water and chopped "*bhoosa*".

2. Materials

a) Earth

Earth shall be good firm loam with clay content ranging from 10% to 20% will give plasticity index of 7. The earth shall be free from objectionable quantities of lime, gravel, coarse sand and roots of other organic matter. Salts and calcium contents shall not exceed 0.5% and 2% respectively; i.e. it shall be good brick earth or selected clay obtained from approved sources. Clay containing more than 0.5% soluble salts, more than 0.2% sulphates and 4% organic content or efflorescent salts or taken from a locality where there are white ants shall not be used. In case of brick earth it shall be reduced into fine powder & free from stones, grass, kankar, roots and other matter.

b) Water

Only fresh and clean water free from earth, vegetations, organic impurities and any other substances likely to cause efflorescence or otherwise prove harmful to the work shall be used. Water containing injurious amounts of oils, acids, alkalis,. Salts, sulphides, chlorides, carbon dioxide shall not be used. The pH Value of water shall range between 6 & 8. Broadly speaking water which does not show an intensive odour or brackish taste shall be acceptable.

3. Preparation

Earth / Clay shall be mixed with water on a plane ground surface especially cleared for the purpose and tempered for at least two days. During this period it shall be worked up at intervals with men's feet and Hand Shovel. Sand or chopped straw shall be added, as desired, to the earth that is too clayey. Mud mortar for plastering shall be prepared as specified above and 1.8 kg of chopped "bhoosa" shall be thoroughly mixed with 0.03 cum of mortar.

4. Consistency

The consistency of mud mortar shall be of a type that it shall readily slide off the face of trowel, but the mortar shall not be so wet that it parts into large drops in falling. No water shall be added to the mortar after it is delivered to job.

5. Pits

Unless otherwise specified or directed by the Engineer-in-charge, the contractor shall make his own arrangements for obtaining the necessary earth / clay for the mortar. When permitted by the Engineer to take earth from the site of work, the contractor shall fill all pits with good earth and dress them off properly on the completion of work.

6. Restriction of Use

Mud mortar shall not be used for any masonry or brickwork likely to remain under water at any time or likely to bear pressure other than directly vertical.

B. Cement Mortar

Composition

Cement mortar shall consist of one part Portland cement to specified number of parts of dry loose sand (Fine aggregate) by volume and sufficient water to produce proper consistency for intended use. Waterproofing agent not exceeding 25% by volume of dry cement shall be added when specially required or directed by the Engineer-in-Charge.

1. Materials

a) Portland Cement

Portland Land cement shall conform to ASTM C 150-94 Type I or B.S.S.12.

b) Sand

Sand shall be such that it passes through a No.16 sieve and not more than 30 percent, passes through a sieve of 100x100 meshes in the square inch. The sand used or supplied shall be clean sand, gritty to the touch and free from any admixture of clay, loam, salts, organic matter or other impurities The sand shall be of such cleanness that when a handful of it is shaken in a glass with clean water and allowed to stand for one hour the precipitation of mud (or flour in the case of screenings) on the sand shall not exceed 10%. If more than this precipitate is found, the sand shall be washed.

The source of the sand is subject to the approval of the Engineer-in-Charge from the designated sources.

c) Water

Water shall conform to specifications for water for mud mortar clause 11.7.2.

2. Mix

Unless otherwise specified or directed by the Engineer-in-Charge, the ingredients for cement mortar shall be proportioned by volume.

3. Preparation

a) Methods and equipment used for mixing mortar ingredients – including their mixing in dry state – shall be such as will accurately determine and control the amount of each separate ingredient entering into the mortar and shall be subject to the approval of the Engineer-in-Charge. Normally cement and sand is thoroughly mixed in a dry state on a pucca platform or in troughs as directed by the Engineer-in-Charge. It shall be gauged with a quantity of water sufficient to make the mortar workable. Water shall be added with a fine rose. Only such quantity of mortar shall be prepared as can be used before the initial setting time.

b) If a mixer is used, it shall be of the approved design. The mixing time after all the ingredients are in the mixer, except for the full amount of water, shall be not less than two minutes. Water shall be added at a uniform rate during the mixing time.

c) Mortar shall be mixed only in sufficient quantities for immediate use and all mortar not used within thirty (30) minutes after addition of the water to the mix shall be wasted. Re-tempering of mortar will not be allowed. Mixing troughs and pans shall be thoroughly cleaned and washed at the end of each day's work. When colour for face work is specified to be mixed in it shall be of approved quality and brand and shall be added in such quantity to obtain the required shade, water proofing material shall be added only when specifically directed.

4. Measurements

The measurement of mortar, if required, shall be done by volume. The unit of measurement shall be cubic meter..

5. Rate

The unit rate shall include the cost of Portland cement, sand and water and the preparation of mortar as per above specifications at the site of work to be defined in the condition of contracts~~.~~

a) Composition

Lime mortars, as specified herein, shall consist of one of the following combinations mixed in specified proportions and water sufficient to produce proper consistency for the use of mortar;

1. Stone lime and Surkhi
2. Kankar Lime and Sand
3. Slaked Kankar or Stone Lime & Cinder

b) Materials

1. Lime

Lime for lime mortars shall be obtained from suitable calcinations of naturally occurring forms of Calcium Carbonates (Lime stone or Kankar)

Lime shall be stored in dry and weather-proof sheds, in a compact heap so as to expose as small an area as possible to air to prevent air slaking and shall not be stored for a long period of time but used as fresh.

The unit rate shall include furnishing, grinding and screening of lime as per specifications, delivery, stacking and slaking at site of work to be defined in contract

2. Surkhi

Surkhi used as substitute for sand shall be made by grinding fully burnt first class bricks, brick bats or burnt clay to powder. On no consideration surkhi shall be obtained from over burnt or under burnt bricks and bats or from kiln lining. Surkhi shall pass through a screen of 12x12 meshes in 6.45 square cms and in case, it is required for works to remain under water, the size of mesh shall be 8x8. It shall in no case pass one of 50x50 meshes in the 6.45 square cms.

Shurkhi shall be measured in bulk, unit of measurement shall be 100 cubic feet.

3. Cinder

Cinder shall be obtained from an approved source. It shall be free from admixtures of clay, dust, vegetation or foreign matter. Only clean surface clinker coal i.e. residue from furnaces of steam boilers using coal fuel only shall form the parent material. These shall be stacked on brick, wooden or other suitable platform so as to be adequately protected from such admixtures. After having been ground in mill and screened, the whole of it shall pass through a screen of 12x12 meshes in the 6.45 square cms but does not pass through a mesh of 50x50 meshes shall be used.

Cinder shall be measured in bulk with unit of measurement shall be 100 cubic feet.

4. Sand

Sand shall conform to specifications, requirements and stipulations specified for sand para 11.7.2 (ii) (2) (b) of cement mortar.

5. Water

Water shall conform to Specifications described under para 11.7.2 (ii) (c), “cement mortar”.

c) Mix

Unless otherwise specified or directed by the Engineer-in-Charge, the ingredients for lime mortar shall be proportioned by volume.

1. **Mortar for Masonry and Brickwork**
Thoroughly slaked and screened stone lime/kankar lime and surkhi/sand shall be measured in boxes and mixes on a pucca platform or in a mixing trough as specified. The troughs, if used, shall be capable of being washed and drained. These ingredients shall be mixed twice in a dry state and then ground in a grinding mill with a quantity of water sufficient to produce a mortar of specified consistency.

2. **Mortar for Plastering and Pointing**
Unless otherwise specified one part of lime mixed with two parts of surkhi by volume shall be kept under water for at least 12 hours and then made to pass through a screen of 12x12 meshes per 6.45 sq. cms. Requisite coloring material shall be added to it and the mortar applied as fresh as possible.

d) Measurement:

The measurement of mortar if required shall be done by volume. The unit of measure shall be cubic meter.

e) Rate:

The unit rate shall include the cost of stone lime/ kanker lime, sand/ surkhi, and water and the preparation of mortar as per above specifications to be defined in the condition of contract.

11.6.3 SOAKING OF BRICKS

Bricks shall be soaked in water before use for a period for the water to just penetrate the whole depth of the bricks. The soaking of bricks would be for 2 to 3 hrs. Alternatively bricks may be adequately soaked in stacks by profusely spraying with clean water at regular intervals for a period not less than six hours. The bricks required for masonry work using mud mortar shall not be soaked. When the bricks are soaked they shall be removed from the tank sufficiently early so that at the time of application they are skin-dry. Such soaked bricks shall be stacked on a clean place where they are not again spoiled by dirt earth etc.

Note 1: The period of soaking may be easily found at site by a field test in which the bricks are soaked in water for different periods and then broken to find the extent of water penetration. The least period that corresponds to complete soaking will be the one to be allowed for in construction work.

Note 2: If the bricks are soaked for the required time in water that is frequently changed the soluble salt in the bricks will be leached out, and subsequently efflorescence will be reduced.

11.6.4 BRICK MASONRY CONSTRUCTION

11.6.4.1 PLACING BRICK MASONRY

a) The methods and equipment used for transporting the bricks and mortar shall be such as will not damage the brick nor delay the use of mixed mortar.

b) All brickwork shall be placed only after the foundation surface has been prepared satisfactory in accordance with these Specifications and the Engineer’s instructions.

c) All bricks to be used in brickwork with mortar joints except with mud mortar joints shall be moistened with water for three to four hours before they are used, by a method which will ensure that each brick is thoroughly and uniformly wetted. All bricks shall be free from water adhering to their surface when they are placed in the brickwork. This bricks shall be laid strictly in accordance with the Drawing or as directed by the Engineer.

d) Brick work shall not be carried out during rains sufficiently heavy or prolonged to wash the mortar from the bricks. Mortar already spread, which becomes diluted by rain, shall be removed and replaced before continuing with the work. Fresh laid brickwork shall be covered with polyethylene sheets to avoid dilution and removal of mortar. Workman shall not be allowed to walk on the brickwork before it is fully set. All walls or other brickwork shall be securely braced and protected against damage by wind and storms during the construction period.

e) Bricks shall be skilfully laid frog up and each bricks shall be set with both bed and vertical joints filled with mortar and the bricks shall be bedded in by firmly tapping with the handle of the trowel. Bricks course shall be carried up as neatly as possible in a uniform manner and carefully plumbed on both sides. No portion of the brickwork shall be raised more than one meter above another at the same time. Straight edges supplied to bricks layers shall have course marked on them with saw cut or measuring rods shall be provided to check the height of course and their horizontality. All unavoidable changes in slopes shall be raked back at a slope of two horizontal to one vertical. All anchors and similar work required to be embedded in brick masonry shall be installed as the construction progress. The exposed face of all brick masonry shall have the smoothest finish and be kept clean and free from streak of mortar. Wherever such streaks are formed they shall be parallel whereas vertical joints in alternate course shall be directly over one another. The thickness of the vertical joints shall be approximately 6 millimetres and the thickness of the horizontal joins shall be 10 millimetres. Except where otherwise specified excess mortar at the outer edges shall be removed and joints drawn straight with the edge of a trowel and straight edge. At the completion of the work all holes or defective mortar joints shall be cut out and re=pointed.

11.6.4.2 DURABILITY

There are four main causes which impair the durability of brickwork: frost action, crystallization of soluble salts, chemical action and moisture movement. Since it is the presence of water in brickwork which is responsible for bringing these causes into action the first safeguard is to protect the work by avoiding unnecessary exposure and providing damp-proof courses, where practicable.

Frost can affect both the bricks and the mortar, and its effects are fairly straightforward. The affected part spalls or crumbles with the action of ice-forming in its saturated pores. Crystallisation of salts and chemical action depend on the presence of soluble salts which may originate in the bricks or the mortar or both. The movement of salts to the surface of the wall is influenced by pore structure of its elements, so that some of the salts from the brick may come out at joints and vice versa. It is possible to control to some extent the incidence of efflorescence and crystallization by ensuring that the parts at which these actions would be least harmful are most porous. In the case of chemical action, an important type of failure occurs when clay bricks containing a dangerous proportion of calcium sulphate are bonded in mortar containing cement or covered with a rendering containing cement. In certain damp conditions the sulphate can combine with cement and cause general expansion and failure of work.

11.6.4.3 BONDS

Bond is the name given to any arrangement of bricks in which no vertical joint of a course is exactly over a vertical joint in another course immediately above or below it, and has the greatest possible amount of lap, which is usually one-fourth the length of a brick.

To ensure good bond the following rules should be rigidly adhered to:

a) Bricks must be arranged in a uniform manner.

b) Fewest possible bats are employed.
c) Vertical joints in every other course must be perpendicularly in line on the internal as well as the external face.
d) Stretchers are to be used only on the faces of the wall; the interior should consist of headers only, as also the footings and corbels.
e) When bedded the length of a brick should equal twice the width, plus one mortar joint.
f) Lateral lap between perpends is ¼ of brick length.

Common types of bonds used in brickwork are described as follows:-

i. English Bond:

It consists of one course of headers and one course of stretchers alternately. In this bond, bricks are laid as stretchers only on the boundaries of courses, thus showing on the face of the wall. The joints in a course running through from back to front of a wall must not be broken. The course which consists of stretchers on the face is known as a stretching course. The courses above or below should consist of headers with the exception of the closer brick, which is always placed next to the quoin header to complete the bond. These courses are called as heading courses.

It may be noticed that in walls the thickness of which is a multiple of a whole brick the same course will show

Either

a) Stretchers in front elevation and stretchers in back elevation.

Or

b) Headers in front elevation and headers in back elevation.

But in walls whose thickness is an odd number of half brick, the same course will show

Either

a) Stretchers in front elevation and headers in back elevation.

Or

b) Headers in front elevation and stretchers in back elevation.

In setting out the plan of a course to any width, the quoin or corner brick should be drawn: then next to the face (which in front elevation shows headers) closers should be to the required thickness of wall; after which all the front headers should be set out and, if the thickness is a multiple of a whole brick, headers in rear should be set out. The intervening space, if any, should always be filled in with headers.

ii. Double Flemish Bond

This bond has headers and stretchers alternatively in the same course, both in front and back elevation. It is weaker than the English Bond because of the greater number of bats and stretchers, but is considered by some to look better on the face. It is also economical, since a greater number of bats may be used in it and thus bricks broken in transit may be utilized. By using the Double Flemish Bond for walls one brick in thickness, it is easier to obtain a better appearance on both sides than with the English Bond.

iii. Single Flemish Bond

It consists in arranging the bricks as Flemish Bond on the face, and English Bond as backing. This is often done on the presumption that it attains the strength of the English Bond and the external appearance of the Double Flemish. It is generally used where expensive bricks are specified for facing. The thinnest wall where this method can be introduced is 1-1/2 brick thick.

iv. Stretching Bond

Stretching bond is used for walls half-brick thick such as partition walls, brick nogging in partitions. All bricks are laid as stretchers upon the face.

v. Heading Bond

All bricks in this bond show as header on face. It is used chiefly for rounding curves, for footings, corbels and cornices.

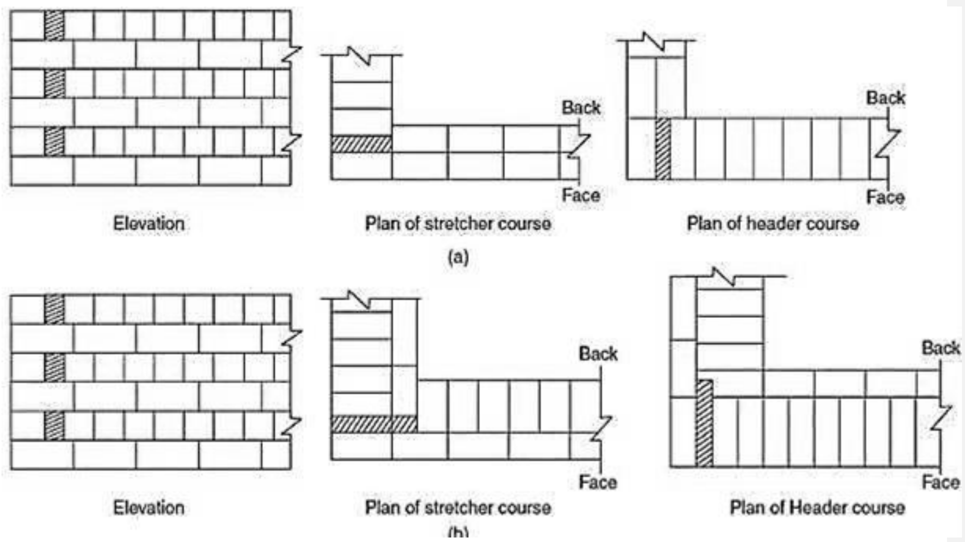
vi. Racking Bond

Walls as they increase in thickness increase in transverse strength but proportionally weaker in longitudinal direction, owing to the fact that stretchers are not placed in the interior of walls. This defect is remedied by using racking courses at regular intervals of four to eight courses in the height of a wall. The joints of bricks laid in this position cannot coincide with the joints of ordinary courses directly above or below, the inclination to the face usually being determined by making the longitudinal distance between the opposite corners equal to the length of brick. It is not advisable to use one racking course directly above another, since there is always a weakness at the junction of the racking with the face bricks.

Racking bonds are most effective when placed in the stretching courses in walls of even an even number of half bricks in thickness. In this way they are effective over a greater area than if they were placed in the heading course.

The alternate courses of racking bonds should be laid in different directions in order to make the tie as perfect as possible. There are two varieties of racking bonds, viz. Herring bond and diagonal.

Fig: English Bond



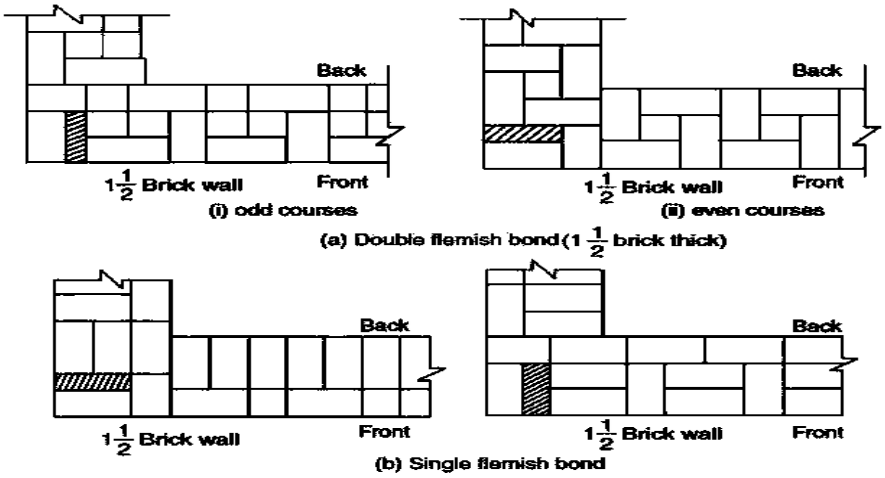


Fig: Double & Single Flemish Bond

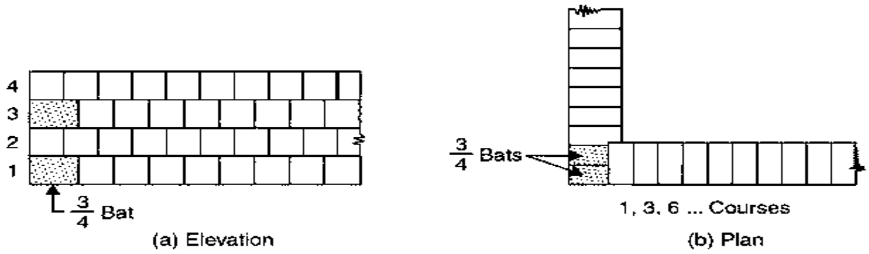


Fig: Header Bond

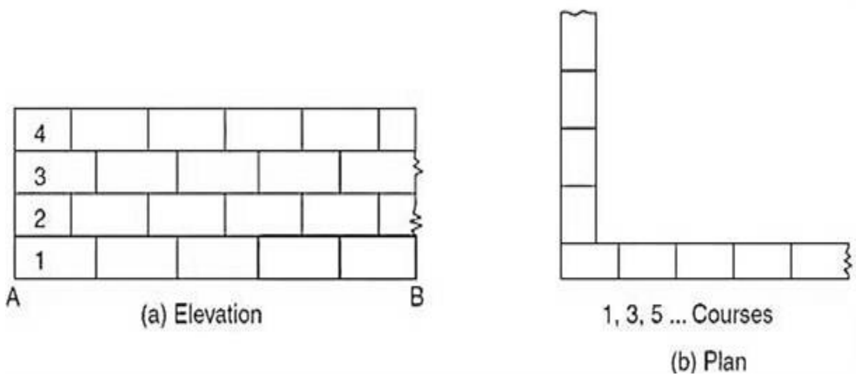


Fig: Stretcher Bond

11.6.4.4 Laying

a) General

The brick laying shall be carried out complete with all embedment and installations for completion of the construction as shown on drawings and directed by the Engineer-in-Charge.

Bricks shall be laid in English Bond unless otherwise specified. For brick work in half brick wall, bricks shall be laid in stretcher bond. Half or cut bricks shall not be used except as closer where necessary to complete the bond. Closers in such cases, shall be cut to the required size and used near the ends of the wall. Header bond shall be used preferably in all courses in curved plan for ensuring better alignment.

Note:

Header bond shall also be used in foundation footings unless thickness of walls (width of footing) makes the use of headers impracticable. Where thickness of footing is uniform for a number of courses, the top course of footing shall be headers.

All loose materials, dirt and set lumps of mortar which may be lying over the surface on which brick work is to be freshly started, shall be removed with a wire brush and surface wetted. Bricks shall be laid on a full bed of mortar, when laying, each brick shall be properly bedded and set in position by gently pressing with the handle of a trowel. It's inside face shall be buttered with mortar before the next brick is laid and pressed against it. Joints shall be fully filled and packed with mortar such that no hollow spaces are left inside the joints.

b) Bedding of Bricks

While bedding bricks, both the bed and side joints must be thoroughly flushed or filled up with mortar.

c) Levelling

While bedding bricks, great care should be taken to keep all courses perfectly level. To do this, the footing and the starting course should be carefully levelled, using a spirit level with a stack at least 10 feet long.

11.6.4.5 Construction of Walls

a) The walls shall be taken up truly in plumb or true to the required batter where specified. All courses shall be laid truly horizontal and all vertical joints shall be truly vertical. Vertical joints in the alternate course shall come directly one over the other. Quoin, Jambs and other angles shall be properly plumbed as the work proceeds. Care shall be taken to keep the perpends properly aligned within following maximum permissible tolerances:

(i) Deviation from vertical within a storey shall not exceed 6 mm per 3 m height.

(ii) Deviation in verticality in total height of any wall of building more than one storey in height shall not exceed 12.5 mm.

(iii) Deviation from position shown on plan of any brick work shall not exceed 12.5 mm.

(iv) Relative displacement between load bearing wall in adjacent storeys intended to be vertical alignments shall not exceed 6 mm.

(v) A set of tools comprising of wooden straight edge, Masonic spirit levels, square, 1 metre rule line and plumb shall be kept on the site of work for every 3 masons for proper check during the progress of work.

All quoins shall be accurately constructed and the height of brick courses shall be kept uniform. This will be checked using graduated wooden straight edge or storey rod indicating height of each course including thickness of joints. The position of damp proof course, window sills, bottom of lintels, top of the wall etc. along the height of the wall shall be marked on the graduated straight edge or storey rod. Acute and obtuse quoins shall be

bonded, where practicable in the same way as square quoins. Obtuse quoins shall be formed with squint showing three quarters brick on one face and quarter brick on the other.
The thickness of brick walls is regulated by the following rules which only apply to walls which are not more than 45 feet long between supports or cross walls and buildings three storey high. Local authority by-laws may be referred for more detail information. Walls built for various types of brick work detailed in table below, should not go beyond the maximum permissible height shown for various thicknesses, subject to the further limitations;

i. The bricks are not less than 9 inches long.
ii. The thickness of external and party walls (i.e. walls separating adjoining building) is not less than 1/16th of the height of the storey in case of ordinary buildings and 1/14th in case of warehouses. The thickness of walls below is increased to a like extent, though any such additional thickness is confined to piers, properly distributed, of which collective width amount to 1/4th of the length of wall.
iii. Thirteen inches and half is the minimum thickness for external party walls of any storey more than 10 feet high.
iv. The thickness of cross walls is 2/3 the thickness of the external party walls but never less than 9 inches9except in case of bricks in cement suitably reinforced with steel). No wall should be considered a cross wall unless it is carried up to the floor of the top most storey and unless in each storey the combined area of openings and recesses is less than 50% of the wall area. Properly bonded cross walls may be considered return walls for determining the length of external or party walls

Materials of which the wall is built	F = Safe pressure in tons per sq.ft	Maximum permissible height for a thickness of				
		9” or 1 brick	13 ½” or 1-½ bricks	18” or 2 bricks	22 ½” or 2-½ bricks	27” or 3 bricks
Brickwork in 1:3 cement mortar	8	25	38	51	..	..
Burnt brick work in lime mortar or lime:cement:sand mortar 1:1:6	4	16	24	32	40	..
Burnt brick work in mud	2 ½	11	17	23	28	34
Sun dried brick in mud	1	6	9	12	15	18

Toothing: The usual method while leaving a brick wall which is to be continued at some future time is to tooth the wall. This consists in leaving alternate stretchers projecting 2 ¼ inches beyond the stretching courses above and below.

b) Raking

The brick work shall be built in uniform layers. No part of the wall during its construction shall rise more than one metre above the general construction level. Parts of wall left at different levels shall be raked back at an angle of 45 degrees or less with the horizontal by setting back 2-1/2 inches at each course, with a maximum of twelve courses, to reduce the possibility and the unsightliness of defects caused by any settlement that may take place in the most recently built portion of the wall. Toothing shall not be permitted as an alternative to racking back. For half brick partition to be keyed into main walls, indents shall be left in the main walls.

c) Other Factors

All pipe fittings and specials, spouts, hold fasts and other fixtures which are required to be built into the walls shall be embedded, as specified, in their correct position as the work proceeds unless otherwise directed by the Engineer-in-Charge.
Top courses of all plinths, parapets, steps and top of walls below floor and roof slabs shall be laid with brick on edge, unless specified otherwise. Brick on edge laid in the top courses

at corner of walls shall be properly radiated and keyed into position to form cut (marrow) corners as specified. Where bricks cannot be cut to the required shape to form cut (marrow) corners, cement concrete 1:2:4 (1 cement :2 coarse sand : 4 graded stone aggregate 20 mm nominal size) equal to thickness of course shall be provided in lieu of cut bricks.

Bricks shall be laid with frog (where provided) up. However, when top course is exposed, bricks shall be laid with frog down. For the bricks to be laid with frog down, the frog shall be filled with mortar before placing the brick in position.

In case of walls one brick thick and under, one face shall be kept even and in proper plane, while the other face may be slightly rough. In case of walls more than one brick thick, both the faces shall be kept even and in proper plane.

To facilitate taking service lines later without excessive cutting of completed work, sleeves shall be provided, where specified, while raising the brick work. Such sleeves in external walls shall be sloped down outward so as to avoid passage of water inside.

Top of the brickwork in coping and sills in external walls shall be slightly tilted. Where brick coping and sills are projecting beyond the face of the wall, drip course/throating shall be provided where indicated.

Care shall be taken during construction that edges of jambs, sills and projections are not damaged in case of rain. New built work shall be covered with gunny bags or tarpaulin so as to prevent the mortar from being washed away. Damage, if any, shall be made good to the satisfaction of the Engineer-in-Charge.

d) Stability

The stability of brickwork is affected in three general ways:

1. By loading a given area of ground beyond its ultimate resistance, by an irregular concentration of great pressures on a soft sub-soil, by the tendency of the sub-stratum to slid or by eccentric loadings, the walls are thrown out of the upright, crack or disintegrate.
2. By bad bonding, resulting in disintegration.
3. By side thrusts which may be distributed or concentrated, and their tendency is to overturn the walls; they are provided for by designing the walls of a sufficient thickness, or by placing buttresses at regular intervals.

11.6.5 JOINTS

The horizontal joints shall be parallel whereas vertical joints in alternative courses shall be directly over one another. The thickness of the vertical joints shall be approximately 6 millimetres and the thickness of horizontal joints shall be 10 millimetres.

Finishing of Joints:

The face of brick work may be finished flush or by pointing. In flush finishing either the face joints of the mortar shall be worked out while still green to give a finished surface flush with the face of the brick work or the joints shall be squarely raked out to a depth of 1 cm while the mortar is still green for subsequently plastering. The faces of brick work shall be cleaned with wire brush so as to remove any splashes of mortar during the course of raising the brick work. In pointing, the joints shall be squarely raked out to a depth of 1.5 cm while the mortar is still green and raked joints shall be brushed to remove dust and loose particles and well wetted, and shall be later refilled with mortar to give ruled finish. Some such finishes are ‘flush’, ‘weathered’, ruled, etc.

11.6.6 CURING

The brick work shall be constantly kept moist on all faces for a minimum period of seven days. Brick work done during the day shall be suitably marked indicating the date on which the work is done so as to keep a watch on the curing period.

11.6.7 SCAFFOLDING

Scaffolding shall be strong to withstand all dead, live and impact loads which are likely to come on them. Scaffolding shall be provided to allow easy approach to every part of the work and safe working.

11.6.8 SINGLE SCAFFOLDING

Where plastering, pointing or any other finishing has been indicated for brick work, single scaffolding may be provided, unless otherwise specified. In single scaffolding, one end of the put-logs/pole shall rest in the hole provided in the header course of brick masonry. Not more than one header for each put-log/pole shall be left out. Such holes shall not be allowed in the case of pillars, brick work less than one metre in length between the openings or near the skew backs of arches or immediately under or near the structural member supported by the walls. The holes for putlogs/poles shall be made good with brick work and wall finishing as specified.

11.6.9 DOUBLE SCAFFOLDING

The brick work or tile work is to be exposed and not to be finished with plastering etc. double scaffolding having two independent supports, clear of the work, shall be provided.

11.6.10 BRICK LAYING IN FREEZING WEATHER

a) PROTECTION OF BRICKS:
All bricks delivered for use in freezing weather shall be fully protected immediately upon delivery by a weather-tight covering that will prevent the accumulation of water, snow or ice on the bricks; loose board covering shall not be permitted.

b) HEATING OF SAND:
All sand shall be heated in such a manner as will remove all frost, ice or excess moisture but will prevent the burning of scorching of the sand.

c) HEATING OF BRICKS:
All frosted bricks shall be defrosted by heating them to a temperature of approximately 180ºF.

d) HEATING OF WATER
All water used shall be heated to a temperature of approximately 180ºF.

e) SLAKING OR SOAKING OF LIME:
All slaking of quick lime or soaking of hydrated lime shall be done at a temperature of at least 60º F and this temperature shall be maintained until lime is incorporated into the mortar.

f) PROTECTION OF MORTAR AGAINST FREEZING:
After the mortar has been mixed it shall be maintained at such temperature as will prevent its freezing at all times and if necessary the contractor shall use metal mortar board equipped with oil torches. No anti-freeze liquid, salt or other substance shall be used in mortar, except when specified or permitted by the Engineer-in-Charge.

g) ENCLOSURES AND ARTIFICIAL HEAT:
All work under construction shall be protected from freezing for a period of 48 hours by means of enclosures, artificial heat or by other suitable methods duly approved by the Engineer-in-Charge.

11.6.11 OPENINGS:

Door and window openings shall have flat or reliving arches or lintels spanning across them as shown in the drawings or as specified.

11.6.12 Centering for all openings shall be strong enough to support the lintels or arches spanning the openings. They shall be subject to the approval of engineer-in charge and shall remaining position till the brick work has set. No additional payment shall me made to contractor for this item of work.

11.6.13 MEASUREMENTS

Brick work shall be measured in cubic metres unless otherwise specified. Any extra work over the specified dimensions shall be ignored. Dimensions shall be measured correct to the nearest 0.01 m i.e. 1 cm. Areas shall be calculated to the nearest 0.01 sq mtrs and the cubic contents shall be worked out to the nearest 0.01 cubic metres.

11.6.13.1 Brick work shall be measured separately in the following stages:

a) From Foundation to Floor one Level (Plinth Level)

b) Plinth (floor one) level to floor two level

c) Between two specified floor levels above floor two level

Note: Brick work in parapet walls, mumty, lift machine room and water tanks constructed on the roof upto 1.2 m height above roof shall be measured together with the corresponding work of the floor next below.

11.6.13.2 No deductions or additions shall be done and no extra payment made for the following:

Note: Where minimum area is defined for deduction of an opening, void or both, such areas shall refer only to opening or void within the space measured.

(a) Ends of dissimilar materials (that is, joists, beams, lintels, posts, girders, rafters, purlins, trusses, corbels, steps, etc.); up to 0.1 m^2 in section;

(b) Opening up to 0.1 m^2 in area (see Note);

(c) Wall plates, bed plates, and bearing of slabs and the like, where thickness does not exceed 10 cm and bearing does not extend over the full thickness of wall;

(d) Cement concrete blocks as for hold fasts and holding down bolts;

(e) Iron fixtures, such as wall ties, pipes upto 300 mm diameter and hold fasts for doors and windows; and

(f) Chases of section not exceeding 50 cm in girth.

(g) Bearing portion of drip course, bearing of moulding and cornice.

Note: In calculating area of an opening, any separate lintel or sills shall be included with the size of the opening but end portions of lintel shall be excluded. Extra width of rebated reveals, if any, shall also be excluded.

11.6.13.3 Walls half brick thick and less shall each be measured separately in ~~square~~ cubic metres ~~stating thickness walls beyond half brick thickness shall be measured in multiples of half brick which shall be deemed to be inclusive of mortar joints~~. For the sizes of bricks, half brick thickness shall mean 115 mm.

Where fractions of half brick occur due to architectural or other reasons, measurement shall be as follows :

(a) upto 1/4th brick-actual measurements and

(b) exceeding 1/4 brick-full half bricks.

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11.6.13.4 String courses, projecting pilasters, aprons, sills and other projections shall be fully described and measured separately in running metres stating dimensions of each projection. Square or rectangular pillars shall be measured separately in cubic metres in multiple of half brick. Circular pillars shall be measured separately in cubic metres as per actual dimensions.

Brick work curved on plan shall be measured like the brick work in straight walls and shall include all cutting and wastage of bricks, tapered vertical joints and use of extra mortar, if any. Brick work curved on plan to a mean radius not exceeding six metres shall be measured separately and extra shall be payable over the rates for brick work in straight walls. Nothing extra shall be payable if the mean radius of the brick work curved in plan exceeds six metres.

Tapered walls shall be measured net as walls and extra payment shall be allowed for making tapered surface for brick work in walls. Brick work with brick tiles shall be measured and paid for separately.

11.6.13.5 RATE

The rate shall include the cost of materials and labour required for all the operations described above except the vertical reinforcement and its encasement in cement mortar or cement concrete. The rate shall also include the following:

(a) Raking out joints or finishing joints flush as the work proceeds;

(b) Preparing tops of existing walls and the like for raising further new brick work. (c) Rough cutting and waste for forming gables, splays at eaves and the like.

(d) Leaving holes for pipes upto 150 mm dia. and encasing hold fasts etc.

(e) Rough cutting and waste for brick work curved in plan and for backing to stone or other types of facing.

(f) Embedding in ends of beams, joists, slabs, lintels, sills, trusses etc.

(g) Bedding wall plates, lintels, sills, roof tiles, corrugated sheets, etc. in or on walls if not covered in respective items and

(h) Leaving chases of section not exceeding 50 cm in girth or 350 sq cm in cross-section.

(i) Brick on edge courses, cut brick corners, splays reveals, cavity walls, brick works curved on plan to a mean radius exceeding six metres.

11.7 BRICK WORK IN ARCHES

The detailed specifications for brick work mentioned in 11.7 shall apply, in so far as these are applicable. Arch work shall include masonry for both gauged as well as plain arches. In gauged arches, cut or moulded bricks shall be used. In plain arches, uncut bricks shall be used.

Brick forming skew-backs shall be dressed or cut so as to give proper radial bearing to the end voussiors. Defects in dressing of bricks shall not be covered by extravagant use of mortar, nor shall the use of chips or bats etc. be permitted. The bricks of the spandrel wall at their junctions with extrudes of the arch shall be cut to fit the curvature of the arch.

11.7.1 CIRCULAR ARCHES

These shall be either (a) plain arches, and shall be built in half brick concentric rings with break joints, or (b) gauged arches built with bricks cut or moulded to proper shape. The arch work shall be carried up from both ends simultaneously and keyed in the centre. The bricks shall be flush with mortar and well pressed into their positions so as to squeeze out a part of their mortar and leave the joints thin and compact. All joints shall be full of mortar and thickness of joints shall not be less than 5 mm nor more than 15 mm.

After the arch is completed, the haunches shall be loaded by filling up the spandrels up to the crown level of the arch. Care shall be taken to load the haunches on two sides of the spandrels.

When the arch face is to be pointed (and not plastered), the face bricks shall be cut to proper shape or moulded, so as to have the joints not more than 5 mm thick. These shall be laid with radial joints to the full depth of the arch. The voussoirs shall break joints to the full depth of the arch.

For gauge arch work, the arch shall be laid out full size on the ground on lime plaster and all joints carefully marked out. Templates shall be then made as a guide for special shapes of bricks; special bricks shall be moulded and burnt. If the amount of work is small they shall confirm in the requirements if the engineer-in charge and shall be carefully cut and rubbed to the required shape. All bricks for as arch shall be prepared in full and set up dry on the ground before the work begins.

11.7.2 FLAT ARCHES

These shall be gauged arches of brick cut or moulded to proper shape. The extrados shall be kept horizontal and the intrados shall be given slight camber of 1 in 100 of the span. The centre of the arch from which joints shall radiate, shall be determined by the point of the inter-section of the two lines drawn from the ends of the arch at the springing level and at 60° to horizontal.

In flat arches, bricks shall be laid with radial joints to the full depth of arch and voussoirs breaking joints with each other. The arch work shall be carried up from both ends simultaneously and keyed in the centre. The thickness of the joints shall not exceed 5 mm. Flat arches may be used for the sake of appearance but for purpose of carrying loads of the wall above, these shall be used in conjunction with relieving arches, lintels placed below.

Segment arches used over rectangular door or window openings shall have a flat rectangular soffit and segmental extrados.

11.7.3 CENTRING AND SHUTTERING

Striking of Centres: The centres shall be struck as noted below,

I. For single segmental arch, centre shall be struck immediately after the arch is finished.
II. For series of segmental arches, centre of each arch shall be struck as soon as the arch is succeeding it is completed.
III. For semi-circular, elliptical or pointed arches, centre shall be struck as soon as brickwork has reached two thirds the height of such arches.

The centring and shuttering for the arch shall be as approved by the Engineer-in-Charge before the arch work is started. It shall be strong enough to bear the dead load of the arch and the live loads that are likely to come upon it during construction, without any appreciable deflections.

The shuttering shall be tightened with hard wood wedged or sand boxes, so that the same could be eased without jerks being transmitted to the arch. The sequence of easing the shuttering shall be as approved from the Engineer-in-Charge. The shuttering shall be struck within 48 hours of the completion of the arch but not before 24 hours. This shall be done after the spandrel has been filled in and the arch loaded.

11.7.4 MEASUREMENT

The length of the arch shall be measured as the mean of the extrados and intrados of the arch correct to a cm. The thickness of the arch shall be measured in multiples of the half brick.

a) The breadth in the direction of the thickness of wall shall be measured as specified.

b) The cubical contents shall be calculated in cubic metre, correct to two places of decimal.

c) For arches exceeding 6 m in spans extra payment shall be made on the actual area of the soffit for additional cost of centring including all strutting, bolting, wedging, easing, striking and its removal.

11.8 BRICK TILE WORK

The work shall be done in the same manner as described in Sub-section 11.7 except that brick tile shall be used instead of bricks. The measurement and rate shall be same as specified under 11.6.13

11.9 HONEY COMB BRICK WORK/PERFORATED BRICK MASONRY

The honeycomb brick work shall be done with specified class of brick, laid in specified mortar. All joints and edges shall be struck flush to give an even surface.

The thickness of the brick honeycomb work shall be half-brick only, unless otherwise specified. Openings shall be equal and alternate with half brick laid with a bearing of 2 cm on either side.

Measurements

The length and height shall be measured correct to a cm. Area shall be calculated in square metres correct to two places of decimal. Honeycomb openings shall not be deducted.

11.10 JOINING OLD BRICK WORK WITH NEW BRICK WORK

In case the height of the bricks of old as well as new work is same, the old work shall be toothed to the full width of the new wall and to the depth of a quarter of brick in alternate courses. In case the height of the bricks is unequal, then the height of each course of new work shall be made equal to the height of the old work by adjusting thickness of horizontal mortar joints in the new wall. Where necessary, adjustment shall be made equal to thickness of old wall by adjusting the thickness of vertical joints. For joining new cross wall to old main walls, a number of rectangular recesses of width equal to the thickness of cross wall, three courses in height and half a brick in depth shall be cut in the main walls. A space of three courses shall be left between two consecutive recesses. The new cross wall shall be bonded into the recesses to avoid any settlement. Joining of old brick work with the new brick work shall be done in such a way that there shall not be any hump or projection at the joint.

Measurements

The height and thickness of vertical face in contact with new work shall be measured to the nearest 0.01 m and the area shall be calculated to the nearest 0.01 sqm.

11.10.1 MOULDING AND CORNICES

The specifications described under 11.7 shall apply in so far these are applicable. Mouldings and cornices shall be made with bricks as specified for brick work. The bricks shall be cut and dressed to the required shape as shown in the architectural drawings.

Cornices shall not ordinarily project by more than 15 cm to 20 cm and this projection shall be obtained by projecting each brick course by more than one fourth of the length. For cornices projecting more than 20 cm and requiring more than quarter bricks projection, metal cramps shall be used and paid for separately. Corbelling shall be brought roughly to shape by plastering with the specified mortar. When the mortar is still green, the mouldings shall be finished straight and true with the help of metal templates. Thickness of plaster shall not be less than half an inch and more than one inch

11.10.2 CURING AND PROTECTION

The mouldings and cornices shall be cured for at least seven days. These shall be protected from the effects of sun and rain by suitable covering and also from damage during the execution of the work.

Measurements

For the purpose of measurements, the sectional periphery of mouldings and cornices (excluding the portion in contact with wall) shall be measured in centimetres and length in metres (fig. below). The girth and length shall be measured correct to a cm. No deduction shall be made from the masonry of wall for the bearing of the moulding and cornices.

11.11 EXPOSED BRICK WORK

11.11.1 FACING BRICKS

The facing bricks made from suitable soils shall be free from cracks, flaws, nodules of free lime warp age and organic matter. These shall be thoroughly burnt and shall have plane rectangular faces with parallel sides and sharp straight right angled edges. Facing bricks shall have uniform colour and even texture. Unless otherwise specified, facing bricks shall be machine moulded only. As far as possible, total requirement of facing bricks for a work shall be arranged from the same kiln. Bricks with chipped edges and broken corners shall not be used.

Facing bricks shall be of 1st class unless otherwise specified, water absorption shall not exceed 20 per cent by weight and efflorescence rating shall be nil. Mortar, Soaking of Bricks and laying shall be as specified in Para 11.7.2, 11.7.3 and 11.7.4 respectively.

Joints in the exposed brick work shall be truly horizontal and vertical and kept uniform with the help of wooden or steel strips. The thickness of joints shall be as per 11.6.5~~11.6.5~~. scaffolding shall be as specified in 11.6.6~~11.6.6~~ and 11.6.7~~11.6.7~~ respectively.

11.11.2 MEASUREMENT

The measurement and rate shall be same as specified under 11.6.13

11.11.3 RATES

The rates shall be as specified in 11.6.13 and shall also include the following :

(a) Labour for selecting bricks and wastage of bricks where use of selected hand moulded brick is specified.

(b) Leaving uniform horizontal and vertical grooves of specified depth and providing joints of required thickness using wooden or steel strips as the work proceeds.

11.11.4 FURTHER REQUIREMENTS

All face work shall be finished with neatly drawn joints and pointed if it has not to be plastered. If it has to be plastered, the joints shall be raked out before any plaster is laid on. The raking shall be done with a hook to a depth of 13mm before the mortar sets each day. Where pointing or plastering to the face work is not provided as a separate item, the joints in the face work shall be struck. For face work, the bricks shall be of true edges, uniform colour and correct dimensions. If specially required, face work shall be laid up with pressed bricks. All brick courses shall be so proportioned that they will work out evenly with the height of the windows and doors. Backing of the pressed brickwork shall be done as per specifications for brickwork, or as specifically directed by the Engineer-in-Charge.

a) Steel reinforcement and steel ties, if any, shall be provided and installed as indicated on the Drawings or directed by the Engineer-in-Charge.
b) Openings or chases shall be provided in the brickwork as shown on the Drawings or required by the Engineer-in-Charge.
c) If, after the completion of any brickwork, brick is out of alignment or level, or does not conform to the lines and grades shown on the Drawings, or shows a defective surface, it shall be removed and replaced by the Contractor at his expense unless the Engineer-in-Charge grants permission, in writing, to patch or replace the defective area.

11.12 CAVITY WALL

11.12.1 GENERAL

It is a wall comprising of two leaves, each leaf being built of masonry units and separated by a cavity so as to provide an air space within the wall and tied together with metal ties or bonding units to ensure that two leaves act as one structural unit. The width of the cavity shall not be less than 50 mm and not more than 115 mm. Each leaf of the cavity wall shall not be less than 75 mm. The space between the leaves either left as cavity or filled with non-load bearing insulating and water proofing material.

11.12.2 MATERIALS

The bricks shall be first class bricks specified in this Section. The mortar shall be cement sand mortar as specified in accordance with the provisions of Sub-section 11.6.2 (B).

The laying of bricks masonry for cavity walls shall comply with provisions of Sub-sections 11.7.3 & 11.7.4. Curing and scaffolding shall be as per Sections 11.6.6 & 11.6.7.

11.12.3 METAL TIES

These may be of galvanised iron, wrought iron, gun metal, brass, copper, stainless steel or any such corrosion resistant metal, made of flats 20 x 5 mm cranked or twisted at their mid-point with ends split and fish tailed. The ties shall be built into horizontal bed joints during erection, placed sloping towards the exterior side to prevent water from flowing along it from outer to inner leaf side.

11.12.4 BONDING UNITS

Length of the Bonding units will be sum of thickness of both leaves plus width of cavity if the leaves are 75 mm or 115 mm. If the leaves are more than 115 mm thick, then the length of a unit will be [(2 ×115) + width of cavity].

Cement concrete used in the bonding units shall not be leaner than 1:3:6 (1 cement : 3 sand :6 aggregate 20 mm nominal size).

11.12.5 SPACING

Metal ties/bonding units shall be spaced not more than 90 cm apart horizontally and 45 cm vertically and staggered in each course. Additional ties shall be used near openings.

11.12.6 RESTRICTIONS

Cavity walls shall not normally be built more than 7.5 metres in height and 9 metres in length. Where large lengths and heights are desired, the wall shall be divided into panels with strengthening measures such as pillars etc. Cavity shall be covered at the top with at least two courses of masonry unit and/or a coping over it.

Adoption of cavity walls is not recommended when heavy concentrated load from beam etc. are to be supported by walls.

11.12.7 MEASUREMENTS AND RATE

(a) Brick work in cavity walls shall be included and measured with general brick work. The width of the cavity shall not be measured. Skin of cavity wall, half brick thickness shall be measured as and paid as described in 11.6.13.

(b) The forming of the cavity shall be given in square metres stating the width of the cavity and shall include the metal ties/bonding unit specifying the numbers per square metre.

(c) Labour and material for closing cavities at the jambs, sills and heads of opening shall be as described and measured separately in running metres.

(d) The item shall include use of device for keeping cavity clear and forming the requisite weep and vent holes and nothing extra on this account shall be payable

11.13 REINFORCED BRICK MASONRY

11.13.1 GENERAL

Reinforced brick masonry shall be constructed as specified and shown on drawings.

11.13.2 BRICKWORK

Brickwork shall be as specified and conform with the provision for construction of brickwork of this section. The mortar shall be cement sand mortar as specified and shall conform with the provision of Clause 11.6.2(Bi).

11.13.3 REINFORCEMENT

The reinforcement for brick masonry could be 18 gauge hoop irons or mild steel bars as specified. The hoop iron shall be of best quality as approved by the Engineer-in-Charge. Mild steel reinforcement shall comply with the provisions of Section 5 – Plain & Reinforced Concrete. Unless otherwise specified in drawings or schedule of quantities, the reinforcement for normal structures shall be as follows;

Wall Thickness (Inches)	Horizontal Bars (9-5/8”) C/C	Vertical Bars (24”) C/C
7 – ½	3/8” dia	3/8” dia
9	3/8” dia	½”
11	½”	½”
12	½”	½”

Refer to the drawings for others wall thickness and special details

a) Vertical reinforcement at jambs of opening and at ends of walls shall be doubled. Horizontal reinforcement above and below all openings shall also be doubled.

b) Reinforcement shall be continuous. Bars may be furnished in any convenient length. All splices shall be lapped at least 14” for 3/8” diameter bars and at least 18” for ½” diameter bars and horizontal reinforcement shall be bent around corners.

11.13.4 SCAFFOLDING & CURING

The scaffolding & curing shall conform to applicable provisions of Section 11.7.6, 11.7.7, 11.7.8, and 11.7.9.

11.13.5 MEASUREMENT

The measurement and rate shall be same as specified under 11.6.13

11.14 BRICK EDGING

The edging shall be of bricks of class specified in the item. The specifications of bricks shall be as described in 11.4~~11.4~~. Trenches of required depth and width shall first be made along edge of the plinth protection to receive the bricks for edging. The bed of trenches shall be compacted to a firm and even surface. The brick shall be laid true to line in cement mortar 1:4 (1 cement: 4 fine sand) with length parallel and butting the plinth protection. The top face of the brick edging shall be in one level to conform to the finished level of the plinth protection adjacent to the edging. After the concreting is done, no portion of the brick edging shall project above the adjacent concrete surface. Cement mortar shall conform to the specification described in Sub-section 11.6.2 (B).

11.14.1 MEASUREMENT

The brick edging shall be measured in running metre correct a cm.

11.15 BRICKWORK IN COPING

11.15.1 SCOPE

While in all respects it shall conform to the requirements for Brick Construction specified hereof, following special requirements shall also be met with, except when it is specially modified by the Engineer-in-Charge.

The top course of all plinth, parapets, steps etc. shall be built in brick on edge. In case of parapet walls the outside half brick shall be weathered and throated. The corners shall be made by cutting fine bricks or by special bricks of 9 inches x 9 inches x 4-1/2 inches (225mm x 225mm x 110mm) size to give a radiated and keyed joints.

11.15.2 MEASUREMENT

The measurement and rate shall be same as specified under 11.6.13

11.16 SUN-DRIED BRICK WORK IN MUD MORTAR

11.16.1 SCOPE

In this case, sun-dried bricks i.e. unburned bricks shall be used. Any defect in uniformity and shape shall not be such as to cause difficulty in obtaining uniform courses with their use. For all other purposes, stipulations and requirements for laying brick work shall be relied.

Brick used for sun dried brick work shall be dry. The contractor shall protect the work from the effects of rain and water till it is roofed and plastered.

11.16.2 MEASUREMENT

The measurement and rate shall be same as specified under 11.6.13

11.17 BRICK MASONRY WITH FIRE CLAY BRICKS AND ALUMINA CEMENT (VITRIFIED MORTAR)

11.17.1 SCOPE

All brickwork required to be constructed under these specifications and for all related purposes or as may be required by the Engineer-in-Charge shall consist of following special materials instead of those prescribed under theses specifications. However, other materials, methods of their proportioning, mixing, forming and placing as well as the stipulations and other requirements shall conform to specifications given under sub-sections 11.7.4 except when any stipulations and requirements are specially modified by the Engineer-in-Charge for any particular occasion. In case, fire clay brickwork is required in arches they shall also conform to specifications 11.8 “Brick Work in Arches”.

11.17.2 MATERIALS

a) Bricks

Only fire clay bricks of specified sizes of approved specifications/approved brands shall be used. These shall also meet the tests specified for them.

b) Cement

Special alumina cement shall conform to BS 915.

c) Sand

Sand required for the mortar shall be produced from crushed fire bricks graded as sand in conformity with Specifications laid down for sand in the sub-section 11.6.2.

11.17.3 MEASUREMENT

The measurement and rate shall be same as specified under 11.6.13

11.18 GHILAFI BRICKWORK

11.18.1 SCOPE

The ghilafi brickwork shall consist of first class brickwork laid in mud mortar at the outer face and the balance work shall be executed in sun dried bricks laid on mud mortar on the inner side conforming to provisions of Sub-section 11.18.

The unit rate for brick work on labour rate basis shall include the cost of carrying out brick work, cutting bricks, whenever required and curing and protecting as per specifications. It shall also include the cost of using and removing scaffolding, shuttering, centering staging, ladders, supports and other tools and plants required for carrying out brick work as per specifications.

The unit rate shall include the cost of pucca bricks, sun-dried bricks, mud mortar and any other material required, in addition to the labour rates.

11.18.2 MEASUREMENT

The measurement and rate shall be same as specified under 11.6.13

11.19 KACHA WALL/PISE WALLING

11.19.1 SCOPE

Kacha wall shall either be of mud walling or Pise walling type as specified.

11.19.2 BUILDING OF KACHA WALLS/PISE WALLING

a) Mud walling shall be constructed from the fifth class clay bricks conforming to Sub-Section 11.4.

Mud walling shall be constructed from the slope moulded clay bricks od size convenient to be handled. Bricks shall be used while moist and shall be placed without any mud mortar in joints.

b) Pise walling shall be made by laying mud in 8 Cms. to 15 Cms (3”- 6”) thick layers and tightly rammed between two parallel boards which from the front and back face of the wall. As soon as the space between boards is completely filling the same shall be moved to the next length and so on till the whole is complete.

11.19.3 MEASUREMENT

The measurement and rate shall be same as specified under 11.6.13

11.20 PARTATIONS WALLS

11.20.1 GENERAL

Brick masonry partition walls shall be one brick thick either flat or on edge.

11.20.2 HOOP IRON

In case the partition walls are to be reinforced, it shall be down with 1” wide, 18” gauge hoop iron placed in course not more than 12” apart and continued for 9” into the main wall on which the partition wall abuts. In case the length of the wall exceed 20 feet or the height exceed 15 feet hoop iron shall be introduced at course not more than 6” apart. M.S bars may also be provided in place of hoop iron as specified.

11.20.3 BRICKS

Bricks used for construction of partition walls shall confirm to the specifications under sub-section 11.4 to 11.6.

11.20.4 MORTAR

The partition walls shall be set in cement mortar not less than 1:3 proportions unless otherwise specified.

11.20.5 SOAKING OF BRICKS

Soaking of bricks shall confirm to the specification under sub-section 11.7.3

11.20.6 WORKMANSHIP

Workmanship in the partition walls is to be the best quality as due to the small thickness of walls great care is to be taken. The total height of the wall in one day shall not exceed 4 feet.

11.20.7 CURING

Curing shall be carried out in the manner as detailed in sub-section 11.7.6

11.20.8 MEASUREMENT

The measurement and rate shall be same as specified under 11.6.13

11.20.9 METHOD OF BONDING WITH RCC FRAME

All brick masonry walls shall be bonded with the column of the R.C.C frame by providing ¼” dia. Reinforcement protruding out of the column at every 12”. The length of the bonding bars shall not be less than 12” with a hook of 1” dia. at the end and allowed to extend out through the holes provided in the form works for the column.

11.21 CONSTRUCTION WITH SEISMIC CONSIDERATIONS

A. General

Foundation of a building is the part of the building below the ground level. The purpose of the foundations is to transfer the load of the construction to the ground. The weight of the structure must be suited to the load capacity of the ground which in turn shall be stable. The structure must also be correctly joined and anchored to the foundations. Generally stepped strip footing should be adopted for load bearing wall construction.

B. Width of foundation: The width of foundation should be sufficient so that soil is able to bear the weight of the building without excessive settlement. If the foundation soil is soft, the width of foundation should be more. Similarly, if the building weight is more, the foundation should have a greater width. A minimum width of 2’-6” is suggested for single storey construction.

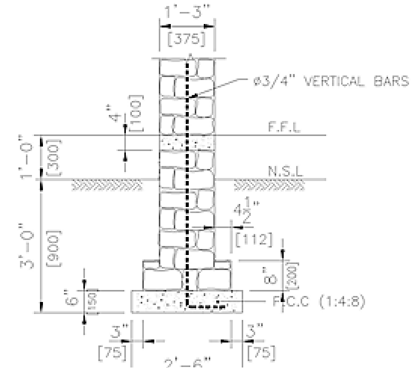
C. Materials of foundation: Mud or mud bricks are not strong enough to resist earthquake forces at the foundation level. It is recommended that the foundation should be preferably built by using dressed stones, burnt clay bricks or concrete blocks. A 3” to 6” thick pad of lean concrete shall be provided under the foundation. The concrete mix proportions for this pad shall be 1:4:8 (one part cement, four parts sand and eight parts crushed aggregates).

D. Depth of foundation: The depth of foundation below existing ground level should be at least 3'-0" for soft soil. For Rocky ground the depth of footing may be reduced to about 1'-6".

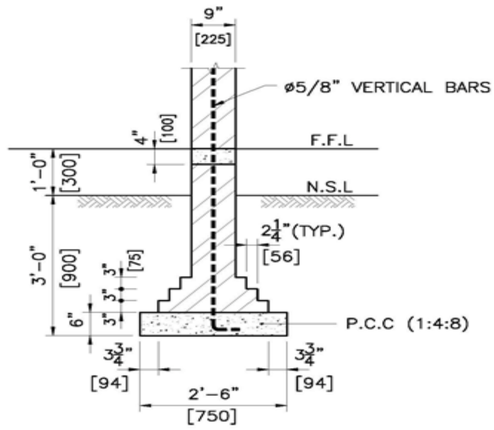
E. Typical Foundations

The following figures present suggested foundation details for stone masonry, brick masonry and concrete block masonry load bearing walls for single storey construction. For double storey construction the width shall be increased by one foot (1 Ft). The depth of foundation shall be reduced for rocky grounds.

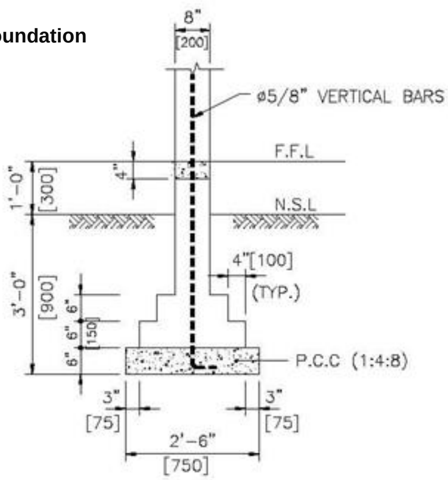
i. Stone Masonry Foundation



ii. Brick Masonry Foundation



iii. Concrete Block Masonry Foundation



In case of loose soil, provide some nominal reinforcement in foundation bed concrete.
If stone soling is used under foundation reduce the thickness of foundation strip to 3”.
The vertical steel bars indicated in the foundations are to be provided at corners and junction of walls.

F. Plinth Masonry

Recommended Construction: The plinth masonry should preferably be constructed using stone or burnt bricks laid in cement mortar. Cement mortar or lime mortar is stronger than mud mortar in binding the stones or bricks in the wall together to resist earthquake forces.

Height of Plinth: The height of the plinth should be above the flood water line or a minimum of 300 mm (1 ft) above ground level. Wherever possible the height of plinth shall not be more than 2’-6”. Where higher plinths are required the thickness of walls below plinth shall be increased.

Waterproofing and Drainage: Water makes the foundation soil weak. In an area that experiences rainfall or snowfall, it is recommended to use a waterproofing layer at the plinth level before starting the construction of wall above the plinth and provide an apron and drain around the house to prevent runoff water that might wet walls or enter the foundation

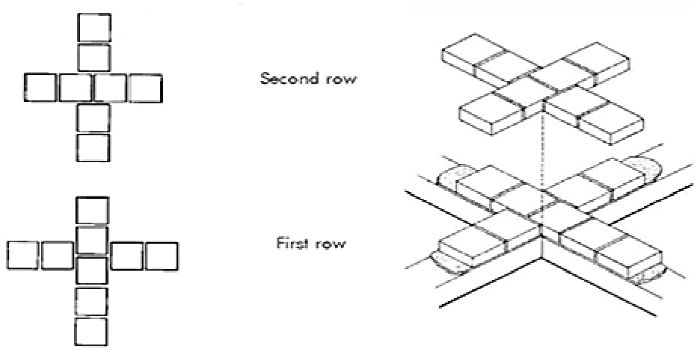
G. Walls

Although a lot of wall construction materials are available, however, one goal of this guideline is to promote local materials:

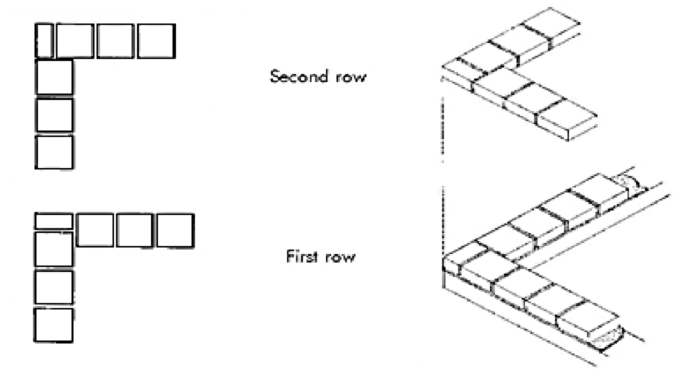
i. Concrete
ii. Blocks/bricks/dressed stones
iii. Brick that are over burnt, under burnt and deformed shall not be used.
iv. Quarry stones that are solid with no obvious fractures shall be used.
v. Boulder stone shall never be used in its natural shape. These boulders should be dressed or semi-dressed before they are laid. Small boulder stones up to 6” may be used by casting them in the shape of large concrete block.
vi. Solid block (concrete or stone) shall be of regular shape, preferably free from broken edges, any type of deformation and cracks. Normal acceptable mix is 1:3:6 (cement: sand: 10 mm down coarse aggregates). Curing of these units for a minimum of seven days shall be done.

H. Patterns for Brick Placing

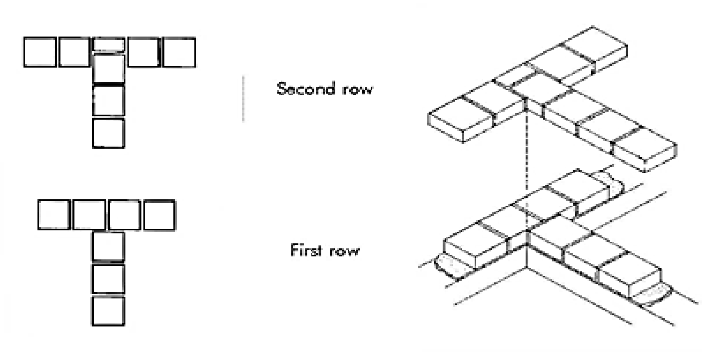
BONDING SIMPLE WALLS



+ shaped walls bonding, bonding of the first and second rows



L-shaped walls bonding, bonding of the first and second rows



T-shaped walls bonding, bonding of the first and second rows

I. Joints

All joints should be raked and faces of wall cleaned at the end of each day's work.
On faces to be plastered, joints shall be raked to 20 mm depth.
Vertical joints of consecutive course should not come directly over one another. Mortar joints shall have uniform thickness and should not exceed 6mm (1/4") and should be fully filled with mortar.

Brick must be lightly mortared on side before laying. Dry or butt joints shall not be used or made.

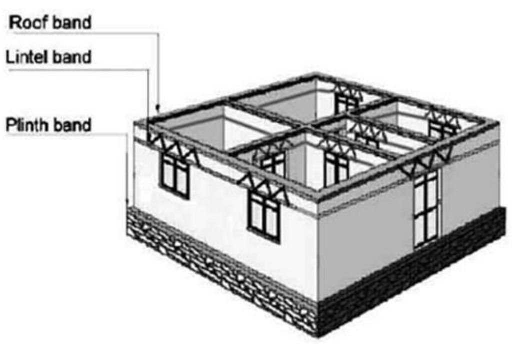
J. Seismic Strengthening Measures

Horizontal Seismic Band: Horizontal seismic bands should be provided at different levels of a wall. A seismic band should be continuous beam that binds, reinforces and makes all parts of the wall at the level of the band to act together. The seismic bands should be provided at three levels. These bands should be well bonded together at the corners.

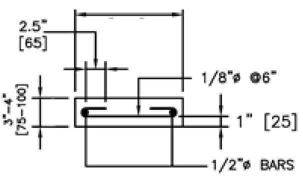
Plinth Band: Plinth seismic band is provided at the plinth level. Where a stone plinth or burnt-brick plinth is constructed, a reinforced concrete plinth band may be used. In that case a separate damp proof course will not be necessary. Plinth band is necessary in a building that is resting on soft soil foundation.

Lintel Band: Lintel seismic band should be provided at the top level of doors and windows, monolithic with the lintels of doors and windows. The lintel seismic band shall be made of reinforced concrete. When the height of the wall is not more than
2.5 m, the lintel band may be merged with roof band.

Roof band: Roof seismic band or ceiling seismic band should be provided just below the roof. This reinforced concrete band will also serve as wall plate for supporting the roof wooden logs or joists, which should be nailed / spiked to this band for ensuring their stability during earthquakes.

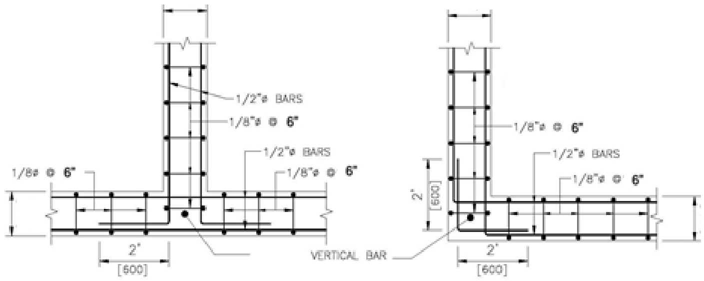


Details of Horizontal Seismic Bands at Plinth/Lintel & Roof Level
The horizontal seismic bands in stone/concrete block or brick masonry walls should be provided using R.C.C 1:2:4 as under



Typical Seismic Band

Details at Corners and T-junctions for Seismic Bands:
The following pattern of steel bars shall be adopted at corners and T-junctions for seismic bands. Seismic bands at the corners and T-junctions must be provided with the following details



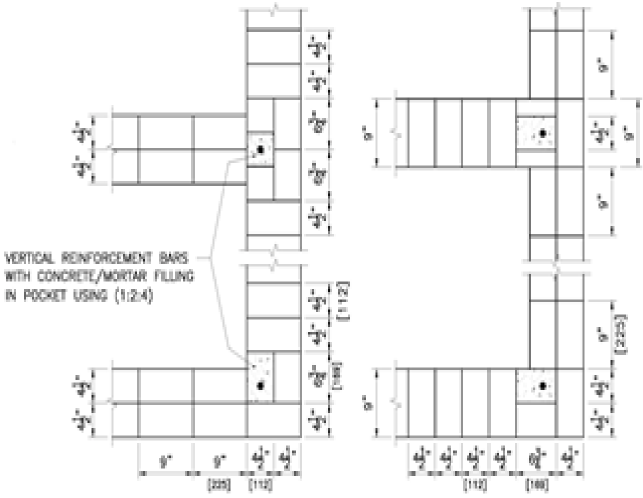
DETAIL OF REINFORCEMENT
AT T JUNCTION OF SEISMIC BANDS

DETAIL OF REINFORCEMENT
AT CORNER OF SEISMIC BANDS

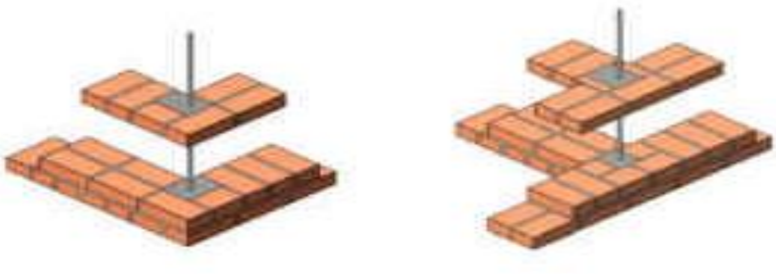
In addition to horizontal seismic bands steel dowels shall be placed at corners and junctions at a vertical spacing of 18” to 24”. The dowels shall comprise 2 Nos. 3/8” ø, 3ft - 4 ft (900-1200) long steel bars with 1/8” ø ties at 6” apart. Expanded metal mesh may also be used in place of steel bars and ties. If room sizes are small, dowel bars may be made continuous

Vertical Wall Reinforcements

Vertical reinforcement, in the form of 5/8” F or min. ½” F bars for brick and concrete block masonry and ¾” F or min 5/8” F bars for stone masonry, shall be provided at corners, junctions and around large openings. Details for incorporating these bars in the masonry are shown in the following figures.



DETAIL OF VERTICAL STEEL BARS
IN BRICK MASONRY



JOINT DETAILS WITH THE VERTICAL REINFORCEMENT
AT CORNER OF BRICK MASONRY WALLS

11.22 MEASUREMENT AND PAYMENT

11.22.1 COMPOSITE RATE

The measurement and payment for the items of the work of Brickwork hereof shall be made corresponding to the applicable CSR items as provided in Contract Agreement and shall constitute full compensation, for procurement, transportation, performance in all respects and completion of work as specified including the site clearance as approved by the Engineer-in-Charge. No deduction shall be made for openings having superficial area of one square foot or less.

11.22.2 LABOUR RATE

The measurement and payment for the items of the work of Brickwork hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurement transportation, performance in all respects and completion of work as specified including site clearance, as approved by the Engineer-in-Charge except the cost of materials to be provided by Department at designated location as defined in the Contract Agreement.

The unit rate (on labour rate basis) for brick work shall include the cost of carrying out brick work, cutting bricks whenever required, curing and protecting, as per specifications. It shall further include the cost of providing, using and removing scaffolding, shuttering, cantering, staging, ladders, supports and other tools and plants required to carry out brick work as per specifications.

11.22.3 COMPOSITE RATE

The unit rate shall include the cost of bricks, mortar and any other material required, in addition to the labour rate detailed above.

11.22.4 EAVE BRICKWORK

Eave bricks shall be laid flat or on edge as specified with a projection of 3 inches and chamfered 1-1/2 inches on the upper edge. It shall be measured by length with unit of measurement as running foot.

11.22.5 BRICKWORK IN REIBMURSEMENT TO DRAIN

Bricks shall be laid flat or on edge as shown on drawings or specified. Each brick shall be set on layer of at least 1/4inch mortar with vertical joints filled with mortar and bedded in by tapping with the handle of trowel. The width of the reimbursement shall be 9 inches and shall be constructed on sides of the roads sloping towards the drain; the slope shall be 1/8 of an inch in 9 inches. Cut and dressed bricks shall be laid in imbursement for laying narrow strips in width along sides of drain, for all curves, bends, slopes, change of slopes and irregular

areas. No extra amount shall be paid for any difficulty or complicated items required during execution.
The thickness of joint shall not be less than ¼ of an inch and not more than 3/8 of an inch. All joints between bricks and along outer end and inner side of reimbursement shall be completely filled with mortar and struck.
The base concrete shall be of specified thickness. All strips, sides and narrow width areas shall be filled with dry bricks on edge or flat.

11.22.6 BRICKWORK IN TEGA TO DRAINS

Bricks shall be laid on 3 inches or 4-1/2 inches in thickness as specified on a bed not less than ¼ of an inch and not more than 3/8 of an inch thick. All external surface joints shall be struck.

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12. STONE MASONRY

SCOPE

It shall cover all stone masonry for use in foundation and plinth; superstructures and walls etc. as shown on the drawings and such other uses as may be specified or directed by the Engineer-in-Charge. The dressing of stones and use of mortar together with its ingredients and proportions shall be specified or directed by the Engineer-in-Charge. Materials used shall conform to stipulations and requirements herein set forth except when such stipulations and requirements are specifically modified by the Engineer-in-Charge for any particular item of work.

The scope shall, however, include furnishing all labor, materials, plant, equipment, scaffolding, staging, ladders, instruments and accessories; and all services necessary to complete the work which shall be finished in a workman like manner true to dimensions and grades shown on the Drawings.

12.1 RANDOM RUBBLE STONE MASONRY

12.1.1. STONE

The stone shall be of the type specified such as granite, trap, limestone, sand stone, quartzite, etc. and shall be obtained from the quarries (referred to constructional material sources study report), approved by the Engineer-in-Charge. Stone shall be hard, sound, durable and free from weathering decay and defects like cavities, cracks, flaws, sand holes, injurious veins, patches of loose or soft materials and other similar defects that may adversely affect its strength and appearance. As far as possible, stones shall be of uniform color, quality or texture. Generally stone shall not contain crypts crystalline silica or chart, mica and other deleterious materials like iron-oxide organic impurities etc. Stones with round surface shall not be used.

The compressive strength of common types of stones shall be as per Table 12.1 and the percentage of water absorption shall generally not exceed 5% for stones other than specified in Table 12.1. For laterite this percentage is 12%.

TABLE 12.1

Type of Stone	Weight (lbs/cft)	Maximum Water Absorption Percentage by weight	Minimum Compressive Strength kg./sq.cm.
Granite	165	0.5	1000
Basalt	225	0.5	400
Lime stone (Slab &Tiles)	160	0.15	200
Sand stone(Slab & Tiles)	140	2.5	300
Marble	170	0.4	500
Quartzite	225	0.4	800
Laterite (Block)		12	35

A. Size Of Stones

Normally stones used should be small enough to be-lifted and placed by hand. Unless otherwise indicated, the length of stones for stone masonry shall not exceed three times the height and the breadth on base shall not be greater than three-fourth of the thickness of wall, or not less than 150 mm. The height of stone for rubble masonry may be up-to 300 mm.

The selection and grading of stones for rubble masonry is largely done at site and the smaller stones are used in the hearting of wall.

B. Dressing

Each stone shall be hammer dressed on the face, the sides and the beds. Hammer dressing shall enable the stones to be laid close to neighboring stones such that the bushing in the face shall not project more than 40 mm on the exposed face.

(i) **Face stone:**

At least 25% stones shall be headers tailing into the work at least 2/3rd the thickness of wall in super structure masonry. Such stones shall not be less than 200 sq. cm in cross sections.

(ii) **Hearting Stones:**

The hearting or interior filling of a wall face shall consist of rubble stones not less than 150 mm in any direction, carefully laid, hammered down with a wooden mallet into position and solidly bedded in mortar. The hearting should be laid nearly level with facing and backing.

(iii) **Quoin Stone:**

Quoin stone shall be less than 0.03 cum in volume.

(iv) **Jamb stones:**

The jambs shall not be made with stones specified for quoins except that the stones which were required to be provided at 1 meter centre to centre on both the exposed faces shall be provided only on the jamb and the length shall be equal to the thickness of the wall for wall up to 60 cm and a line of headers shall be provided for walls thicker than 60 cm as specified for bond.

(v) **Courses and Thickness of Joints**

Courses:

The masonry shall be carried out in regular courses of height not exceeding 50 cm and masonry on any day will not be raised more than 60 cm in height when using mortars having compressive strength less than 20 kg./sq. cm at 28 days and 100 cm when using mortars exceeding this strength.

Thickness of Joints:

The joint thickness shall not exceed 30 mm at any point on the face. Chips of the stone and spalls shall be wedged into seating bed of face stones to avoid excessive bed thickness. No pinning shall be allowed to avoid excessive joint thickness.

12.1.2. MORTAR

The mortar used for joining shall be as specified complying with applicable provisions of cement mortar Section-11 Brickwork.

12.1.3. LAYING

a) Stone shall be laid on their natural bed and shall be solidly bedded full in mortar with close joints, chips of stone spalls be wedged into the work wherever necessary. No dry work or hollow spaces shall be allowed and every stone whether large or small shall be carefully selected to fit snugly the interstices between the large stones. Masonry shall be built breaking joints in all the three directions. Bond stone and headers shall be properly laid into the work and shall be marked by the contractor with white lead paint. The bond stones shall be provided as specified in para. The masonry work in wall shall be carried up true to plumb or to specified batter.

Random rubble masonry shall be brought to the level courses at plinth, window sills, lintel and roof levels. Leveling shall be done with concrete comprising of one part of the mortar as used for masonry and two parts of graded stone aggregate of 20 mm nominal size.

The masonry in structure shall be carried uniformly. Where the masonry of one part is to be delayed, the work shall be raked back at an angle not steeper than 45°.

Raking out joints

All the joints on the faces to be pointed or plastered shall be raked out with raking tool to a depth of 20mm while the mortar is still green.

b) The stone masonry in freezing weather shall comply with all the requirements of brickwork for the same conditions as specified in Sub-section 11.7.10 – Brickwork.

12.1.4. BOND STONES

Though bond stones shall be provided in walls up-to 600 mm thickness, a set of two or more bond stones overlapping each other by at least 150 mm shall be provided in a line from face to back as shown on Drawings and approved by the Engineer-in-Charge. In case of highly absorbent types of stones (porous lime stone and sand stone etc.) the bond stone shall extend about two-third into the wall, as through stones in such walls a set of two or more bond stones overlapping each other by at least 150 mm shall be provided. Each bond stone or a set of bond stones shall be provided for every 0.5 m^2 of the wall surface and shall be provided at 1.5 m to 1.8 m apart clear in every course.

In case of highly absorbent types of stones (porous lime stone and sand stone etc.) single piece bond stones may give rise to dampness. For all thicknesses of such walls a set of two or more bond stones overlapping each other by at least 15 cm shall be provided. Length of each such bond stone shall not be less than two-third of the thickness of the wall.

Where bond stones of suitable lengths are not available pre-cast cement concrete block of 1:3:6 mix(1 cement : 3 coarse sand: 6 graded stone aggregate 20 mm nominal size) of cross section not less than 225 square centimeters and length equal to the thickness shall be provided.

At least one bond stone or a set of bond stones shall be provided at 1.5 m to 1.8 m apart clear in every course. (Bond stones shall be marked suitably with paint as directed by the Engineer-in-Charge).

12.1.5. QUOIN AND JAMB STONES

The quoin and jamb stones shall be of selected stones neatly dressed with hammer or chisel to form the required angle. Quoin stones shall not be less than 0.01 cum in volume. Height of quoins and jamb stones shall not be less than 15 cm. Quoins shall be laid header and stretcher alternatively.

12.1.6. JOINTS

Stones shall be so laid that all joints are fully packed with mortar and chips. Face joints shall not be more than 20 mm thick.

The joints shall be struck flush and finished at the time of laying when plastering or pointing is not to be done. For the surfaces to be plastered or pointed, the joints shall be raked to a minimum depth of 20 mm when the mortar is still green.

12.1.7. SCAFFOLDING

Single scaffolding having one set of vertical support shall be allowed. The supports shall be sound and strong, tied together by horizontal pieces, over which the scaffolding planks shall be fixed. The inner end of the horizontal scaffolding member may rest in a hole provided in the masonry. Such holes, however, shall not be allowed in pillars fewer than one meter in width or near the skew back of arches. The holes left in masonry work for supporting scaffolding shall be filled and made good with 1:3:6 cement concrete (1 cement : 3 sand : 6 stone aggregate 20 mm nominal size).

12.1.8. CURING

Masonry work in cement mortar shall be kept constantly moist on all faces for a minimum period of seven days.

12.1.9. PROTECTION

Green work shall be protected from rain by suitable covering. The work shall also be suitably protected from damage, mortar dropping and rain during construction.

12.1.10. MEASUREMENTS

The length, height and thickness shall be measured correct to a cm. The thickness of wall shall be measured at joints excluding the bushing. Only specified dimensions shall be allowed;

anything extra shall be ignored. The quantity shall be calculated in cubic metre nearest to two places of decimal.

The work under the following categories shall be measured separately.

a. from foundation to plinth level (level one)
b. work in or under water and or liquid mud,
c. work in or under foul positions.

(i) Above plinth level and upto floor five level.

(ii) Above floor five level to every floor/floors or part thereof.

(iii) Stone masonry in parapet shall be measured together with the corresponding item in the wall of the storey next below.

12.1.10.1 No deduction shall be made nor extra payment made for the following:

(i) Ends of dissimilar materials (that is joists, beams, lintels, posts, girders, rafters purlins, trusses, corbels, steps etc.) upto 0.1 sqm in section.

(ii) Openings each upto 0.1 sqm in area. In calculating the area of openings, any separate lintels or sills shall be included alongwith the size of opening but the end portions of the lintels shall be excluded and the extra width of rebated reveals, if any, shall also be excluded.

(iii) Wall plates and bed plates, and bearing of shades and the like, where the thickness does not

exceed 10 cm and the bearing does not extend over the full thickness of the wall.

Note: The bearing of floor and roof shall be deducted from wall masonry.

(iv) Drain holes and recesses for cement concrete blocks to embed hold fasts for doors, windows etc.

(v) Building in masonry, iron fixture, pipes upto 300 mm dia, hold fasts of doors and windows etc.

(vi) Forming chases in masonry each upto section of 350 sq cm.

Masonry (excluding fixing brick work) in chimney breasts with smoke of air flues not exceeding 20 sq dm (0.20 sq m) in sectional area shall be measured as solid and no extra payment shall be made for pargetting and coring such flues. Where flues exceed 20 sq dm (0.20 sq m) sectional area, deduction shall be made for the same and pargetting and coring flues shall be measured in running metres stating size of flues and paid for separately. Aperture for fire place shall not be deducted and no extra payment made for splaying of jambs and throating.

Apertures for fire places shall not be deducted and extra labour shall not be measured for splaying of jambs, throating and making arch to support the opening.

Square or Rectangular Pillars: These shall be measured as walls, but extra payment shall be allowed for stone work in square or rectangular pillars over the rate for stone work in walls. Rectangular pillar shall mean a detached masonry support rectangular in section, such that its breadth does not exceed two and a half times the thickness.

Circular Pillars (Columns): These shall be measured as per actual dimensions, but extra payment shall be allowed for stone work in circular pillars over the rate for stone work in walls. The diameter as well as length shall be measured correct to a cm.

Tapered walls shall be measured net, as per actual dimensions and paid for as other walls.

Curved Masonry: Stone masonry curved on plan to a mean radius exceeding 6 metres shall be measured and included with general stone work. Stone work circular on plan to a mean radius not exceeding 6 metres shall be measured separately and shall include all cuttings and waste and templates. It shall be measured as the mean length of the wall.

12.1.11. RATE

The rate shall include the cost of materials and labour required for all the operations described above and shall include the following:

(a) Raking out joints for plastering or pointing done as a separate item or finishing flush as the work proceeds.

(b) Preparing tops and sides of existing walls for raising and extending.

(c) Rough cutting and waste for forming gables cores, skew backs or spandrels of arches, splays at eaves and all rough cutting in the body of walling unless otherwise specified.

(d) Bond stones or cement concrete bond blocks.

(e) Leading and making holes for pipes etc.

(f) Bedding and pointing wall plates, lintels, sills etc. in or on walls, bedding roof tiles and corrugated sheets in or on walls.

(g) Building in ends of joists, beams, lintels etc.

12.2 UNCOURSED & COURSED RUBBLE MASONRY

12.2.1. GENERAL

Random Rubble Masonry shall be un-coursed or brought to courses as specified.

12.2.2. UNCOURSED RUBBLE MASONRY

Un-coursed random rubble masonry shall be constructed with stones of sizes as referred in 12.1.2 and shapes picked up random from the stones brought from the approved quarry. Stones having sharp corners or round surfaces shall, however, not be used. No dressing of stone shall be required and stone shall be laid on its quarry bed. Each stone shall be wedged strongly into position by using sprawl or chips. The construction of un-coursed Rubble Masonry shall be carried as specified in 12.0.

12.2.3. COURSED RUBBLE MASONRY

12.2.3.1. General

Random rubble masonry brought to the course is similar to un-coursed random rubble masonry except that the courses are roughly leveled at intervals varying from 300 mm to 900 mm in height according to the size of stones used

12.2.3.2. Stone

Shall be as specified in 12.1.1

12.2.3.3. Size Of Stone

Shall be as specified in 12.1.2

12.2.3.4. Dressing

Face stones shall be hammer dressed on all beds, and joints so as to give them approximately rectangular block shape. These shall be squared on all joints and beds. The bed joint shall be rough chisel dressed for at least 80 mm back from the face, and side joints for at least 40 mm such that no portion of the dressed surface is more than 6 mm from a straight edge placed on it. The remaining unexposed portion of the stone shall not project beyond the surface of bed and side joint. The bushing on the face shall not project more than 40 mm as an exposed face and 10 mm on a face to be plastered. The hammer dressed stone shall also have a rough tooling for minimum width of 25 mm along the four edges of the face of the stone, when stone work is exposed.

12.2.3.5. Mortar

The mortar for jointing shall be as specified under Clause 12.1.4.

12.2.3.6. Laying

All stones shall be wetted before use. The walls shall be carried up truly plumb or to specified batter. All courses shall be laid truly horizontal and all vertical joints shall be truly vertical. The height of each course shall not be less than 15 cm nor more than 30 cm.

Face stones shall be laid alternate headers and stretchers. No pinning shall be allowed on the face. No face stone shall be less in breadth than its height and at least one third of the stones shall tail into the work for length not less than twice their height.

The hearting or the interior filling of the wall shall consist of stones carefully laid on their proper beds in mortar; chips and spalls of stone being used where necessary to avoid thick beds of joints of mortar and at the same time ensuring that no hollow spaces are left anywhere in the masonry. The chips shall not be used below the hearting stone to bring these up to the level of face stones. The use of chips shall be restricted to the filling of interstices between the adjacent stones in hearting and these shall not exceed 10% of the quantity of stone masonry.

The masonry in a structure shall be carried up uniformly but where breaks are unavoidable, the joints shall be raked back at angle not steeper than 45°. Toothing shall not be allowed.

12.2.3.7. Bond Stones

Shall be as specified in sub section 12.1.6, except a bond stone or a set of bond stones shall be inserted 1.5 to 1.8 meters apart, in every course.

12.2.3.8. Quoins

The quoins shall be of the same height as the course in which these occur. These shall be at least 450 mm long and shall be laid stretchers and headers alternatively. These shall be laid square on the beds, which shall be rough-chisel dressed to a depth of at least 100 mm. In case of exposed work, these stones shall have a minimum of 25 mm wide chisel drafts at four edges, all the edges being in the same plane.

12.2.3.9. Joints

All bed joints shall be horizontal and all side joints vertical. All joints shall be fully packed with mortar, face joints shall not be more than one or two cm thick.

When plastering or pointing is not required to be done, the joints shall be struck flush and finished at the time of laying. Otherwise, joints shall be raked to a minimum depth of 20 mm by raking tool during the progress of work, when the mortar is still green.

12.2.3.10. Scaffolding/Curing

Shall be specified under section 12.1.9 & 12.1.10.

12.2.3.11. Measurements and rates.

Shall be as specified under 12.1.10 and 12.1.11

12.2.4. DRY RUBBLE MASONRY

12.2.4.1. Size Of Stone

Dry rubble masonry shall be constructed with the largest practicable size of the stone available the larger stone being used in the lower courses.

12.2.4.2. Dressing Of Stone

Stone shall be roughly dressed to secure the maximum bedding surface without unduly reducing the size of the stone. Each course shall be built through the entire thickness of the wall.

12.2.4.3. Bond Stone

Bond stone shall be provided in each course at an interval of 5 feet. It shall be of the height of the course in which it is to be used, at least as broad and of the greatest length procurable. No bond stone shall be less than 2 feet long. When the length is less than the thickness of the wall 2 or more stones shall be used overlapping each other by at least 6 inches to provide through bond from front to back. All bond stones shall be separately stacked before use and marked so that they can be identified after having been built in the wall.

12.2.4.4. Laying

Wherever required, filling behind dry stone walls shall be done immediately with stone refuse or chips. Earth shall not be used where stone refuse is available.

12.3 PLAIN ASHLAR MASONRY

Stone shall be of the type specified. It shall be hard, sound, durable and tough, free from cracks, decay and weathering and defects like cavities, cracks, flaws, sand holes, veins, patches of soft or loose materials etc. before starting the work, the contractor shall get the stones approved by Engineer-in-Charge. Every stone shall be cut to the required size and shape and fine machine dressed to the full depth so that a straight edge lay along the side of stone shall be in full contact with it.

12.3.1. SIZE OF STONE

Normally stones used should be small enough to be lifted and placed by hand. The length of the stone shall not exceed three times the height and the breadth on base shall not be greater than three- fourth of the thickness of wall nor less than 15 cm. The height of stone may be upto 30 cm.

12.3.2. DRESSING

Every stone shall be cut to the required size and shape chisel dressed on all beds and joints so as to be free from waviness and to give truly vertical and horizontal joints. In exposed masonry, the faces that are to remain exposed in the final position and the adjoining faces to a depth of 6 mm shall be the fine chisel dressed so that when checked with 60 cm straight edge, no point varies from it by more than 1 mm. The top and bottom faces that are to form the bed joints shall be chisel dressed so that variation from 60 cm straight edge at no point exceeds 3 mm. Faces which are to form the vertical joints should be chisel dressed so that variation at any point with 60 cm straight edge does not exceed 6 mm. Any vertical face that is to come against backing of masonry shall be dressed such that variation from straight edge does not exceed 10 mm. All angles and edges that are to remain exposed in the final position shall be true, square and free from chippings' sample of dressed stone shall be prepared for approval of Engineer-in-Charge. It shall be kept at the worksite as a sample after being approved.

12.3.3. MORTAR

The mortar for jointing shall be as specified in Clause 12.1.4.

12.3.4. LAYING

All stones shall be wetted before placing in position. These shall be floated on mortar and bedded properly in position with wooden mallets without the use of chips or under pinning of any sort.

The walls and pillars shall be carried up truly plumb or battered as shown in drawings. All courses shall be laid truly horizontal and all vertical joints shall be truly vertical.

In case of ashlars' work without backing of brick work or coursed rubble masonry, face stone shall be laid headers and stretchers alternately unless otherwise directed. The headers shall be arranged to come as nearly as possible in the middle of stretchers above and below. Stone shall be laid in regular courses of not less than 30 cm in height and all the courses shall be of same height, unless otherwise specified.

For ashlars' facing with backing of brick work or coursed rubble masonry face stone shall be laid in alternate courses of headers and stretchers unless otherwise directed. Face stone and bond stone course shall be maintained throughout. All connected masonry in a structure shall be carried up nearly at one uniform level throughout, but where breaks are avoidable, the joint shall be made in good long steps so as to prevent cracks developing between new and old work.
When necessary, jib crane or other mechanical appliances shall be used to hoist the heavy pieces of stones and place these into correct positions, care being taken that the corners of the stone are not damaged. Stone shall be covered with gunny bags, before tying chain or rope is passed over it, and it shall be handled carefully. No piece which has been damaged shall be used in work.

12.3.5. BOND STONES

Shall be as specified in 12.1.6

12.3.6. JOINTS

All joints shall be full of mortar. These shall be not more than 6 mm thick. Face joints shall be uniform throughout and a uniform recess of 20 mm depth from face shall be left with the help of the steel plate during the progress of work.

12.3.7. POINTING

All exposed joints shall be pointed with mortar as specified. The pointing when finished shall be sunk from stone face by 5 mm or as specified. The depth of mortar in pointing work shall not be less than 15 mm.

12.3.8. CURING

Masonry work in cement mortar shall be kept constantly moist on all faces for a minimum period of seven days.

12.3.9. PROTECTIONS

Green work shall be protected from rain by suitable covering. The work shall also be suitably protected from damage, mortar dropping and rain during construction.

12.3.10. SCAFFOLDING

Double scaffolding having two sets of vertical supports shall be provided. The supports shall be sound and strong, tied together with horizontal pieces over which scaffolding planks shall be fixed.

12.3.11. MEASUREMENTS

The finished work shall be measured correct to a centimetre in respect of length, breadth and height. The cubical contents shall be calculated in cubic metre nearest to two places of decimal.

12.4.1.1 No deduction nor any extra payment shall be made for the following:

(i) Ends of dissimilar materials (that is joists, beams, posts, girders, rafters, purlins, trusses, corbels, steps etc.) upto 0.1 sqm in section.

(ii) Openings upto 0.1 sqm in area. In calculating the area of opening, any separate lintels or sills shall be included alongwith the size of the opening but the end portion of the lintels shall be excluded and extra width of rebated reveals, if any, shall also be excluded.

(iii) Wall plates and bed plates and bearing of Shades and the like, where the thickness does not exceed 10 cm and the bearing does not extend over the full thickness of the wall.

Note : The bearing of floor and roof slabs shall be deducted from wall masonry.

(iv) Drainage holes and recesses left for cement concrete blocks to embed hold-fasts for doors and windows, building in the masonry iron fixture and pipes upto 300 mm diameter.

(v) Stone walling in chimney breasts, chimney stacks, smoke or air flues not exceeding 0.20 sqm in sectional area shall be measured as solid and no extra measurement shall be made for pargetting and coring such flues. Where flues exceed 0.20 sqm in sectional area, deduction shall be made for the same and pargetting and coring flues paid for separately.

Square, Rectangular or Circular Pillars: Shall be measured and paid for as walls, but extra payment shall be allowed for such pillars and columns over the rate for stone work in walls.

Rectangular pillars shall mean a detached masonry support, rectangular in section, such that its breadth shall not exceed two and half times the thickness.

Curved Stone Work: Stone work curved on a plan to a mean radius exceeding six metres shall be measured net and included with general stone work. Stone work circular on a plan to a mean radius not exceeding six metres shall be measured separately and extra payment shall be allowed and shall include all cutting and waste and templates. It shall be measured as the mean length of wall.

12.3.12. RATE

The rate shall include the cost of materials and labour required for all the operations described above. Stone facing or wall lining upto and not exceeding 8 cm thickness shall be paid for under “Stone work for wall lining etc. (Veneer work)”. The stone work of thickness exceeding 8 cm shall be paid under relevant items of work.

12.4 PUNCHED ASHLAR (ORDINARY) MASONRY

12.4.1. STONE

It shall be as specified in 12.3. In case of red or white sand stone, stone shall be red or white as specified in the item. In red sand stone, white patches or streaks shall not be allowed. However, scattered spots up to 10 mm diameter will be permitted.

12.4.2. SIZE OF STONE

It shall be as specified in 12.3.1.

12.4.3. DRESSING

It shall be as specified in 12.3.2 except that the faces exposed in view shall have a fine dressed chisel draft 2.5 cm wide all-round the edges and shall be rough tooled between the drafts, such that the dressed surface shall not be more than 3 mm from a straight edge placed over it.

12.4.4. OTHER DETAILS

The specifications for mortars, laying and fixing, bond stone, joints, pointing, curing, protections and scaffolding shall be same as specified in 12.3.

12.5 MOULDED, SINK, CARVED ASHLAR MASONRY

12.5.1. STONE

It shall be as specified in 12.3 and 12.3.1.

12.5.2. DRESSING

Every stone shall be cut to the required size and shape and chisel dressed on all beds and joints so as to be free from any waviness and to give perfectly vertical, horizontal, radial or circular joints with adjoining stones as the case may be. The dressed surface shall not be more than 3 mm from a straight edge placed on it. The face shall be gauged, cut, chamfered, grooved, and rebated sunk or plain molded and fine tooled as shown in the working drawings. The joints 6 mm from the face shall also be fine tooled so that straight edge laid along it is in contact with every point. It shall be finest surface which can be given to a stone with the chisel and without rubbing.

In case of sink or moulded masonry, the corner stone shall be dressed at true right angles or true to the shape as specified, the corners being straight and vertical. For arch dome or circular work the stone shall be dressed to required wedge shape so that joints shall be truly radial.

12.5.3. SAMPLE

The full size layout of the moulding etc. shall be prepared on platform from which sheet templates shall be cut and the stone dressed to templates to a uniform and fine finish. All visible angles and edge shall be True Square and free from chippings. A sample of dressed stone shall be prepared for approval and it shall be kept as sample after being approved by Engineer-in-Charge.

In case of Ashlar moulded and carved columns a full size model of the required moulding, carving etc. shall be prepared in plaster of Paris and kept at site of work as sample work after being approved by the Engineer-in-Charge. The stones shall be moulded and carved in accordance with the approved model to a uniform and fine finish.

12.5.4. OTHER DETAILS

It shall be as specified in 12.3.3, 12.3.4 and 12.3.6 to 12.3.9.

12.5.5. CENTERING AND SHUTTERING

Centering and shuttering required for arch dome or circular moulded work shall be proposed by the Contractor and approved by the Engineer-in-Charge.

12.5.6. MEASUREMENTS

The dimensions of the circumscribing rectangles of the dressed stone used in the work shall be measured correct to a cm and cubical contents shall be calculated in cubic metres, nearest to two places of decimal.

In case of sunk or moulded work the measurements for the work shall be taken course by course. The plain stone used in conjunction with sunk or moulded stone shall be measured and paid for under the relevant item of stone work.

Sunk or moulded work in rectangular, square and circular pillars, moulded cornices and string courses shall be measured under stone work sunk or moulded but extra payment shall be allowed over the general work in each case. No such extra payment shall be allowed for moulded string and plinth courses.

In case of arch dome or circular moulded work for arches exceeding six metres in clear span extra payment for additional cost of centering shall be made on the actual area of soffit including strutting, bolting, wedging, easing, striping and removal.

12.5.7. RATE

The rate includes the cost of all materials and labour involved in all the operations described above, including centering and shuttering for arch, dome or circular moulded work.

12.6 SHELVES, COPING, PLAIN, CORNICES, STRING COURSES ETC.

12.6.1. STONE

Stone shall be of uniform color and texture and of the kind as stipulated.

12.6.2. DRESSING

The exposed faces and sides of shelves shall be chisel dressed such that the dressed surface shall not be more than 3 mm from a straight edge placed on it. All visible angles and edges shall be free from chippings. The surfaces to be buried in the masonry shall be rough dressed.

12.6.3. LAYING

These shall be laid in mortar of specified mix and fixed as shown in drawing or as directed by the Engineer-in-Charge.

12.6.4. OTHER DETAILS

Specifications for pointing, curing, protections and scaffolding shall be as specified in 12.3.3, 12.3.4 and 12.3.6 to 12.3.9.

12.6.5. MEASUREMENTS

The length and breadth of the finished work shall be measured in metre correct to cm. The area should be calculated in sq. metre correct to two places of decimal..

12.7 STONE MASONRY IN FREEZING WEATHER

Stone Masonry in freezing weather shall be carried out in accordance with the provisions of Clause 11.7.10 - Brick laying in freezing weather. For purpose of application of this Clause, “Brick” shall be deemed to have been replaced with stone.

12.8 DRY STONE UNCOURSED PITCHING, REVETMENT

12.8.1. GENERAL

The stone will be perfectly sound and as regular in shape as possible. Their length will be about equal to the thickness of the required pitching or revetment without the backing.

The side of the bank will be trimmed to the required slope and profiles will be put up at required intervals to ensure regular work and uniform slope throughout.

The stone will be laid closely in position and firmly bedded, the length being made perpendicular to the face of the pitching or revetment.

The toe will be thoroughly secured against slipping by a properly constructed masonry wall in cement mortar.

12.9 MEASUREMENT AND PAYMENT

12.9.1. COMPOSITE RATE

The measurement and payment for the items of the work of Stone Masonry hereof shall be made corresponding to the applicable CSR items as provided in Contract Agreement and shall constitute full compensation, for procurement, transportation, performance in all respects and completion of work as specified including the site clearance as approved by the Engineer-in-Charge.

12.9.2. LABOUR RATE

The measurement and payment for the items of the work of Stone Masonry hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurement transportation, performance in all respects and completion of work as specified including site clearance, as approved by the Engineer-in-Charge except the cost of materials to be provided by Department at designated location as defined in the Contract Agreement.

12.10 GLOSSARY

Ashlar

Stone masonry using dressed square stone blocks of given dimensions having faces perpendicular to each other and laid in courses.

Bed Joint

The joint where one stone presses on another for example, a horizontal joint in a wall or radiating joint between the voussoirs or arch.

Block

a) Hollow Block (Open and Closed Cavity):

A concrete masonry unit with any one of the external dimension greater than the corresponding dimension of a brick and having one or more large holes or cavities which either pass through the block (open cavity) or do effectively pass through the block (closed cavity) and having the solid material between 50% and 75% of the total volume of the block calculated from the overall dimensions.

b) Solid Block:

A concrete masonry unit with external dimensions greater than corresponding dimension of a brick and having solid material not less than 75% of the total volume of the block calculated from over all dimension.

Bond

An interlocking arrangement of structural units in a wall to ensure stability.

Bond Stone (through Stone)

Selected long stone used to hold a wall together transversely.

Corbel

Stone bonded well into the wall with part of it projecting out of the face of wall to form a bearing surfaces.

Cornice

A horizontal moulded projection which crowns or finishes either a wall, any horizontal division of wall, or any architectural feature.

Cramp

A small piece of metal or the hardest or toughest stone procurable, sunk in mortises and fixed across joints as additional ties. The ends of metal cramps are bent at right angles and stone cramps are dovetailed.

Course

A layer of stones in wall including the bed mortar.

Dowels

Dowels are small sections of metal, stone or pebbles bedded with mortar in corresponding mortise in bed or side joint or adjacent stones.

Jamb

The part of the wall at the side of an opening.

Joggle

A key between the stones by providing a groove in one stone to take a corresponding concealed projection in the edges on the other stone.

Natural Bed

The planes of stratification that occurs in sedimentary rocks.

Parapet
A solid or pierced guard wall for flat stone terrace or balcony (or a bridge) or a curb wall at the lower part of a pitched roof which is exposed to atmosphere on face back and top.

Quoin
A quoin is the external angle of wall or building. The term is also applied to stone specially selected and neatly dressed for forming such angle.

Random
Random or irregular size and shapes.

Reveal
The part of the jamb between the frame and the arris.

Rubble Masonry
Masonry built of stones either irregular in shapes as quarried or squared and only hammer dressed and having comparatively thick joints. As far as possible, stones for rubble masonry shall be angular.

Skewback
Sloping surface against which the springing of an arch rests.

Spandrel
Space between the haunches below the decking level.

String Course
A horizontal band, plain or moulded, usually projects slightly from the face of wall.

Surfacing or Dressing of Stones
The stones are dressed to have different surfaces as indicated below.

Template or Bed Block
A block of stone or concrete bedded on a wall to distribute the pressure from a concentrated load.

Self-Faced Surfaces
Surfaces of stone slabs used for roofing, flooring, lintels etc. as obtained from quarry.

Squared Back Surface
Means the surface shall be dressed back at right angles to the face of the stone.

Chisel Drafted Margin
The dressing done with a drafting chisel in narrow strips of width generally 2 to 5 cm. Chisel drafted margin shall be punch dressed.

Hammer Dressed Surface
A hammer dressed stone shall have no sharp and irregular corners and shall have a comparatively even surface so as to fit well in masonry. Hammer dressed stone is also known as hammer faced, quarry faced and rustic faced. The bushing from the general wall face shall not be more than 40 mm on exposed face and 10 mm on faces to be plastered.

Rock Faced Surface

A rock faced stone shall have a minimum of 25 mm wide chisel drafted margin at the four edges, all the edges being in the same plane.

Rough Tooled Surface

A rough tooled surface shall have a series of bands, made by means of a plane chisel 4 to 5 cm wide, more or less parallel to tool marks all over the surface. These marks may be either horizontal, vertical or at an angle of 45° as directed. The edges and corners shall be square and true. The depth or gap between the surface and straight edge, held against the surface shall not be more than 3 mm (Rough tooled stones are used where fairly regular plane faces are required for masonry work).

Punched Dressed Surface

A rough surface is further dressed by means of punch chisel to show series of parallel ridges. The depth of gap between the surface and a straight edge held against the surface shall not exceed 3 mm. Punched dressed stones are used where even surfaces are required.

Close Picked Surface

A punched stone is further dressed by means of point chisel so as to obtain a finer surface, ridges or chisel marks left over being very tiny. The depth of gap between the surface and a straight edge kept over the surface shall not exceed 1.5 mm.

Fine Tooled Surface

Close picked surface is further dressed so that all the projections are removed and fairly smooth surface is obtained. The surfaces shall have 3 to 4 lines per centimeter width depending on the degree of hardness of stone and degree of fineness required. This type of dressing is commonly adopted for ashlar work.

Polished Surface

Surfaces having a high gloss finish. Polishing of stones shall be done by rubbing them with suitable abrasive, wetting the surface where necessary with water. Alternatively polishing of stones shall be done by holding them firmly on the top of revolving table to which some abrasive material like sand or carborundum is fed. The final polishing shall be performed by rubber or felt, using oxide of lime (called by trade name as putty powder) as a polishing medium.

Moulded

Cut to profile of a molding with punched dressed surfaces, unless otherwise specified.

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13. ROOFING

13.1 GENERAL

The covering or the upper part of a building constructed to preserve it from exposure to weather is known as roof. Roofs are designed to suit the needs of different climatic conditions keeping in view the available materials. For instance, in plains where rainfall is meagre and heat intense, a thick, flat roof is more suitable to ensure greater protection from the sun. In coastal areas, however, where temperature is more or less even almost all the year round, but rainfall heavy, a pitched or sloping roof is desirable.

The Work shall include complete performance and construction of roofs shown on drawings as specified hereof.

13.2 REINFORCED CEMENT CONCRETE ROOFING

13.2.1 ROOFING

The reinforced concrete roofing shall be as shown on Drawings and shall be constructed in accordance with the provisions of Section 5 – Plain and Reinforced Concrete.

13.2.2 ROOFING PROTECTION

The roof protection consisting of water proofing, insulation, earth layer and clay tiles shall be made as shown on drawings and complying with the applicable provisions of Section 8 – Damp Proofing & Water Proofing, Section 11 Brick work, Sub-clause 13.8 for Insulation and as approved by the Engineer-in-Charge.

13.3 FIRST CLASS TILE ROOFING

13.3.1 DESCRIPTION OF WORK

It is made up of different material viz. clay tiles, R.C.C. or wooden battens and mud. The following operation is involved in its construction.

1. Laying of first layer of tiles on batten in 1:6 cement sand mortar.
2. Laying of second layer of tiles in 1:6 cement sand mortar over a bed of half an inch thickness 1:6 cement sand mortar.
3. Half an inch thick 1:6 cement sand plaster over second layer of tiles.
4. Application of a coat of 1.7 kg. hot bitumen per square meter which is blinded with sand.
5. Four-inch earth filling finished with one-inch mud plaster with gobri leaping.

The work shall be performed as shown on drawings and approved by the Engineer-in-Charge. The second layer of tiles is laid by breaking joints in both directions with the first layer of tiles laid underneath. The size of tiles is as mentioned in Clause 13.2.2. Bitumen coating at the rate of 34 Ibs per 100 square feet of surface area or 1/16 of an Inch thick is given for making the roofs waterproof. In order to safeguard against attaching bitumen, sand is generally sprinkled over the bituminous coating at the rate of one cubic foot per 100 square feet of surface area. Battens are placed at 12 inches apart centre to centre.

13.3.2 MATERIALS

1. TILES:

Unless otherwise specified, tiles used in both the layers shall be of size specifications mentioned in Section 11 – Brickwork.

2. CLAY:

Clay used in mud mortar or earth filling should be obtained from good earth containing 20% to 30% fine sand, the clay should not contain more than 0.5 % soluble slats, more than 0.2 % sulphate and more than 4% organic contents. It shall not contain any gravel, coarse sand, kanker, roots of grass and plant. The clay shall comply with the specifications for Clay – Mud Mortar, Section 11 - Brickwork.

3. BITUMEN:

Bitumen shall be refined cut – back bitumen having viscosity (standard Tar Viscometer) of 110 to 150 seconds at 40 degrees C.

4 Battens

The battens shall be of specified type and size and shall have proper finished surface on top so as to give a good bearing to the tile.

The following types of battens could be used.

a. Timber battens

The battens shall be of timber complying with the provisions of Clause 16.3.
The battens shall be prepared for sizes and lengths as specified.

b. Pre-cast RCC Battens

Pre-cast RCC Battens shall be manufactured for sizes and length complying with the provisions of Section 5 - Plain and Reinforced Concrete.

c. Mild Steel Battens

Mild steel battens shall be of angle or tee sections complying with AST M-36.
The battens shall be correctly placed and fixed as specified.

13.3.3 CONSTRUCTION OF ROOF

1. Laying of Battens

The battens shall be spaced 12 inches apart centre to centre in accordance with the size of the tile as shown on drawings and shall be placed in straight and parallel lines.

2. Slope To Roof

The necessary main slope in the roof shall be formed by sloping the beam or battens.

3. Laying Of First Layer Of Tiles

Over the battens the first layer of tiles shall be laid in specified mortar with the joints coming over the centre of the battens. Tiles shall be laid straight and square. All vertical joints shall be as fine as possible as specified on drawings and approved by the Engineer-in-Charge.

4. Laying Of Second Layer of Tiles

The second layer of tiles shall then be laid on half an Inch thick bed of specified mortar spread over the first layer of tiles. The Joints shall be broken in both directions with the first layer of tiles laid underneath. The vertical joints shall be as fine as in the case of first layer of tiles and shall be flushed with mortar at top.

5. Bonding Of Tiles With Parapet Wall

Tiles resting on wall shall have bearing of preferably 4 1/2 inches, and in no case less than 3 Inches. These tiles shall butt closely against the brickwork of the parapet wall leaving no voids wherever possible, the ends of the tiles shall be bonded into the Brickwork with specified mortar.

6. Cement Plaster To Parapet

The portion of the parapet wall between the tiles and drip course shall be plastered with half an inch thick cement sand plaster of 1:3 ratio, unless otherwise specified.

7. Bed For Bitumen Coating

Half an inch thick cement sand plaster of specified ratio shall then be laid over the surface of the second layer of tiles to serve as a bed for bitumen.

8. Curing of Bed

The bed shall be cured for seven days, and the surface shall then be allowed to dry thoroughly before bitumen is laid.

9. Application Of Bitumen - Thickness

Bitumen shall be heated to a temperature specified by the manufacturer and poured on the surface to be treated and pulled out so that the minimum thickness is 1/16 of an inch. The coat of bitumen shall be continued along with the parapet wall up to a drip course.

10. Blending Of Bituminous Coating

    The bitumen coat 1.70 kg / square meter shall be blended with sand at the rate of 0.30 cubic meter per 9.5 square meter of the surface area.

11. Earth filling and Mud Plaster

    Four inches thick of good earth (clay) conforming to Specifications as mentioned above, shall then be put and shall be thoroughly rammed and watered. The roof shall be finished with one Inch thick mud plaster with gobri leaping in accordance with provision of Clause 15.1.12, Mud Plaster, and Finishing. This shall be done before laying the drip to ensure a close Joint with the wall.

12. Khurras

    Khurras shall be made before the earth is laid as specified in Clause 13.9.

13. Pointing Of Tiles Underneath

    Unless otherwise specified, on the completion of the work the underside of the tiles shall be washed and neatly pointed with 1:2 cement sand mortar.

14. Filling Spaces Between Battens

    In case of wooden battens the spaces over the beam and between the battens shall be closed by one-inch planks nailed to distance pieces which in turn are nailed to the battens. Where concrete battens have been used the spaces shall be filled with I:3:6 cement concrete block of exact size and laid in spaces with 1:3 cement sand mortar. The filling shall be equal to the battens in height and the outer faces shall be exactly in line with the edge of the beam. For Tee iron/girder beams the filling shall be with mild steel flat pieces of the same thickness as of Tee/Girder tack welded at the faces.

15. Painting With Preservations

    The top surface of wooden battens in contact with the tiles and the end shall be painted with an approved preservative.

13.3.4 MEASUREMENTS

Length and breadth shall be measured correct to a cm. The measurements shall be taken for the finished work, (terracing of stipulated thickness with mud plaster, gobri leaping and tile paving and grouting) over the tiled surface, in superficial area.

No deductions in measurements shall be made for either openings or recesses for chimney stacks, roof lights or khurras, of area upto 0.40 sqm. No extra shall be paid either for any extra materials or labour involved in forming such openings, recesses etc. For areas exceeding 0.40 sqm deductions will be made in the measurements for the full opening but extra shall be paid for any extra labour, materials etc. in forming such openings.

For plus or minus deviation from the average thickness stipulated for the mud plaster in the item, payments will be adjusted in the rate admissible to the contractor for the relevant schedule item provided that such deviations were authorised by the Engineer-in-Charge in writing.

13.4 SECOND CLASS TILE ROOFING /PLAIN CEMENT CONCRETE TILES SPECIFICATIONS

13.4.1 SECOND CLASS TILE ROOFING

Second class tile roofing shall conform to Specifications No. 13.2.2. &13.2.3 in all respects except that only one layer of tiles shall be laid instead of two and their size shall be l2”x6”x2”.

13.4.2 PLAIN CONCRETE TILE ROOFING

It is exactly the same as first class tile roofing except that cement concrete tiles are used. Cement concrete tiles shall be of the size as specified and shall be procured from an approved source. The tiles shall be of 1:2:4 concrete mix unless otherwise specified and shall be fully cured.

13.3.4 MEASUREMENTS

Length and breadth shall be measured correct to a cm. The measurements shall be taken for the finished work, (terracing of stipulated thickness with mud plaster, gobri leaping and tile paving and grouting) over the tiled surface, in superficial area.

No deductions in measurements shall be made for either openings or recesses for chimney stacks, roof lights or khurras, of area upto 0.40 sqm. No extra shall be paid either for any extra materials or labour involved in forming such openings, recesses etc. For areas exceeding 0.40 sqm deductions will be made in the measurements for the full opening but extra shall be paid for any extra labour, materials etc. in forming such openings.

For plus or minus deviation from the average thickness stipulated for the mud plaster in the item, payments will be adjusted in the rate admissible to the contractor for the relevant schedule item provided that such deviations were authorised by the Engineer-in-Charge in writing.

13.5 GALVANIZED CORRUGATED STEEL (C.G.S) SHEET ROOFING SPECIFICATION

13.5.1 SCOPE

Unless otherwise specified, galvanized steel sheet roofing (corrugated) shall be constructed in accordance with the following specifications.

13.5.2 MATERIALS

13.5.2.1 Galvanized Corrugated Steel Sheets

i. General

Corrugated steel sheets shall be made of ASTM A-36 mild steel, well annealed, even in temper and thickness free from holes, cracks, blisters and other defects. Corrugated steel sheets shall be perfectly rectangular, the corrugations parallel with the sides and regular in curve pitch and depth, and the weight of any ten sheets to be within 7 ½ per cent margin of the weights given below:

ii. Weight

The weight and thickness of corrugated steel sheets before galvanizing shall be as follows:

- No. 24 B.-G. to be 0.02476 inch thick and to weigh 1.01lbs per square foot of girthed surface.
- No. 22 B.-G. to be 0.03125 inch thick and to weigh 1.27 Ibs. per square foot of girthed surface.
- No. 20 B.-G. to be 0.0392 inch thick and to weigh 1.59 Ibs. per square foot of girthed surface.

The allowance for increase in weight by galvanizing shall be 2 ozs, per square foot of girthed surface which weight includes both sides.

iii. Galvanizing

Galvanized corrugated steel sheets shall be thoroughly and evenly coated with zinc, and to be free from stains bare spots and other defects.

iv. Dimensions

The sheets shall be of standard dimensions. The diagonal distance between opposite corner of sheets shall not differ by more than ¾ inch.

iv. Paint

When not galvanized, all corrugated steel sheets shall be coated immediately after manufacture with one coat of oil paint applied by dipping or brushing over the whole of the surface of each sheet.

v. Corrugations

Unless otherwise specifically ordered the corrugations shall be of standard pattern-3 inches pitch and 3/4 inch deep. The widths shall be as under;

8/3 Corrugations	2 ft. 2 ins. measured straight and
	2 ft. 6 ins. measured along the girth
10/3 Corrugations	2 ft. 8 ins. measured straight and
	3 ft. measured along the girth.

vi. Fixing accessories

Hook bolts, screws, bolts, nuts, rivets, washers shall be galvanized or until otherwise specified by Engineer-In-charge.
Sealing material shall be bituminous mastic or of any other approved quality.

vii. Flashing Gutters

Flashing gutters shall conform to Specifications No. 13.10.3 for Flashing Gutters.

13.5.3 LAP

a. End lap shall be minimum of 6 inches for slope and 4 inches for vertical falls which shall be sealed with specified sealing material, complying with ASTM D-1850.
b. Side lap shall be formed on the sides of the sheet, away from the prevailing direction of wind. The side lap shall vary from one to two corrugations as specified.

13.5.4 INSULATING MATERIAL

Wherever specified, insulating material of approved quality shall be laid either between the purlins and the sheet or under purlins incorporating air gap. Insulation material shall conform with provisions of Sub-Section 13.8.

13.5.5 C.G.S SHEET INSTALLATIONS

i. **Purlin Spacing**

Purlins shall be of the steel or timber of requisite size as specified and shall be fixed over principal rafters for installation of CGS Sheets.
Purlin spacing for roof covering with G.C.S. sheets shall be arranged with a view to using standard sheets of uniform length throughout, and the trusses shall be designed for purlin spacing to suit the standard length of these sheets to avoid unnecessary cuttings. Ridge

purlins shall be as near to the ridge as possible having regard to the type of ridge capping to be used and the manner in which it is to be fixed.

ii. **Holes**

The holes for fixing bolts shall be made through crown of the corrugations and shall be either punched or drilled and shall be 1/16 of an inch larger in diameter than the bolts or fixing screws to be used.

Holes shall be in the exact position to suit the purlins and no holes for fixing bolts shall be nearer than 1-1/2 inches to the end of the sheet. These holes shall be made in a manner that the arises of the punched hole shall come on top when the sheets are laid. Where 4 sheets overlap, holes shall be drilled and not punched.

iii. **Laying of Sheet**.

Before the laying of sheet begins it shall be seen that all purlins are in true plane correctly spaced and securely fixed. The purlin spacing and the length of sheet shall first be checked to see that the arrangement will provide the specified overhanging at the eaves and the laps. The eave course shall be laid first and work shall start at the leeward end of the building so that side laps have better protections from rain driven by the prevailing wind. The top edges of eave sheet shall extend at least 1 ½" inches beyond the back of steel purlin or 3 inches beyond the centre line of a timber purlin.

iv. **Fixing Sheets**

Sheets shall be fixed to steel purlin by hook bolts and to timber purlin by mushroom-headed galvanized drive screws. Hook bolts and drive screws shall be from 1/4 of an inch to 3/8 of an inch in diameter as specified and shall be spaced at an interval of not more than 15 inches. Sheets shall be secured at every purlin by at least 2 bolts. Nuts or heads of drive screws shall have specially made washers to render the holes waterproof. Washers shall be "Limpet" patent doom and shall be bedded on bituminous felt. Screws or bolts shall be tightened sufficiently to seat washers over the corrugation.

Ridges and hips shall be laid starting from directions as laying of sheets. Final pieces shall also be provided for closing the end of ridge line at gable end.

v. **Ridges and Hips**

a) General accessories: Ridge or hip capping, wherever possible shall be secured to the purlin by the same bolts or screws which secured the sheeting.

b) Ridge cap shall be made up of galvanized flat steel conforming to Clause 13.5.2.1(i) or Flat Steel Sheet ASTM A-36 or otherwise specified:

In case (a) above is not possible as the purlin is not sufficiently near the ridge, the capping shall be secured to the sheet by 1/4 of an inch to 3/8 of an inch diameter bolts: two roofing bolts to each wing capping at centre not further apart than the bolts used for sheets. The lap of the capping along the ridge shall not be less than 6 inches and shall be so arranged as to protect the joints from the prevailing wind.

c) Hip cap shall be cut to the required mitre and shall be close butted. The slope joints shall be covered with plain ridge cap which shall be secured through the roof sheet or the slope runner by one bolt on each side at the same spacing as for the roof sheets. Hip caps shall have a minimum lap of 6 inches.

Measurement

The measurements for ridges and hips shall be taken for the finished work along the centre line of the ridge and hip lines in length, correct to a cm. The laps in adjacent ridges or hip pieces shall not be measured. The underlay of ridges under expansion joint pieces where the latter are provided shall however be measured

vi. **Special Fastening Against Cables**

For any situation exposed to strong winds, sheets shall be fastened down above the eaves by continuous length of 1 ½” x ½” flat iron bars bolted down every 5 feet by ½” bolt built a foot into the wall and secured at the lower end by a 3” square washer. The fixing shall be with J-bolts.

vii. **Painting Sheet**

Wherever desired, sheets shall be painted with ICI, BERGER, NIPPON or equivalent as approved by the Engineer-in-Charge.

13.3.4 MEASUREMENTS

The length and breadth shall be measured correct to a cm. Area shall be worked out in sqm correct to two places of decimal.

No deduction in measurement shall be made for opening upto 0.4 sqm and nothing extra shall be allowed for forming such openings. For any opening exceeding 0.4 sqm in area, deduction in measurements for the full opening shall be made and in such cases the labour involved in making these openings shall be paid for separately. Cutting across corrugation shall be measured on the flat and not girthed. No additions shall be made for laps cut through.

The superficial area of roof covering shall be measured on the flat without allowance for laps and corrugations. Portion of roof covering overlapping the ridge or hip etc. shall be included in the measurements of the roof.

Roof with curved sheets shall be measured and paid for separately. Measurements shall be taken on the flat and not girthed.

13.6 CORRUGATED ASBESTOS CEMENT SHEET ROOFING

APPLICABLE STANDARDS

- BS 691-1963
- BS 430-1964

13.6.1 GENERAL

Corrugated asbestos cement sheets shall conform to the approved Drawings and shall be procured from standard manufacturer. Unless otherwise specified, corrugated asbestos cement sheet roofing shall be constructed in accordance with the following specifications.

13.6.2 MATERIALS

a. **AC Corrugated Sheets**

i. **Classification**

Corrugated sheets shall be classified according to the sizes and form of the corrugations as follows:

Type of Sheet	Depth of Corrugation	Centres of Corrugations
Small	Under 2”	2-7/8” and 3”
Large Section	2” and Over	5-3/4” and 6”
Alternate Flat and Corrugated section	2” and over	13-1/3“ usually

ii. **Tolerance**

The sheets shall be corrugated in a true and regular manner. The corrugated sheets shall not vary from the standard dimension of length and width by more than 0.25%.

iii. **Breaking Strength**

When tested wet the average breaking load of 3 specimens shall not be less than the vales given in the following table:-

Class of Sheet	Span at which tested		Minimum width of sheet tested		Minimum average breaking load per inch width of
	ft	in	ft	in	Lbs
Small Section	2	6	2	0	12
Large Section	3	6	3	0	26
Alternate flat and corrugated section	3	6	3	6	26

If breaking strength of a specimen is less than 70% of the average breaking strength of the 3 specimens tested, a further 3 specimens shall be tested and the results combined with the results of the previous two tests, the lowest results having been eliminated. The lowest breaking strength of any one of the 3 specimens shall not be less than 70 % of the average breaking strength of the specimen.

(iv) **Colour**

Pigments that are embodied in the asbestos cement for colouring purposes shall be of permanent colour. They shall not contain substances deleteriously affecting cement, such as lead oxide. The proportions of water soluble chloride and of water soluble sulphates together shall not exceed 2.5 per cent by weight of pigment.

The finish product shall be free from visible defects and shall have been manufactured for at least four weeks before use.

b. **Fixing accessories**

Hook bolts, nuts, and screws shall be galvanized or of any other approved quality. Washers shall be bituminous and galvanized iron or of any other approved type and quality.

c. **Sealing Material**

When specially required, sealing material shall consist of mastic of approved quality.

d. **Flashing Gutters**

Flashing gutters shall conform to provisions of Sub-Section 13.10.2.

13.6.3 LAP

a) End lap shall be of a minimum size of 6 inches.
b) Side lap shall be formed on the sides of the sheet away from the prevailing wind. It shall be half the corrugation of sheets.

13.6.4 OVERHANGING

The minimum end overhanging in case of eave verges and cable ends shall be 12 inches. Overhanging verges shall be supported by purlins over the full width of the sheet.

13.6.5 SHEET INSTALLATIONS

i. **Purlin Spacing**

The purlins shall be as specified in Clause 13.5.5.

Purlin spacing for roof covering with ACC sheets shall be arranged with a view to using standard sheets of uniform length throughout, and the trusses shall be designed for Purlin spacing to suit the standard length of these sheets to avoid unnecessary cuttings. Ridge purlins shall be as near to the ridge as possible having regard to the type of ridge capping to be used and the manner in which it is to be fixed.

ii. **Holes**

Holes in sheets shall always be drilled and shall on no account be punched. They shall be 1/16 of an inch larger in diameter than that of bolt or fixing screw, and shall be drilled through the crown of the corrugations. Holes shall be drilled in exact position to suit the purlins. No hole shall be made in valleys of corrugations and closer than 1-1/2 inches from the edge.

iii. **Laying of Sheet**

Before sheeting begins the structure shall be inspected to see that all purlins are in true plane correctly spaced and securely fixed. Purlin spacing and the length of sheet shall be checked to see that the arrangement provides the specified laps and overhanging. The eave course shall be laid first, and work shall start at the leeward end of the building, so that the side laps shall have better protection from rain driven by the prevailing winds. The top edge of eave sheets shall extend 3 inches beyond the central line of purlins. Close fittings of sheets at the junction of side and end lap shall be ensured.

iv. **Fixing Sheets**

G. I. bolts and screws required for fixing sheets shall be 1/4 to 5/16 of an inch in diameter. Nuts or heads of screws shall bear evenly on washers. Bolts or screws shall be fixed with G. I. washers over bituminous washers to fit tightly on the outer face of the sheet. Bolts or screws shall in the first operation be tightened lightly. They shall be tightened fully when about a dozen of sheets have been laid in position.

For metal angle purlins the sheet shall be secured by bolts of 'J' or 'L' shape. For wooden purlins the sheet shall be fixed with gimlet pointed roofing screws which shall not be hammer-driven.

Ridges and hips shall be laid starting from directions as laying of sheets. Final pieces shall also be provided for closing the end of ridge line at gable ends.

v. **Ridge Cap**

Capping shall be secured to the ridge purlins by the same bolts or screws which secured the sheeting: if ridge purlin is not sufficiently near the ridge to permit this each wing of the ridge, capping shall be secured to the sheeting by 1-1/2” x5/16” roofing bolts.

Other asbestos cement accessories such as flashing etc. shall be secured either to the structure or by the roofing bolt of the sheeting.

vi. **Painting**

When specially required, the paint used for painting of sheets shall be of ICI, Berger or Nippon or as approved by the Engineer-in-Charge.

Measurement:

The superficial area of the surface painted shall be measured in square metres. No deduction in measurements shall be made for unpainted areas of roof slab occupied by chimney stacks, roof lights etc. of areas, each upto 40 sq. decimetre. The measurements of length and breadth shall be taken correct to a cm.

13.6.6 MEASUREMENTS

The length and breadth shall be measured correct to a cm. Area shall be worked out in sqm correct to two places of decimal.

No deduction in measurement shall be made for opening upto 0.4 sqm and nothing extra shall be allowed for forming such openings. For any opening exceeding 0.4 sqm in area, deduction in measurements for the full opening shall be made and in such cases the labour involved in making these openings shall be paid for separately. Cutting across corrugation shall be measured on the flat and not girthed. No additions shall be made for laps cut through.

The superficial area of roof covering shall be measured on the flat without allowance for laps and corrugations. Portion of roof covering overlapping the ridge or hip etc. shall be included in the measurements of the roof.

Roof with curved sheets shall be measured and paid for separately. Measurements shall be taken on the flat and not girthed.

13.7 PLAIN ASBESTOS CEMENT SHEETING

Where the plain Asbestos Cement Sheeting specified shall be used for roofing. The procurement and installation shall comply with the applicable provisions of the Clause 13.6.

13.8 INSULATION MATERIAL

The ‘thermopore’ where specified for insulation of the roofing shall be extruded polystyrene complying with the provisions of ASTM C-578 – Standard Specification for Rigid Cellular Polystyrene Thermal Insulation and as approved by the Engineer-in-Charge. The contractor shall submit samples of the material for approval before use.

13.9 KHURRAS, PARNALAS AND SPOUTS

13.9.1 TOP KHURRAS

Unless otherwise specified, top Khurras shall be 24 inch x 24 inches x 2 inches and shall be made of 1:2:4 cement concrete 1-1/2” inch thick, laid on 1:4:8 cement concrete. The outside edge of the Khurras shall be flush with the level of the mud plaster or leepai and the surface shall slope uniformly from that place to the outlet, which shall be 2 inches lower than the edges. Concrete shall have a slope 1:1 at the sides so as to be overlapped by earth and mud plaster. Cement concrete shall be continued into the outlet so as to ensure a watertight joint.

Measurement:

Khurras shall be counted in numbers

13.9.2 BOTTOM KHURRAS ON ROOF

Unless otherwise specified bottom khurras on top of verandah or similar roofs shall be 24X24 inches and will consist of a 1-1/2 inch layer of I:2:4 cement concrete laid on 1:4:8 cement concrete. The surface shall be shaped like a saucer drain, the depth of the saucer being 2 inches, and joining up with the roof drain, described in paragraph 13.9.7.

Measurement:

Khurras shall be counted in numbers

13.9.3 BOTTOM KHURRAS ON GROUND

Unless otherwise specified, bottom khurras when used on the ground, in conjunction with spouts, shall be 4 feet x 2 feet x 7-1/2 inches and shall consist of bricks on edge laid in cement, laid on 3 inches of 1**:**4**:**8 cement concrete.

Measurement:

Khurras shall be counted in numbers

13.9.4 REVEALED PARNALAS

Unless otherwise specified, revealed parnala's shall be made by leaving a channel 7 inches wide and 2-1/4inches deep in the wall during construction, and afterwards plastering the channel with 1:3 cement plaster. The corner of the channels shall be rounded to a radius of one Inch in plastering. If revealed parnala's are left in a wall made of brickwork in mud, the bricks shall be laid in cement mortar (I:3) for a depth of 4-1/2 inches from the back and sides of the parnala's, this work being included in the rate.

13.9.5 KHASSI PARNALA'S

Unless otherwise specified, khassi parnala's shall consist of two fillets of cement plaster. (1:3) raised 1-1/2 inches and spaced 9 inches apart, the space in between being plastered with 1:3 cement plaster. The fillets shall be prismatic in section (but with all corners and angles rounded), the Inner sides being at right angle to the wall and the outer sides sloping.

Unless otherwise specified, khassi parnala's shall in no case be made on top of the cement or other plaster on the wall, but made In contact with the brickwork or masonry after raking out the Joints.

Measurement:

Khurras shall be counted in numbers

13.9.6 SPOUT

Unless otherwise specified, spouts shall be made of PVC, cast iron, AC and reinforced cement concrete and shall have an open Channel 3-1/4 inches x 3-1/2 inches with a semi-circular bottom. They shall project at least 15 inches from the face of the wall and shall be built into the wall for a depth of at least 13-1/2 inches. The part built into the wall shall be sufficiently thickened to provide adequate support for the overhanging portion. Spouts shall be fixed at a slope not flatter than 1 in 6 and shall have a lip at the lower edge to allow water to drip clear.

13.9.6 CEMENT CONCRETE GOLA

A chase of 75 mm wide and 75 mm deep shall be cut in the parapet wall just above the junction of lean concrete with parapet wall and it shall be filled with cement concrete 1:2:4 (1 cement : 2 coarse sand : 4 stone aggregate 10 mm and down gauge) the external face finish with a slope of 1 : 0.75 and the exposed surface of the gola shall be plastered with cement mortar 1 : 3 (1 cement : 3 fine sand).

Expansion joint at every 3.5 to 4.5 metres shall be provided and filled with bitumen filler. The bitumen filler shall be prepared by mixing bitumen, cement and coarse sand in the ratio of 80 : 1 : 0.25 (80 kg of hot bitumen : 1 kg of cement and 0.25 cum of coarse sand). The finished surface shall be cured for at least 7 days.

Measurements

The length of the finished gola shall be measured at its junction with the wall face correct to a cm. No deduction shall be made in measurements for gaps for water outlets

13.9.7 ROOF DRAIN

Roof drains shall be provided on verandah and similar roofs to conduct water, discharged by the parnala's of a higher roof, to the outlet. They shall run in a straight line from the bottom khurra of one to the (top) khurra for the outlet concerned. Unless otherwise specified, the drain shall be saucer-shaped in section, the depth being 2 inches. Drains shall be made of 2 inches thick 1:2:4 cement concrete laid on cement concrete 1:4:8 of a section to give the necessary shape, with edges flush with the roof plaster.

13.10 GUTTERS AND FLASHINGS

13.10.1 SCOPE

Unless otherwise specified, gutters and flashings shall be constructed with plain galvanised iron/steel & plain AC sheets of the following specifications.

Galvanized steel sheets shall be:-

For gutters No. 18 S.W.G. to No. 22 S.W.G

For flashings No. 20 S.W:G. to No. 24 S.W.G.

The galvanised steel sheets shall conform with the provisions of Clause 13.5.

The ACC valley gutters shall be 1/4" to 3/8" thick and the sizes as specified. The AC sheets shall conform to the provisions of Clause 13.6.

13.10.2 GUTTERS

13.10.2.1 General

(i) Unless otherwise specified, gutters shall be semi-circular in shape, made of the material specified above and shall be properly finished and laid in specified shape. Gutters shall be supported with brackets fixed to wall or roofing at a specified distance apart.

(ii) The overall width of the sheet as specified shall mean the peripheral width of the gutter including the rounded edges. The longitudinal edges shall be turned back to the extent of 12mm and beaten to form a rounded edge. The ends of the sheets at junctions of pieces shall be hooked into each other and beaten flush to avoid leakage.

13.10.2.2 Slope

Gutter shall be laid with a minimum slope of 1 in 120.

13.10.2.3 Laying and fixing

(i) Gutter shall be supported on and fixed to M.S. flat iron brackets bent to shape and fixed to the requisite slope. The maximum spacing of brackets shall be 1.20 metres.

(ii) Where these brackets are to be fixed to the sides of rafters, they shall be of 40x3mm section bend to shape and fixed rigidly to the sides of rafters with 3 Nos. 10mm dia bolts, nuts and washers. The brackets shall overlap the rafter not less than 30 cm and the connecting bolts shall be at 12 cm centre to centre.

(iii) Where the brackets are to be fixed to the purlins, the brackets shall consist of 50x3mm M.S. flat iron bent to shape with one end turned at right angle and fixed to the purlin face with 2 Nos. of 10mm dia bolts nuts and washers. The bracket will be stiffened by provision of 50x3mm. M.S. flat whose over hung portion bent to right angle shape with its longer leg connected to the bracket with 2 Nos. 6mm dia M.S. bolts, nuts and washers and its shorter leg fixed to face of purlin with 1 No. 10mm dia, bolt, nut and washer. The overhang of the vertical portion of the bracket from the face of the purlin shall not exceed 22.5 cm with this arrangement. The spacing of the brackets shall not exceed 1.20 metres.

(iv) The gutter shall be fixed to the brackets with 2 Nos. G.I. bolts and nuts 6mm dia, each fitted with a pair of G.I. and bitumen washers. The connecting bolts shall be above the water line of the gutters.

(v) For connection to down take pipes, a proper drop end or funnel shaped connecting piece shall be made out of G.S. sheet of the same thickness as the gutter and riveted to the gutter, the other end tailing into the socket of the rain-water pipe. Where over necessary stop ends, angles etc., should be provided.

13.10.2.3 Measurement

The measurement of gutters shall be taken for the finished work in length correct to a cm along the centre line of the gutters. The measured length of the finished gutters will include the length over accessories such as drop ends, stop ends, nozzles and angles, though the rate for the same shall not include the cost of the accessories unless specially described in the item. Laps between the adjacent pieces of gutter and gutter section or between gutter section and accessories shall not be measured.

Accessories such as drop ends, stop ends, nozzles and angles shall be measured and paid for separately. Union clips (loose sockets) shall not be measured separately as they are included in the rate for gutters.

13.10.2.3 Rates

The rate for the gutters shall not, unless otherwise specified in the description of item, include the cost of providing and fixing accessories such as drop ends, stop ends, nozzles and angles. The rate shall include the cost of providing and fixing all union clips (loose sockets), all connecting G.I. bolts, nuts and bitumen and G.I. washers, M.S. flat iron brackets and their fixture to the gutter sections and to the roof members, non-asbestos rope and plastic roofing compound.

Extra over the rate for the gutter shall be paid for providing and fixing accessories, stop ends, drop ends, angles and nozzles. Where brackets of 50 × 3 mm size are provided in place of brackets of 40 × 3 mm size as indicated above extra rate will be paid for separately

13.10.3 FLASHING

When the edge of a roof sheeting, or of a valley gutter is turned up against a wall, the edge shall be weather-proofed with a flashing. The flashing shall be inserted into the brickwork or masonry joints to a depth of 2 inches, the joints being filled up with 1:3 cement mortar unless otherwise specified. It shall be further secured in the joint by means of galvanized iron clip, in at least 4 Inches into the masonry. The lower edge of the flashing shall overlap the sheeting below it by at least 4 inches, the edges of the sheeting and flashing being left free to expand and contract. Wherever flashing has to be laid at a slope, it shall be stepped at each course of the masonry, the steps being cut back at an angle of not less than 30 degrees to the vertical.

Fixing accessories and holes are to be the same as used for the adjoining sheets. Each sheet should be fixed at every purlin or rail by at least two bolts situated at the side laps and three intermediate fastenings for use with galvanized or aluminium corrugated profiles.

In addition to purlin or rail fixings, side laps are to be secured by means of seam bolts at maximum 300 mm centres. The use of self-tapping screws or blind rivets are not permitted. Provide neoprene washers under bolt heads.

Measurement

The length of the valleys and flashing shall be measured for the finished work correct to a cm. The laps along the length of the valley or flashing pieces, including the portion embedded in masonary, shall not be measured.

Rates

The rate for valleys, shall be for all the labour and materials specified above, including painting, cost of seam bolts and the cost of requisite G.I. hook bolts, nuts and washers required over and above those needed for connecting the roof sheets to the roof members. The rate for valleys shall exclude the cost of boarding underneath which shall be paid for separately. The rate for flashing shall be for all the labour and materials specified above, and shall include the cost of painting

13.11 FLAT STEEL SHEET ROOF (G.I. SHEETS)

13.11.1 SCOPE

Unless otherwise specified, plain flat steel sheet roofing shall be constructed. In accordance with the following specifications.

13.11.2 MATERIAL

Unless otherwise specified, material shall conform to the following specifications:

(a) **Flat Steel Sheets**

i) **Sheets**

Flat steel sheets shall be made of ASTMA-36 mild steel, well annealed, even in temper and thickness, free from hales, cracks, blisters and other defects.

The sheets shall be perfectly rectangular and the weight of any ten sheets to be within 7 1/2 per cent margin of the, weights given in below.

The weight and thickness of sheets before galvanizing shall be as follows:

a) No. 24 B.-G.to be 0.02476 inch thick and to weigh 1.01 Ibs/Square foot.
b) No. 22 B.-G.to be 0.03125 inch thick and to weigh 1.27 Ibs/ Square foot.
c) No. 20 B-G.to be 0.039 inch thick and weigh 1. 59 lbs/Square foot.

The allowance for increase in weight by galvanising shall be 2 oz./ square foot.

ii) **Galvanizing**

Galvanized steel sheets shall be thoroughly and evenly coated with zinc and shall be free from stains, bare spots and other defects.

iii) **Painting**

When not galvanized all sheets shall be coated immediately after manufacture with one coated oil-paint applied by dipping or brushing over the whole of the surface of each sheet.

iv) **Dimensions**

The sheets shall be of standard dimensions. The diagonal distance between opposite corner of sheets shall not differ by more than 3/4 inch.

The galvanised flat steel sheets shall be in the form of rolls in accordance with the above specifications.

a) Fixing Accessories

Fixing accessories shall be screws and clips and shall be of approved quality and shall be invariably galvanized.

b) Timber

The timber for Roll Battens/Boarding shall be wooden conforming to the provisions of Clause 16.3 – Woodwork.

13.11.3 ROOFING CONSTRUCTION

a. **Roofing Boarding**

The sheeting shall be laid on boarding of wood of thickness specified. The boarding shall be butt jointed unless specified otherwise with two screws (3”) holding each board to each rafter. Only that side of the boarding shall be wrought which is not covered by sheets.

b. **Roll Battens**

The roll battens shall be of specified wood, 2” by 1-1/2” in section, with the top rounded to the curve of the ridge. They shall be fixed at the correct spacing, in parallel rows and secured to the boarding from underneath with 3” screws spaced not more than 2-1/2 feet apart.

c. **Preparing Sheets**

The longitudinal edges of the sheets shall be curved to a radius of half an inch to that the rolled edge stands ¾ of an inch above the sheet. The top end of the upper most sheet shall be bent up 1-1/2”.

d. **Laying Sheets**

The sheet shall be laid between the battens from the lower edge of the roof upwards. The lower edge of the first sheet shall be held to the planking by galvanized iron clips 6”x3/4”x1/8” at the two edges and then middle. The upper edge shall be kept under the lower edge of the next sheet which shall be held by an equal number of similar clips but 8” long. The 8” clips shall be fixed to the boarding by two screws at one end leaving the other end free for at least 6” to allow the lower sheet to be tucked underneath. The top most sheet, the upper edge of which has already been turned up, will butt against a batten 1-1/2”x1” running between the roll battens and parallel to the ridge plate and the turned up portion shall be screwed to this batten. The turned up longitudinal edges shall be kept down by 2”x1”x1/4” galvanized iron pieces recessed into and screwed to the battens with 2” screws. Two such clips shall be used at the ends and two spaced equally in between.

e. **Preparing and Fixing Rolls**

Rolls shall be made from 5” wide strips bent to a radius of 1” and leaving 1-1/2” gap between the edges. They shall then be slipped down the roll battens so as to enclose the turned edges of the roofing sheets. Rolls shall be held at the lower end, in each case by a clip, 6”x3/4”x1/8” countersunk into the batten and screwed to it.

f. **Ridge Sheeting**

Unless otherwise specified, the ridge shall be made from 2 feet strips, one longitudinal edge of which shall be turned up 1-1/2” to a radius of ½”. The ridge sheet shall be laid on longitudinal planking which shall be of wood and thickness specified, butt jointed and unwrought both sides. The ridge boarding shall be fixed on top of roll battens after the rolls have been fixed in place and shall be secured with 2” screws per board to each roll batten.
The lower longitudinal edge of the ridge shall be secured by clips 6”x3/4”x1/8” screwed to the battens through the boarding, with 2” screws.

g. **Ridge Roll (Wooden)**

The ridge roll shall be made to a radius equal to the thickness of the ridge plate and with the edges separated by thickness of the beam and slipped over the ridge sheets so as to enclose the turned-up edges.

h. **Laps**

Roof sheets and rolls shall not overlap to a length of less than 6”. Ridges, sheets and ridge roll shall not overlap to a length of less than 9”.

i. **Wood Preservative**

Unless otherwise specified, all boarding, battens and fillets shall be given two coats of hot creosote or other approved wood preservative.

j. **Bending by Machine**

A machine of approved type shall be used for turning the edges of sheets and making all rolls. No hammering shall be allowed.

k. **Hips, Valleys, Gutters and Flashings**

Valleys, gutters and flashings shall be made in accordance with the approved drawings. Hips shall conform to the above paras (f) and (g) of the specifications for ridges except that the end is stopped with a piece of galvanized iron sheet cut to fit. The junction between the ridges and hips shall be capped with milled lead sheeting weigh 5 lbs per square foot. The lead sheet cap shall be carefully moulded to fit and shall have less than 9” overlap.

13.11.4 MEASUREMENT:

Length and breadth shall be measured correct to a cm and its area shall be calculated in square metres correct to two places of decimal.

The superficial area of roof coverings shall be measured on the flat without allowance for laps and corrugations. Portions of roof covering overlapping the ridge or hips etc. shall be included in the measurements of the roof.

Roof with curved sheets shall be measured and paid for separately. Measurements shall be taken on the flat and not girthed. The breadth of the roof shall be measured along the rest of the curved sheets.

No deductions in measurements shall be made for opening upto 0.4 sqm and nothing extra shall be allowed for forming such opening. For any opening exceeding 0.4 sqm in area, deduction in measurements for the full opening shall be made and in such cases the labour involved in making these openings shall be paid for separately. Cutting across corrugation shall be measured on the flat and not girthed.

The rate shall include the cost of all the materials and labour involved in all the operations described above except otherwise stated. This includes the cost of roof sheets, polymer coated or L hook, bolts and nuts, bituminous and galvanised iron washers.

13.12 PLASTIC ROOFING (FIBRE GLASS)

13.12.1 SCOPE

The scope of work includes of supply of all materials and construction of plastic (Fibre Glass)roofing complete as shown on drawings in accordance with the specifications and as approved by the Engineer-in-Charge.

13.12.2 MATERIALS

a) The preformed plastic panels or corrugated translucent sheets made from thermosetting polyester resins to comply with BS 4154 and are to match with the profile of the roofing as specified and shown on drawings.

The thickness and colour of plastic panels shall be as designated in drawings. The sheets shall be procured from an approved source.

b) The fixing accessories shall consist of G.I. bolts nut, limpets and washers for installation and jointing of sheets.

c) Roll battens/boards shall be wooden, aluminium and mild steel sections as shown on drawings. The wooden battens and section shall conform with the provisions of Clause 16.3 - Woodwork.
The steel sections shall be made of galvanised steel sections conforming ASTM A-36. The aluminium sections shall be conforming BS 1474.

13.12.3 ROOF CONSTRUCTION

The fibre glass sheets shall be laid on the previously installed boarding frame and firmly secured with the holding accessories following the procedure for flat steel sheets Clause 13.11.3. The over laps and ridges shall be provided in accordance with the provisions of Clause 13.11.3(f) and (g).

13.12.3 MEASUREMENT:

Length and breadth shall be measured correct to a cm and its area shall be calculated in square metres correct to two places of decimal.

The superficial area of roof coverings shall be measured on the flat without allowance for laps and corrugations. Portions of roof covering overlapping the ridge or hips etc. shall be included in the measurements of the roof.

Roof with curved sheets shall be measured and paid for separately. Measurements shall be taken on the flat and not girthed. The breadth of the roof shall be measured along the rest of the curved sheets.

No deductions in measurements shall be made for opening upto 0.4 sqm and nothing extra shall be allowed for forming such opening. For any opening exceeding 0.4 sqm in area, deduction in measurements for the full opening shall be made and in such cases the labour involved in making these openings shall be paid for separately. Cutting across corrugation shall be measured on the flat and not girthed.

The rate shall include the cost of all the materials and labour involved in all the operations described above except otherwise stated. This includes the cost of roof sheets, polymer coated or L hook, bolts and nuts, bituminous and galvanised iron washers.

13.13 WOODEN CEILING

13.13.1 BOARDS

i) Boards shall be of the class of timber and of finished thickness as specified in the description of the item and shall be in accordance with the general specifications for wood work. Only selected boards of uniform width shall be used. Unless otherwise specified in the description of the item or shown in the drawings, the width of boards selected for use shall not be less than 100 mm nor more than 150 mm.

ii) The specific width of boards once selected within these two limits shall be maintained throughout and shall not be varied except in the first and last lines of boards adjustment to the two walls, where remaining odd width shall be adjacent equally on both sides. The maximum length of the board in the finished work shall be 180 cm. The minimum length of board in the finished work shall be such that it will span at least two spacing of the supporting frame work except where shorter lengths are unavoidable, depending on the arrangements of the lines of heading joints which shall be carried out to the pattern ordered by the Engineer-in-Charge.
The boards shall be plained true on the exposed side.

(iii) Unless stipulated otherwise in the description of the item, the longitudinal joints of the boards shall be tongued and grooved, while the heading joints shall be of the square butt type and shall occur under the centre line of the supporting joint. Heading joints in adjacent boards shall not be placed over the same joists, those in alternate boards being arranged in the same line, except where the joints are to be concealed by headings.

13.13.2 FRAME

Generally timber for frame shall conform to the provisions of Clause 16.3 – Woodwork.

Timber frame of the class of timber and section specified in the description of the item or as ordered by the Engineer-in-Charge shall be provided. The width of the frame scantling shall not be less than 50 mm. The arrangements and spacing of the frame scantling shall be as per design furnished. The frame shall be given two coats of approved preservative paint before the boarding is screwed. The frame and paints thereof shall be paid for separately unless specifically included in the description of the item. M.S. angles shall be used for suspending the frame and paid for separately.

The bottom surface of the frame shall be checked and corrected to true plans and slopes as specified and shown on drawings.

13.13.3 MILD STEEL SCREWS

Screws shall be got approved from the Engineer-in-Charge before fixing. They shall be of the slotted counter sunk head type of length not less than the thickness of the board plus 20 mm. The designation number shall not be less than 9 for screws of length 40 to 50 mm and shall not be less than 6 for screws of length 25 to 35 mm.

13.13.4 FIXING

The outer lines of boards shall be accurately fixed, parallel and close to the wall. Each subsequent plank shall be carefully jointed up. The boards shall be fixed to the frame scantling above with two screws at each of frame and one at every intermediate joist. The screws shall be counter sunk and the screw holes filled with putty or sloping out wax.

The unexposed faces of planks shall be painted with wood preservative before fixing.

13.13.5 FINISHING

The exposed side of the boards shall be truely level and plane. The joints shall be truely parallel and/or perpendicular to the walls.

Beadings shall then be fixed to the ceiling, to the size and pattern required. These shall be measured and paid for separately unless specifically included in the description of the ceiling item.

13.13.6 MEASUREMENT:

Length and breadth shall be measured correct to a cm. Areas shall be worked out to nearest 0.01 sqm. The superficial area of the finished work ceiling shall be measured in square metres.

No deduction in measurements shall be made for openings of areas upto 40 square decimetre. Nothing extra shall be payable either for any extra material or labour involved in forming such openings. For openings exceeding 0.40 sqm in area, deductions in measurements for the full opening will be made and in such case any labour involved in making these openings shall be paid for separately in running metres.

Wooden ceiling of boardings fixed to curve surfaces in narrow widths shall be measured and paid for separately and shall include making the joints to proper splay.

Circular cutting and waste shall be measured and paid for separately in running metres.

13.14 CEILING WITH THERMOPORE

13.14.1 THERMOPORE SHEETS

Thermopore Sheets shall be procured from on approved source and shall be of thickness as specified. The thermopore shall comply with ASTM-C578-04sheets. The thermopore sheets shall be fixed on wooden frame for installation as ceiling.

13.14.2 FRAME

Frame of the class of timber and section specified in the description of the relevant item or as ordered by the Engineer-in-Charge shall be provided. The width of the scantlings provided shall be sufficient to provide a minimum nailing surface of 50 mm. The longitudinal and header scantlings shall be so arranged that (a) the sheets can be fixed to form the panel arrangements required as per drawings or as ordered by the Engineer-in-Charge (b) the longitudinal scantling to which the boards are mainly fixed are spaced at 30 to 45 cm centres, the actual spacing selected depending on the width of the cut board in the panel arrangement, (c) all edges of the cut board units are supported either on the longitudinal scantlings or on the header scantlings or on both.

The frame shall be given two coats of approved preservative paint (to be paid for separately) before the thermopore sheets are fixed on wooden frame and will be paid for separately. The frame and painting thereof shall be paid for separately unless specifically included in the description of the ceiling item. Bottom surface of the frame shall be checked and corrected to true planes and slopes.

13.14.3 NAILS

The sheets shall be fixed to the frame scantling with G.I. headless nails 2.24 mm dia when the joints are to be left exposed. Where the joints will be covered with beadings, the sheets are to be fixed to the frames scantlings with G.I. felt headed (clout) nails 2.5 mm dia. The length of the nails shall generally be equal to thickness of sheet plus 25 mm so that their grip on the framing holding members will not be less than 25 mm.

13.14.4 FIXING

The boards shall be laid with lengths parallel to all joints centered over the framing members. Where joints are to be covered, the boards may be spaced 3 to 6 mm apart as described in the respective manufacturers' specifications. Where joints are to be left exposed the sheets shall be butt laid with their edges abutting in moderate contact, but without having to force them into place. The boards shall be supported and held tight to the frame with timber pieces the later being moved outwards as the nailing proceeds. The boards are first nailed to the intermediate framing member proceeding from the centre of the board outwards, the edges being nailed last.

13.14.5 FINISHING

The exposed side of the thermopore sheet frame shall be truly level and plane without any local bulges or sags. The joints shall be truly parallel and/or perpendicular to the walls. The width of joints shall be uniform. Care shall be taken to see that the uniformity of colour of the sheets is not spoilt during the fixing operations.

13.14.6 MEASUREMENT

Length and breadth of the roofing insulation shall be measured correct to a cm and the surface area worked out in square metre of the finished work.

No deduction shall be made for openings of areas upto 40 square decimetre. No extra payment will be made for any extra material or labour involved in forming such openings. For openings exceeding 40 square decimetre in area, deduction for the full opening will be made, but nothing extra will be paid for any extra material or labour involved in forming such openings.

13.15 PAINTING OF ROOF SLAB WITH HOT BITUMEN

13.15.1 SCOPE

Where specified a bitumen coat shall be applied on roof as specified and approved by the Engineer-in-Charge. Unless otherwise approved by the Engineer-in-Charge, the bitumen shall conform to ASTM Designation D-449-89.

13.15.2 PREPARING THE SURFACE

The surface shall be painted only when it is fully dry. The surface to be painted shall be cleaned with wire brushes and cotton or gunny cloth. All loose materials and scales shall be removed and the surface shall be further cleaned with a piece of cloth lightly soaked in kerosene oil.

13.15.3 PAINTING WITH BITUMEN

The contractor shall bring the bitumen to site in its original packing and shall open and use it in the presence of the Engineer-in-Charge or his authorised representative. The containers shall not be removed from the site until the painting job is completed and the Engineer-in-Charge has satisfied himself regarding the quantity of bitumen actually used and has given his permission to remove the empty containers.

The surface prepared and treated shall be painted uniformly with bitumen of approved quality such as residual type petroleum bitumen of penetration 80/100, hot cut back bitumen or equivalent as per specifications of the manufacturer. The coat of bitumen shall be continued 15 cm along the vertical surfaces joining the roof. In case of parapet walls it shall be continued upto the drip courses. Residual type petroleum bitumen of penetration 80/100 shall be heated to a temperature of not less than 180 degree C and not more than 190 degree C and shall be applied on the roof surface at not less than 180 degree C. Similarly, hot cut back bitumen shall be heated to a temperature of not less than165 degree C and not more than 170 degree C and shall be applied on the surface at not less than 165degree C.

Care shall be taken to see that no blank patches are left. The quantity of bitumen to be applied per 10 square metres of roof surface shall be 17 kg, unless otherwise stipulated in the description of the item. It shall be carefully regulated so that the application is uniform at the stipulated rate of 17 Kg. per 10 square metres.

13.15.4 SPREADING SAND

Immediately after painting, dry, clean sharp coarse sand at the rate of 60 cubic decimetre per 10 Sq.m. shall be evenly spread and levelled over the surface when the bitumen is still hot.

13.16 CAST IRON RAIN WATER PIPES

13.16.1 CAST IRON PIPES& FILLING

Cast Iron pipes and fillings shall conform to BS 78 for spigot and socket vertically cast pipes and BS 1211 for spigot and spun pipes. The pipes shall be perfectly, smooth and cylindrical, their inner and outer surfaces being as nearly as practicable concentric. These shall be sound and of uniform castings, free from laps, pin holes or other imperfections and shall be neatly finished and carefully fitted both inside and outside. The ends of pipes shall be reasonably square to their axes. The pipes shall be procured from an approved source.

13.16.2 DIMENSIONS

C.I. rain water pipes shall be of the dia. specified in the description of the item and shall be in full length of 1.8 metre including socket ends of the pipes, unless shorter lengths are required at junctions with fittings. The pipe lengths shall be in each case be with socket. The pipes shall be supplied without ears unless otherwise specifically mentioned. The pipes supplied shall be factory painted (with a tar base composition) both inside and outside which shall be smooth and tenacious. Every pipe shall ring clearly when struck all over with a light hand hammer. When shorter pipes are cut from full lengths they shall be cut with a hacksaw. The sizes, weights, sockets and tolerances of pipes shall be as shown in Table 13.16.

TABLE 13.16
Dimensions and Weight of C.I. Rain Water Pipes

		Nominal size of pipes (Internal diameter in mm)	50	75	100	125	150
1		**PIPE**					
	a)	External diameter in mm	53	79	104	130	156
		Tolerance in mm	± 3	± 3	± 3.5	± 3.5	± 4
	b)	Thickness in mm	3	3	3	3	4
		Tolerance in mm	± 1	± 1	± 1	± 1	± 1
		Nominal size of pipes (Internal dia. in mm)	50	75	100	125	150
	c)	Nominal weight of 1800 mm					
		long pipe without ears in kg	7.50	11	14	20	26
		Tolerance in weight	(-) 10%	(-) 10%	(-) 10%	(-) 10%	(-) 10%
		Tolerance in length in mm	± 13	± 13	± 13	± 13	± 13
2		**SOCKET**					
	a)	Internal diameter in mm	63	89	114	139	167
		Tolerance in mm	± 3	± 3	± 3	± 3	± 3
	b)	Thickness in mm	4	4	4	4	4
		Tolerance in mm	± 1	± 1	± 1	± 1	± 1
	c)	Internal depth in mm	60	65	65	75	75
		Tolerance in mm	± 10	± 10	± 10	± 10	± 10

Note:

1. All dimensions are in mm.
2. Pipes weighing more than the nominal weight may be accepted provided they comply in every other respect with the requirements of the standard.
3. The above table applies only to rain water pipes fixed on wall face.
4. For pipes and fittings which are to be embedded in masonry, specifications shall correspond with those of pipes for soil, waste, and vent pipes.

13.16.3 FIXING AND JOINTING

i) Pipes shall be either fixed on face of wall or embedded in masonry, as required in the description of the item.

ii) Plain pipes (without ears) shall be secured to the walls at all joints with M.S. holder bat clamps. The clamps shall be made from 1.6 mm thick galvanised M.S. sheet of 30 mm width, bent to the required shape and size so as to fit tightly on the socket of the pipe, when tightened with screw bolts. It shall be formed out of two semi-circular pieces, hinged with 6 mm dia M.S. bolt on one side and provided with flanged ends on the other side with hole to fit by the screw bolt and nut, 40 mm long. The clamp shall be provided with a hook made out of 27.5 cm long 10 mm diameter M.S. bar, riveted to the ring at the centre of one semi-circular piece. The clamps shall be fixed to the wall by embedding their hooks in cement concrete block 10 x 10 x 10 cm in1:2:4 mix (1 cement : 2 coarse sand : 4 graded stone aggregate 20 mm nominal size) for which necessary holes shall be made in the wall at proper places. The clamps shall be kept about 25 mm clear off finished face of wall, so as to facilitate cleaning and painting of pipes.

Note:

Where G.I. sheet clamps are not provided, M.S. sheet clamps of 3 mm thick and 20 mm wide shall be used for making the clamps.

iii) The pipes shall be fixed perfectly vertical or to the lines as directed. The spigot of the upper pipe shall be properly fitted in the socket of the lower pipe such that there is a uniform annular space for filling with the jointing material. The annular space between the socket and the spigot shall be filled with a few turns of cotton spun yarn soaked in neat cement slurry. These shall be pressed home by means of caulking tool. More skins of yarn shall be wrapped if necessary and shall be rammed home. The joint shall then be filled with stiff cement mortar 1:2 (1 cement : 2 fine sand) well pressed with caulking tool and finished smooth at top at an angle of 45 degree sloping up. The joints shall be kept wet for not less than 7 days by tying a piece of gunny bag, four fold, to the pipe and keeping it moist constantly.

iv) Where pipes are to be embedded in masonry, these shall be fixed in masonry work as it proceeds. In such cases care shall be taken to keep the pipes absolutely vertical or to the line as directed by the Engineer-in-Charge. The pipe shall have a surrounding of 12 mm minimum thickness of mortar at every portion of the external surface. The mortar shall be of the same mix as is used in the masonry. The joint shall be caulked with lead as soon as the next length of pipe is placed in position. The open end (socket end) of the pipe shall be kept closed till the next length is fitted and jointed, to prevent any brick bats or concrete or pieces of wood falling in and choking the pipe.

The depth of lead from the lip of socket shall be 25 mm minimum. In case of 100 mm dia. 75 mm and 50 mm pipes, the quantity of lead required per joint shall be 1.00 kg, 0.66 kg and 0.50 kg respectively for purpose of reckoning theoretical Consumption.

In order to ensure that required quantity of lead is poured into the joint and to control wastage of lead, at the beginning, three or four samples shall be made and the quantum of lead per joint approved by the Engineer-in-Charge.

The actual consumption of lead should be within ± 5% of the approved sample job subject to the provision that a variation of ± 20% shall be allowed over the theoretical quantity of lead due to dimensional tolerances. This variation includes allowances of wastage also.

v) The spigot end shall butt the shoulder of the socket and leave no gap in between. The annular space between the socket and the spigot will be first well packed in with spun yarn leaving 25 mm from the lip of the socket for the lead. The joint shall then be fully lead caulked approved by the Engineer-in-Charge.

13.16.4 MEASUREMENTS:

The rate shall include in the case of fittings fixed on the face of wall, the cost of all materials and labour involved in all the operations described above including jointing including the supply and fixing the M.S. holder bat clamps in walls and the anchoring concrete. Unless otherwise specified in the description of the item, the rate shall apply for fittings without access doors. In the case of fittings forming part of a rain water pipe line embedded in masonry, the rate shall be for supplying and embedding the fittings in masonry.

13.17 CAST IRON ACCESSORIES FOR RAIN WATER PIPES

13.17.1 C.I. FITTINGS

C.I. accessories such as bends of various degrees, heads, offsets of different projections, branches and shoes shall be of approved quality complying with BS-78.Bends shall be of the nearest standard degree as actually required at site. Heads shall be of the flat or corner type as required. Offsets shall be of the projection as stipulated in the description of the item. Branches shall be single or double as described in the item and shall be of the nearest standard degree as actually required. Standard shoes shall be of overall vertical length, 180 mm for 75 mm dia., 205 mm for 100 mm dia and 275 mm for 150 dia sized pipe from top of socket to lowest tip of shoe. Shoes of longer lengths if used shall be in lengths 300 mm, 375 mm, 450 mm, or 600 mm from top of socket to lowest tip of shoe of as actually required at site.

13.17.2 DIMENSIONS

The fittings shall be of the diameter specified in the description of the item. The thickness of the fittings and details of spigots and sockets shall be same as those of the corresponding size of straight pipes. The fittings shall be supplied without ears unless otherwise specifically mentioned in the item. The fittings shall be factory painted with a tar basis composition both inside and outside which shall be smooth and tenacious. Every fitting shall ring clearly when struck all over with a light hard hammer. The fittings shall be of standard size and their individual weights shall conform to the weights given in the Table 13.17.

TABLE 13.17
Weight of C.I. Rain Water Pipe Fittings

Sr. No.	Description	75 mm dia	100 mm dia	150 mm dia	Unit
		Kgs.	Kgs.	Kgs.	
1.	Bends (Plain)	3.20	4.50	9.10	Each
2.	Offsets (Plain)				
a)	55 mm projection	2.70	5.00	8.20	Each
b)	75 mm projection	3.20	5.50	9.10	Each
c)	115 mm projection	4.10	5.90	9.50	Each
d)	150 mm projection	4.50	6.40	10.40	Each
e)	225 mm projection	5.00	7.30	11.80	Each
f)	300 mm projection	6.00	8.60	12.70	Each
Sr. No.	Description	75 mm dia	100 mm dia	150mm dia	Unit
		Kgs.	Kgs.	Kgs.	
3.	Branches (Plain)				
	Single	5.00	7.30	14.50	Each
	Double	6.80	10.00	19.10	Each
4.	Standard shoes (Plain)	3.20	4.10	8.60	Each
5.	Longer shoes (Plain)				
a)	300 mm	3.20	5.00	-	Each

b)	375 mm	4.10	5.50	-	Each
c)	450 mm	5.50	6.40	-	Each
d)	600 mm	7.30	8.60	-	Each
6.	Heads	6.40	6.80	11.30	Each
7.	Extras:				
a)	For ears cast on any fitting and short pipes	0.90	0.90	1.35	Each
b)	For inspection doors fitted on any fitting	1.80	1.80	2.25	Each

Note:

1. The above table applies only to rain water fittings which are part of pipe lines fixed on wall face. Permissible tolerance in weight of fittings shall be 5%.
2. For fittings to be used with pipe lines to be embedded in masonry, specifications shall correspond with BS 437 of pipe fittings for soil, waste and vent pipes.
   Fixing and jointing shall be as specified in 13.16.3(iii).

13.17.3 MEASUREMENTS:

The rate shall include in the case of fittings fixed on the face of wall, the cost of all materials and labour involved in all the operations described above including jointing including the supply and fixing the M.S. holder bat clamps in walls and the anchoring concrete. Unless otherwise specified in the description of the item, the rate shall apply for fittings without access doors. In the case of fittings forming part of a rain water pipe line embedded in masonry, the rate shall be for supplying and embedding the fittings in masonry.

13.18 UPVC PIPES FOR ROOF DRAINS

These pipes and fittings conform to ISO 3633 and EN 1329 and available in 50, 75,110 and 160 mm outside dia. in standard length of 3 to 4 meters.

Sr. No	Nominal Size	Nominal Outside Dia (dn)	Wall Thickness	
			Min	Max
1	50	50	3.0	3.5
2	75	75	3.0	3.5
3	110	110	3.2	3.8
4	160	160	3.2	3.8

13.18.1 JOINTING METHODS

A. Solvent Cement Jointing

For jointing pipe to pipe or pipe to fitting with solvent cement, both parts are to be joined must be clean and dry. Chamfer the pipe end and remove any dust or grease from both ends/sides. Apply cement solvent cement using a paint brush on both sides of spigot end and the inside socket, then insert the spigot end fully into the socket edge with a panel or felt tip pen on the pipe. Remove excess solvent cement with dry cloth. The joint may be tested after 24 hours or as per instructions of Engineer-in-Charge.

B. Rubber Ring Push Fit Jointing:

Clean pipe's spigot and form the outside and the sealing groove of the fitting from inside. Insert rubber ring into the socket end of the pipe/ fitting. To avoid dislocation during/ after jointing (pipe to fitting or pipe to pipe), always ensure that the rubber ring is fixed in the right direction. Apply the lubricant (soap solution) uniformly to the spigot end and sealing ring. Push the spigot end into the socket containing sealing end, until fully fixed. Prior to insertion mark the position of socket edge on the wall pipe with a pencil or felt tip pen and withdraw the pipe from the socket by approximately 10mm to allow for the thermal expansion.

13.18.2 MEASUREMENT:

The fittings shall be measured by numbers. The pipes shall be measured net when fixed correct to a cm. excluding all fittings along its length.

The rate shall include the cost of all materials and labour involved in all the operations described above including jointing but excluding the supply and fixing of wall plugs and PVC clips which shall be paid for separately.

Note : These pipes shall be used only in shaft or unexposed location to avoid damage to these pipes due to willful act.

13.19 SPRAYED POLYURETHANE ROOF TREATMENT SYSTEM

13.19.1 GENERAL

The roof waterproofing system shall be as follows:

- **Layer 1:** Sprayed foam of polyurethane complying with BS 5241-part 1 applied to provide a maximum thermal transmittance value of 0.60 W/m^2. °C and with a thickness not less than 35 mm.
- **Layer 2**: Liquid protective membrane applied to a minimum dry film thickness of 800 microns.
- **Layer 3:** A protection layer of 100 grams per square meter (g/sm) of geotextile.
- **Layer 4:** Grade 20 concrete protective screed applied to slope with a minimum thickness of 50 mm and slope not less than 1:80

13.19.2 MATERIALS

A. Polyurethane Foam

The polyurethane foam shall be sprayed to a minimum thickness of 35 mm. The basic component of the polyurethane foam shall be polyol resin and isocynate liquid which are pumped under pressure in metered amounts. The blowing agent in the polyol resin shall be environmentally friendly, meeting the requirements of environmental local authorities. During spraying operation, the temperatures, pressures, and volumes of mixing shall be properly controlled as per manufacture's recommendation to achieve the required physical properties listed in table.

Physical Property	Test Result	Test Method
Min Core Density	36 Kg/m^2	
Min Compressive Strength	2.0 Kg/cm^2	Method 3 of BS 4370 Part 1
Max Thermal Conductivity (initial Value)	0.018 W/mk	Method 7 of BS 4370 Part 2
Max Water Absorption (by volume)	6.5 %	Appendix B of BS 5241 Part 1
Min Closed Cell Content (by volume)	90%	Method 10 of BS 4370 Part 2

The containers for the raw materials of the sprayed PU foam shall have the manufacturer's name, product identification and shelf life clearly printed.
The waterproofing system materials quality shall be checked on a regular basis. Initially test specimens should be taken from every 100 m^2. Once satisfactory standard has been established the area per test shall be increased to 500 m^2.

B. Protective Waterproofing Coating
The protective waterproofing coating shall be cold liquid applied to form a seamless membrane. The coating shall be a one component moisture curing based on polyurethane elastomer. The finished surface shall provide an elastomeric, flexible membrane that is free from pin- holes, blisters and any other defect. All coating components shall be compatible with the foam to avoid any chemical reaction. The finished membrane shall have a minimum elongation of 300% and a recovery of 90%. The minimum dry film thickness shall not be less than 800 microns.

C. Geotextile Sheet:
A layer of 100 gsm of non-woven needle punched geotextile sheet. The sheet shall be made from continuous thermally bonded polypropylene filaments.

D. Protective Screed
The screed concrete shall be complied with clause 5.8 of section 5 (Plain and Reinforced Concrete) of this specification. Joints and expansion joints in the screed shall be treated with approved sealant.

E. Coating for Exposed Areas
Whenever coating is required to be used in exposed areas, the coating shall be especially formulated to resist the effect of sun light and provide waterproofing properties. The coating applied shall be cold liquid applied and shall form a seamless membrane after application. The coating shall be based on polyurethane and the ultimate elongation of the finished product shall not be less that 120%.

13.19.3 WORKMANSHIP

A. Surface Preparation
Before application of foam the roof slab shall be dry and cleaned to remove loose particles, dust, laitance, efflorescence, etc. Surfaces must be approved by the Engineer prior to application including fillet application. No other activity shall be permitted on the roof during the application of polyurethane foam. The end levels of application shall be marked from datum.

B. Polyurethane Foam Application

Spraying shall be carried out when the weather is within the following conditions unless approved by the Engineer-in-Charge:

- Wind speed is not excessive to disrupt the spraying operation and cause damages to the adjacent properties.
- Relative humidity is not in excess of 90%
- Temperature within the manufacturer allowable limits
- No rain or imminent rain condition.

The foam shall be applied in layers as recommended by the supplier such that the total specified minimum thickness is built up in layers and the cells of the PU foam are vertical. The first coat or layer (Flash coat) shall be thinner than the subsequent layers. The time required between one layer and the other shall not be less than 2 minutes and not greater than 15 minutes. The finished surface shall be even and smooth without pinholes, discontinuities or undulations.

C. Protective Membrane Application

The liquid protective membrane shall be applied in accordance with the manufacturer's recommendations. The membrane shall be applied to the PU foam as soon as possible but not before the foam is completely dry (follow manufacturers specifications). Particular attention shall be given to locations where it is likely to have failures such as water spouts, up stands, edges, etc. The finished surface of the membrane shall be free from pin holes and it shall not have any uncurled areas or any other observable defects.

D. Geotextile Sheet Layer

The Geotextile sheet shall be placed directly over the coating when the coating is dry. The sheet shall be placed after conducting the flood test. Adequate time shall be given for the coating to cure as recommended by the manufacturer. Overlaps in the geotextile sheet shall be at least 200mm and all joints shall be sealed by the approved waterproof coating.

E. Roof Screed

Screed shall be laid to the thickness and falls shown on the approved detailed drawings to a minimum thickness of 50mm and shall be kept wet and protected and cured as per direction of Engineer-in-Charge. Care shall be taken to ensure that screeds are level at abutments with walls etc. The screed shall be constructed to a slope not less than 1:80 and finished evenly.

13.19.4 MEASUREMENT:

Length and breadth of the roofing insulation shall be measured correct to a cm and the surface area worked out in square metre of the finished work.

No deduction shall be made for openings of areas upto 40 square decimetre. No extra payment will be made for any extra material or labour involved in forming such openings. For openings exceeding 40 square decimetre in area, deduction for the full opening will be made, but nothing extra will be paid for any extra material or labour involved in forming such openings.

13.20 EXTRUDED POLYSTYRENE BOARD ROOF TREATMENT SYSTEM

13.20.1 GENERAL

The roof treatment system is conducted by using two method

13.20.2 METHOD-I:

Layer 1: Application of water proofing layer, laying of bitumen coating at the rate of 34 lbs/100ft^2(1.7 kg/m^2) of surface area or 1/16" thick is given for making the roofs water proof or by the application of water proofing chemical as per drawings or direction of Engineer-in-Charge.
Layer 2: Laying of polyurethane board.
Layer 3: Laying of polythene sheet of specified gauge as mentioned on drawings or as per direction of Engineer-in-Charge.
Layer 4: Provision of mud layer of the thickness given in drawings.
Layer 5: Cement mortar of 1 inch thickness.
Layer 6: Laying of roof tiles.

13.20.3 METHOD-II:

Layer 1: Application of water proofing layer, laying of bitumen coating at the rate of 34 lbs/100ft^2(1.7 kg/m^2) of surface area or 1/16" thick is given for making the roofs water proof or by the application of water proofing chemical as per drawings or direction of Engineer-in-Charge.
Layer 2: Laying of polyurethane board.
Layer 3: Laying of polythene sheet of specified gauge as mentioned on drawings or as per direction of Engineer-in-Charge.
Layer 4: Application of foam concrete.
Layer 5: Laying of roof tiles.

13.20.4 MATERIALS

A. Extruded Polystyrene Board

The polystyrene board XPS board is provided as discussed above in 25,38,50,75 mm (1", 1.5", 2", 3") respectively thicknesses. This is board have highly water resistant, lower values of thermal conductivity, high resistant to freeze and thaw cycle, non-toxic, light weight, long life available in sizes of (LxW) 6ft x 3ft, 8ft x 3ft, 6ft x 2ft, 8ft x 2ft. The edges profiles of the sheets for joining may be of butt joint, ship lap and Tung and grove type. To achieve the best quality the board should fulfil the following requirements as given in the table given below.

Measurement

Length and breadth of the roofing insulation shall be measured correct to a cm and the surface area worked out in square metre of the finished work.

No deduction shall be made for openings of areas upto 40 square decimetre. No extra payment will be made for any extra material or labour involved in forming such openings. For openings exceeding 40 square decimetre in area deduction for the full opening will be made, but nothing extra will be paid for any extra material/labour involved in forming such openings.

Board fixed to curved surfaces in narrow widths shall be measured and paid for separately. Circular cutting and waste shall be measured and paid for separately in running metres.

Sr.No	Item	Unit	Result	Testing Method
1	Colour	------	Pink, Green, Blue	
2	Cell Structure	--------	Closed very fine	
3	Density (min)	Kg/m^3	32~38 ± 10%	BS 4370 Method 2
4	Thermal Conductivity.	BTU in/ft^2.hr.°F W/mk	0.199 0.026	ASTM C-518 KS M 3808-05
5	Compressive Strength	KPa	250~400	ASTM D 1621
6	Coefficient of linear thermal expansion	mm/mk	0.07	BS 4370 Method 13
7	Temperature Limits	°C	-50/ +75	------
8	Fire classification	------	A	BS 3837 Part 1 1986

13.21 PLASTER OF PARIS (GYPSUM ANHYDROUS) CEILING OVER WOODEN STRIPS

13.21.1 Frame

The frame work shall be of the specified wood. In case of sloping roofs, wooden battens of suitable section (depending upon the span and load to be carried) shall be firmly fixed as main supports, to the underside of the tie beams of the trusses at required spacing by means of bolts and nuts of proper size. In case of flat roofs, the battens shall be securely fixed to the walls and pillars by holding down bolts and shall be fastened to the slabs above with iron straps of suitable sections and encroached therein. Cross battens of 50 x 40 mm sections at 40 cm centres or so, shall then be fixed at right angles to the main battens. The frame work shall be treated with approved wooden preservative before fixing. The underside of the frame work shall be true to planes and slopes.

The frame work for ceiling shall be paid for separately unless specifically included in the description of the ceiling item.

13.21.2 Wooden Strips

Wooden strips of size 25 x 6 mm of first class kailwood, (unless otherwise stipulates specifically in the description of the item) shall be fixed to the cross battens, in the parallel rows with gaps of 10 mm in between adjacent rows, by means of felt headed (clout) nails. The strips shall be fixed butt jointed and not overlapped. The joints shall be staggered. The minimum length of strips to be used shall be 1.5 m depending upon the length of strips required.

13.21.3Wire Mesh

Wire mesh shall then be fixed to the underside of wooden strips and their junctions with the battens with nails at pitch of 15 to 20 cm as ordered by the Engineer-in-Charge. The rabbit wire mesh shall be straight, tight and perfectly true to planes and slopes and without any sagging and shall be slightly below the underside of the laths to allow the plaster to encase the metal round.

13.21.4 Plaster of Paris

The plaster of Paris shall be of the calcium-sulphate semi-hydrate variety. Its fineness shall be such that when sieved through a sieve of IS sieve designation 3.35 mm for 5 minutes the residue left on it after drying shall be not more than 1% by weight. It shall not be too quick setting. Initial setting time shall not be less than 13 minutes. The average compressive strength of material determined by testing 5 cm cubes after removal from moulds, after 24 hours and drying in an oven at 40degree C till weight of the cubes is constant, shall not be less than 84 kg per square metre.

13.21.5 Applications

The material will be mixed with water to a workable consistency. Plaster of Paris shall be applied to the underside of the laths over the rabbit wire mesh in suitable sized panels and finished to a smooth surface by steel trowels. The plaster shall be applied in such a manner that it fully fills the gaps between the laths and the thickness over the laths is as specified in the description of the item. The joints shall be finished flush to make the ceiling in one piece. The finished surface shall be smooth and true to plane, slopes or curves as required.

13.21.6 Measurements

Length and breadth of superficial area of the finished work shall be measured correct to a cm. Area shall be calculated in square metre correct to two places of decimal. No deduction will be made to openings of areas upto 40 square decimetre nor shall extra payment be made either for any extra material or labour involved in forming such openings.

For openings exceeding 40 square decimetre in area, deduction in measurements shall be made but extra payment will be made for any extra material or labour involved in making such openings.

Curved surfaces shall be measured and paid for separately from flat surfaces. The work shall be deemed to comprise of flat surfaces only unless specifically stated otherwise in the description of the item.

Any sunk or raised mouldings in the plaster shall be measured and paid for separately, deductions being made from plastering on ceiling only if the width exceeds 15 cm. Ceiling at a height greater than 5 metres shall be so described and measured separately stating the height.

13.21.7 Rate

The rate shall include the cost of all materials and labour involved in all the operations described above including all scaffolding, staging etc. The frame work mentioned in above supporting the ceiling will be paid for separately unless otherwise stipulated in the description of the item.

The rate does not include for any raised or sunk mouldings or for any patterned finishing of the surface which will be measured and paid for extra over the plaster work.

13.22 MEASUREMENT AND PAYMENT

13.22.1 COMPOSITE RATE

The measurement and payment for the items of the work of Roofing hereof shall be made corresponding to the applicable CSR items as provided in Contract Agreement and shall constitute full compensation, for procurement, transportation, performance in all respects and completion of work as specified including the site clearance as approved by the Engineer-in-Charge.

13.22.2 LABOUR RATE

The measurement and payment for the items of the work of Roofing hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurement transportation, performance in all respects and completion of work as specified including site clearance, as approved by the Engineer-in-Charge except the cost of materials to be provided by Department at designated location as defined in the Contract Agreement.

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14. FLOORING

14.1 GENERAL

The tier or levels which divide a building in two stages or storeys are called floors. These are made of materials quite different both in composition and construction. They range from relatively thin covering, contributing little or no structural strength to a building, to much thicker materials capable of withstanding reasonable stresses, and in some designs, essential to the strength of the building.

14.2 EARTH FLOORING

14.2.1 SCOPE

Unless otherwise specified, earth flooring shall be constructed in accordance with the following specifications.

14.2.2 MATERIAL

Earth (clay) shall conform to following Specifications:

Source: Clay shall be obtained from good earth containing 20 % to 30% fine sand.

Quality: Clay shall not contain more than 0.5% soluble salts more than 0.2% sulphate and more than 4% organic contents. It shall not contain any gravel, coarse sand, kanker roots of the grass and plant.

14.2.3 LAYING AND CONSOLIDATION

Earth shall be placed in layers of six inches and shall be sprinkled with water and rammed to such an extent that a layer of 6 inch thick loose earth evenly spread is reduced to 4 inches in thickness. The consolidated surface shall be such that a very faint impression can be made on it with the heel of a boot or the blow of a rammer.

14.2.4 MEASUREMENTS

Length and breadth of the flooring shall be measured correct to a cm and area shall be calculated in square metres correct to two places of decimal. Length and breadth shall be measured before laying skirting, dado or wall plaster. No deduction shall be made nor extra paid for voids not exceeding 0.20 sqm. Deduction for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 sqm.

14.3 MUD FLOORING

14.3.1 SCOPE

Unless otherwise specified, mud flooring shall be constructed in accordance with the following specifications.

14.3.2 MATERIAL

a) Earth (clay) shall conform to Specifications as mentioned above 14.2.
b) Mortar shall conform to Specifications in Section 11- Brickworks Mud Mortar.

Laying

After laying earth floors as per Specifications 14.2 for Earth Flooring, the surface shall be finished with one-inch-thick mud plaster with *gobri leeping* conforming to Specifications in Section 15.1.12 for Mud Plaster.

14.3.3 MEASUREMENTS

Length and breadth of the flooring shall be measured correct to a cm and area shall be calculated in square metres correct to two places of decimal. Length and breadth shall be measured before laying skirting, dado or wall plaster. No deduction shall be made nor extra paid for voids not exceeding 0.20 sqm. Deduction for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 sqm.

14.4 BRICK OR TILE FLOORING

14.4.1 SCOPE

Unless otherwise specified brick or tile flooring shall be constructed in accordance with the following specifications:

14.4.2 MATERIAL

a) Brick or tile shall conform to Specifications as mentioned in Section 11 for Clay Bricks.
b) Mortar shall conform to Specifications as mentioned in Section 11– Brickwork, Mortars.

14.4.3 BASE

The construction and preparation of base for ground floor and subsequent levels shall comply with the provisions of Clause 14.10.

14.4.4 WETTING OF BRICKS/TILES

Bricks or tiles shall be wetted in accordance with the Specifications mentioned in Section 11 for Brick work

14.4.5 PATTERN

The laying of bricks or tiles shall be plain, diagonal, herring-bone or any other specified pattern.

14.4.6 JOINTS

a) Where pointing is not to be done the Joints shall not exceed 3/16 inch in thickness. The mortar oozing out of the joints shall be struck off with trowel or wiped off with damp cloth.
b) Where pointing is to be done the joints shall not exceed 3/8 inch in thickness. The mortar in the Joint shall be raked out one inch deep while it is still green.

14.4.7 POINTING

Otherwise specified, the joints shall be flush pointed with specified mortar.

14.4.8 THICKNESS OF BEDDING MORTAR

Unless otherwise specified the floor shall be laid on 3/4-inch-thick minimum bed of specified bedding mortar spread evenly on the base.

14.4.9 LAYING OF BRICKS/TILES

Bricks/tiles shall be laid with specified mortar in position on the bedding mortar.

14.4.10 PROTECTION

Flooring shall be allowed to mature, undisturbed, and protected from the effects of weather. It shall be kept wet for at least 7 days after completion. If pointing is to be done, it shall be kept wet for at least 14 days after the completion of pointing.

14.4.11 SURFACE

Surface shall be finished to specified levels. All joints shall be uniform, true and parallel and square bricks shall be rubbed to ensure this where it is very necessary, without extra cost.

14.4.12 EDGE WITH BULL NOSED BRICKS

No damaged bricks or tiles shall be used. Bats shall not be used except to close any course of bricks or tiles. Unless otherwise specified, the overhanging edge of the paving shall be finished off by special bull-nosed bricks.

14.4.13 MEASUREMENTS

Length and breadth of the flooring shall be measured correct to a cm and area shall be calculated in square metres correct to two places of decimal. Length and breadth shall be measured before laying skirting, dado or wall plaster. No deduction shall be made nor extra paid for voids not exceeding 0.20 sqm. Deduction for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 sqm.

14.5 MARBLE TILE FLOORING

14.5.1 SCOPE

Unless otherwise specified marble flooring shall be constructed In accordance with the following specifications.

14.5.2 MARBLE

Marble slabs of an approved quality shall be used. The marble shall be super white, Lasbela, Ziarat, Loralai or Badal as specified.

14.5.3 MORTARS

Cement sand mortar on which marble tiles are placed shall be 1:3 unless otherwise specified

14.5.4 BASE

For ground and subsequent floors, the base shall be laid as per Specifications 14.10.

14.5.5 SIZE COLOUR AND PATTERN

Marble shall be of the size colour and pattern, as specified.

14.5.6 THICKNESS DRESSING OF EDGES AND JOINTS

All slabs shall have a true plain surface and shall be accurately sawn; truly square at edges to the full thickness. All marble slabs shall have a minimum thickness of 3/4" of an Inch. No Joints shall be more than 1/16 of an Inch in thickness. Slabs projecting over the edges of veranda or steps shall have their edges finished with a bull-nosed ending.

14.5.7 PREPARATION OF BASE

Before laying marble slabs, the surface of the base shall be washed and scrubbed with wire brushes. Where they are to be laid directly over roof slab, the later shall be roughened while it is still green.

14.5.8 THICKNESS OF BEDDING MORTARS

Marble slabs shall be laid over Specified bedding mortar not more than 3/4 of an inch thick.

14.5.9 LAYING

Slabs shall be laid in position on bedding mortar in specified pattern. The joints shall be filled with specified putty.

14.5.10 LEVELS

The surface of marble slabs when laid shall be perfectly true, level, projected or sloped.

14.5.11 PROTECTION AND CURING

The floor shall be protected from the effects of weather. During the progress of work and for 10 days after laying the floor shall be kept watered. Three clear days shall be given for setting before anyone is allowed to walk over, but no weight shall be brought on the surface till 7 clear days have elapsed after the completion of laying.

14.5.12 POLISHING

The day after the tiles are laid all joints shall be cleaned of the cement grout containing matching pigment with a wire brush or trowel and all dust and loose mortar removed and cleaned. Joints shall then be grouted with grey or white cement mixed with or without pigment to match the shape of the marble tiles.

The surface shall thereafter be grounded evenly with machine fitted with coarse grade grit block (No. 60). Water shall be used profusely during grinding. After grinding the surface shall be thoroughly washed to remove all grinding mud, cleaned and mopped. It shall then be covered with a thin coat of grey or white cement, mixed with or without pigment to match the colour of the topping of the wearing surface in order to fill any pin hole that appear. The surface shall be again cured. The second grinding shall then be carried out with machine fitted with fine grade grit block (No. 120).

The final grinding with machine fitted with the finest grade grit blocks (No. 320) shall be carried out the day after the second grinding described in the preceding para or before handing over the floor, as ordered by the Engineer-in-Charge.

For small areas or where circumstances so require, hand grinding/polishing with hand grinder may be permitted in lieu of machine polishing after laying. For hand polishing the following carborundum stones, shall be used:

1st grinding	—	coarse grade stone (No. 60)
Second grinding	—	medium grade (No. 80)
Final grinding	—	fine grade (No. 120)

In all other respects, the process shall be similar as for machine polishing. After the final polish, oxalic acid shall be dusted over the surface at the rate of 33 gm per square metre sprinkled with water and rubbed hard with a pad of woollen rags. The following day the floor shall be wiped with a moist rag and dried with a soft cloth and finished clean.

If any marble tile is disturbed or damaged, it shall be refitted or replaced, properly jointed and polished. The finished floor shall not sound hollow when tapped with a wooden mallet.

14.5.13 MEASUREMENT

Length and breadth shall be measured before laying skirting, dado or wall plaster. No deduction shall be made nor extra paid for voids not exceeding 0.20 sqm. Deductions for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 sqm.

The flooring done either with strips (in one operation) or without strips (in alternate panels) shall be treated as same and measured together.

14.5.14 RATE

Marble stone flooring with different kind of marble shall be measured separately and in square metre correct to two places of decimal. Length and breadth shall be measured correct to a cm before laying skirting, dado or wall plaster. No deduction shall be made nor extra paid for voids not exceeding 0.20 square metre. Deductions for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 square metre. Nothing extra shall be paid for laying the floor at different levels in the same room. Steps and treads of stairs paved with marble stone slabs shall also be measured under the different item of work. The width of treads shall be measured from the outer edge of the nosing, as laid, before providing the riser.

14.6 GLAZED TILE OR CEMENT TILE FLOORING

14.6.1 SOURCE

Unless otherwise specified, the work of glazed tile or cement tile flooring shall be done in accordance with the Specifications 14.4 for Brick or Tile Flooring in all respects, except with the following modifications:

14.6.2 GLAZED TILES

The glazed tiles shall be of an approved quality as specified hereunder.

a) **Composition**

Glazed tiles shall be manufactured from ball clay, china stone & flint fired to not less than 1200 ˚C.

b) **Quality**

The tiles shall be non-slippery fully glazed on the face, uniform in colour free from cracks and other defects arises to be sharp and true.

c) **Shape**

Tiles shall be true and even face and even thickness throughout. The backs shall be with bond undercut key sufficient to ensure a good grip of the fixing medium. For wall tiling the tiles shall have holed formed in the edges to take galvanized or copper clamps.

14.6.2.1 MEASUREMENTS

Length and breadth shall be measured before laying skirting, dado or wall plaster. No deduction shall be made nor extra paid for voids not exceeding 0.20 sqm. Deductions for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 sqm. The flooring done either with strips (in one operation) or without strips (in alternate panels) shall be treated as same and measured together.

14.6.3 CEMENT TILES

Cement tile shall be of an approved quality as specified. All tiles shall be laid in water for 36 hours before they are laid. The joints shall not be more than 1/16 of an inch which shall be grouted with cement, matching the colour of the tiles. When necessary the tiles shall be cut with wire saw to the exact size having a clean sharp edge so as to have fine joints. Saw dust shall be used as the work proceeds for removing stains etc.

MEASUREMENTS

Length and breadth shall be measured before laying skirting, dado or wall plaster. No deduction shall be made nor extra paid for voids not exceeding 0.20 sqm. Deductions for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 sqm.

14.7 MOSAIC TILES FLOORING

Unless otherwise specified mosaic tile flooring shall be done in accordance with the Specifications No. 14.4 For Brick or Tile Flooring in all respect, except with the following modifications: -

The mosaic tiles shall conform to the following Specifications:

14.7.1 SOURCE

The mosaic tiles shall be obtained from an approved source. If manufactured by the Employer through a contractor, the method of manufacturing shall be 'approved by the Engineer-in-charge.

14.7.2 QUALITY

Tiles shall be hydraulically pressed and fully cured. They shall be uniform in colour, free from cracks and other defects like efflorescence and crazing, the arises to be sharp and true. Pattern tiles shall bear the approved pattern on their faces. Mosaic tiles shall have polished surfaces. The constituent materials shall be as specified by the Engineer-in-charge.

14.7.3 SHAPE

Tiles shall be true and even on face and of even thickness throughout. The backs shall be with bond under-cut key sufficient to ensure a good grip of the fixing medium. For wall tiling, tiles shall have holes formed in the edges to take galvanized or copper cramps.

14.7.4 SIZE

The size of the tile shall be as specified.

14.7.5 TEST

A fully dried tile when immersed in water for any length of time shall not absorb water more than 2.5 per cent of the weight of dry tile.

14.7.6 LAYING OF TILES

All tiles shall be kept in water for 36 hours before they are laid.

The joints shall not be more than 1/16 of an inch which shall be grouted with specified mortar.

The joints shall be rubbed with very fine carborandum stone so that slight projections or edges of mortar etc. rising above the surface of tiles are levelled.

14.7.7 MEASUREMENTS

Length and breadth shall be measured before laying skirting, dado or wall plaster. No deduction shall be made nor extra paid for voids not exceeding 0.20 sqm. Deductions for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 sqm.

14.8 DRY BRICK PAVING

14.8.1 SCOPE

Unless otherwise specified dry brick paving shall be done in accordance with the following specifications

14.8.2 MATERIAL

a) Bricks shall conform to Specifications as mentioned in Section 11 for Clay Bricks.
b) Sand shall conform to Specifications No. 14.10 for Base for Flooring.
c) Mud mortar shall conform to Specifications as mentioned in Section 11 - Brickwork.

14.8.3 PREPARING SURFACE

The ground surface shall be thoroughly watered, well rammed and shall be dressed to the specified slope, camber or cross grade.

14.8.4 LAYING

Bricks shall be laid dry, on edge or flat in the specified pattern over half an inch-thick mud plaster given on the surface. The joints shall not exceed one quarter of an inch in thickness. After laying the bricks the Joints shall be sand grouted. Where required, the joints shall be filled with specified cement sand mortar.

14.8.5 MEASUREMENT

Length and breadth of the flooring shall be measured correct to a cm and area shall be calculated in square metres correct to two places of decimal. Length and breadth shall be measured before laying skirting, dado or wall plaster. No deduction shall be made nor extra paid for voids not exceeding 0.20 sqm. Deduction for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 sqm.

Brick flooring when laid in diagonal herring bone bond or other pattern as specified or directed by the Engineer-in-Charge shall be measured separately.

14.9 WOODEN FLOORS

14.9.1 FLOOR BEARER GROUND FLOOR

In the case of ground floors, floor joists (bridging joists) shall rest on pillars, dwarf walls, rails or beams as may be specified.

The plinth under the flooring shall be excavated to the depth specified by the Engineer-in-charge and dressed level and rammed. If directed a suitable protective layer as approved by the Engineer-in-Charge shall be laid otherwise dwarf walls or pillars shall be built on the specified concrete foundation. The dimensions and spacing shall be as indicated in the drawings or otherwise directed by the Engineer-in-Charge.

14.9.2 FLOOR BEARER SUSPENDED FLOORS

In the case of upper floors, the bridging joists shall rest on wall plates, beams, rails or on other joists as shown on the drawings, or otherwise directed by the Engineer-in-Charge.

14.9.3 FLOOR BEARERS MATERIAL AND FIXING

The timber for the floor joists shall be of the kind specified and shall be in accordance with the specifications for wood work. The full number of joists for each continuous floor shall be laid and dressed to one level and tested before flooring is commenced.

14.9.4 PRESERVATIVES

All joists wall plates, bearers and the underside of planking shall be given two coats of hot wood preservative such as solignum creosote or coal tar as directed by the Engineer-in-Charge. The rate does not include this work, which shall be paid for separately according to the rates for painting with these materials.

14.9.5 BOARDING MATERIALS AND SIZE

The boarding for the floor shall not be planned on the underside in the case of ground floors and suspended floors to be coiled. Unless otherwise specified or shown in the drawings, in the case of deodar, kail or chir wood, the boards or battens shall be 1-1/2”, inches thick, not more than 6” inches wide and not more than 20 feet long. In the case of teak, they shall be 1-inch-thick, 4 inches wide and as long as possible. No board shall be less than 6 feet long, the ends being truly squared up after any split portion has been sawn off. All boards shall be uniform and parallel in width and shall have the same thickness.

14.9.6 JOINTS

The planks shall be planed true on one side (on both sides for uncoiled upper floors) the edges to be planed, rebated or tongued and grooved as directed by the Engineer-in-charge. Unless otherwise specified, the edges shall be tongued and grooved, with concealed joints for teak wood floors, and rebated joints for other floors.

14.9.7 PLANKING METHOD OF LAYING

The outer lines of boarding shall be accurately fixed paralleled with and close to the wall. Each subsequent line shall have the side joints carefully joined up and shall then be cramped into position by floor cramps, and nailed or screwed as specified, so that the heads shall be sunk below the finished surface of floor, or otherwise fixed with "secret joints". The cramps shall not be removed until the nails or screws have been fixed. The ends of plank shall rest on the centre of joist, and the ends of no two adjacent planks shall be on the same joist. Paved floors shall be stopped under a brass strip screwed to wooden floors where the two meet.

14.9.8 NAILS AND SCREWS

The nails or screws shall be subject to the approval of the Engineer-in-charge and shall have a length at least twice the thickness of the plank, two being used at each end and one at every Intermediate joist alternately on opposite sides of the plank. All screws shall be oiled before Insertion.

14.9.9 PLANNING

After the floor has been laid, it shall be planned in both directions and made perfectly smooth. All depressions in the wood nail holes and all small defects of every kind, where permitted by the Engineer-In-charge to remain in the work, shall unless otherwise specified, be filled with "Beaumont age" or stopping out wax.

14.9.10 MEASUREMENT

Length and height shall be measured correct to a cm and its area shall be calculated in sqm correct to two places of decimals for a specified the thickness. Length shall be measured as the finished length of skirting. Height shall be measured from the finished level of floor correct to 5 mm.

14.10 BASE FOR FLOORING

Unless otherwise specified, the base of all ground floors shall be constructed in accordance with the following specifications:

14.10.1 PREPARATION OF SUB-BASE

Earth (clay) conforming to following Specifications shall be used for sub-base:

Source:

Clay shall be obtained from good earth approved by the Engineer-in-Charge containing 20 % to 30% fine sand.

Quality:

Clay shall not contain more than 0.5 % soluble salts more than 0.2 % sulphate and more than 4% organic contents. It shall not contain any gravel, coarse sand, kanker, the grass and plant.

Earth filling shall be done up to the specified level in a layer of six inches and shall be properly watered and consolidated as specified hereunder:

Earth shall be placed in layers and shall be sprinkled with water and rammed to such an extent that a layer of 6 inches thick loose earth evenly spread is reduced to 4 inches in thickness. The consolidated surface shall be such that a very faint impression can be made on it with the heel of boot or the blow of hammer.

The sub-base shall be properly levelled before sand filling.

14.10.2 SAND FILLING

Sand filling shall be done as specified and shown on Drawings in layers not more than 3 Inches thick and shall be rammed after saturation to such an extent that a three-Inch layer is reduced to about two Inches after compaction.

Sand shall conform in all respects to the specifications for fine aggregate under Section 5 – Plain Reinforced Concrete except for its grading i.e. it shall pass through a sieve No. 16 and not more than 30 per cent shall pass through a sieve No. 100.

14.10.3 BRICK BALLAST

Brick ballast to be used in the base of floors shall be obtained from well burnt or over-burnt bricks which are hard, durable and strong. Brick ballast shall be free from impurities, quarry sap, dust, dirt; and solubility characteristics. The size of brick ballast shall be specified or as directed by the Engineer-in-Charge.

14.10.4 CONCRETE

Concrete shall be cement concrete as specified and shown on drawings complying with the provisions of Section 5 – Plain and Reinforced Concrete.

14.10.5 CONCRETE LAYING

Concrete shall be laid in one operation in a uniform layer of specified thickness, absolutely true and parallel to the required level of the finished surface and to the entire satisfaction of the Engineer-in-charge.

14.10.6 SURFACING TO BOND WITH CONCRETE

Concrete shall be cured for at least 7 days before any topping is laid. The surface shall be kept wet and protected from earth, dirt or other foreign matter. Before laying the topping, 'the surface' shall be washed and scrubbed with wire brushes so that the concrete and the topping are well bonded.

14.10.7 LEVELS AND SLOPES

Unless otherwise specified, the base shall be perfectly level. A slope of 1:64 shall, however, be provided in veranda and bath rooms.

14.10.8 BASE FOR FIRST & SUBSEQUENT FLOORS

The top surface of the roof slabs shall be roughened with wire brushes while it is still green. The base shall be constructed with cement concrete complying with the provisions of Section 5 – Plain and reinforced concrete, as specified, shown on drawings and approved by the Engineer-in-Charge. The brickbats shall be placed under concrete where specified. Further operations shall comply with the requirements of preparation of base for ground floor.

14.11 CEMENT CONCRETE FLOORS

a) They comprise cement concrete (1:2:4) topping laid in panels over a base. Thickness of topping varies with requirement. The thickness varies from 1-1/2 inch to 3 inches. For 1-1/2” or more thickness, it can be laid either in single or double layers. In later case half an inch-thick wearing surface composed of 1 part of cement and 2 parts of very fine aggregate is laid immediately on the lower layer of cement concrete in the ratio of 1:3:6 by volume. To avoid, cracks the area of a panel is restricted to 16 square feet unless otherwise approved by the Engineer-in-Charge

b) The concrete for flooring shall comply with the requirements of Section 5 – Plain & Reinforced Concrete.

c) Division strips shall be cut from 5 mm thick glass plate in width as specified in drawings or as directed by the Engineer-in-Charge

14.12 TERRAZZO / MOSAIC FLOOR

14.12.1 SCOPE

The work shall include furnishing all labour material and equipment and performing all operations as required to lay the Terrazzo floors which include but is not limited to;

- Sub-base in sand and brick ballast and terrazzo wearing course in accordance with Clause 14.10.
- Base in cement concrete as specified.
- Grinding and polishing or washing if not polished.
- Skirting, Dado in Terrazzo.

14.12.2 MATERIALS

a) Cement, Sand, Aggregate for concrete and water shall conform to relevant specifications given in Section - 5, Concrete.

b) Sub-base / Base shall conform to the provisions of Clause 14.10.

c) Marble chips shall be crushed marble and shall be best quality white or coloured. It shall have an abrasive hardness of not less than 16 and the size shall vary from No. 4 to 8 as specified or as directed by the Engineer-in-Charge.

d) Dividing strips of glass shall be 5mm thick and 38mm wide or as required in the Drawings.

e) Mineral Pigment for colouring the matrix of terrazzo / mosaic shall be of the best quality and purity and shall be alkali resistant, sun proof and lime proof with a specific gravity similar to that of Portland Cement and as approved by the Engineer-in-Charge.

f) Commercial products for polish shall be of the best quality available as approved by the Engineer-in-Charge.

14.12.3 BASE & WEARING SURFACE

The ground shall be prepared and sub - base laid as Shown in the Drawings in accordance with the requirements of sub-section 14.10. Concrete of 220 kg/cm2 strength (1:2:4) shall then be mixed and laid in the manner specified for cement concrete floor, using a minimum quantity of water for workability. The net thickness specified for wearing surface shall be that obtained after grinding and polishing.

14.12.4 DIVIDING STRIPS

Floors shall be laid in panels of about 1.2 x 1.2 meters or of size and pattern as shown on the Drawings. Dividing strips of glass as specified shall be provided and fixed to exact levels making an allowance for grinding. Glass strips shall not be less than 5 mm thick and of width equal to the total thickness of cement concrete base and terrazzo topping or as specified or as directed by the Engineer-in-Charge.

14.12.5 PLACEMENT

The cement concrete base shall be levelled with a trowel and straight edge, consolidated and finished with steel trowels to an even but rough surface. the top layer of cement marble chips mixed in the proportion of 1:2 (1 cement and 2 marble chips) and pigment, if required, shall be laid over it within 24 hours. The cement and marble chips must be mixed dry in such quantities as are sufficient for a unit of specified shade. Water shall be added to only such quantities as can be mixed thoroughly and consumed in less than 30 minutes, the quantity of water being. the minimum for workability. Mixing must be done on water tight platform and any mix not used within 30 minutes shall be discarded .and removed from the site. A layer of cement and marble chipping mixture should be well trowelled into the surface of the base concrete before filling to the top level of the screeds. The layer should be well compacted and all voids shall. be filled in. A layer of neat cement, of the specified colour shall then be well trowelled into the surface leaving a plain smooth surface.

14.12.6 SURFACE GRINDING & FINISHING

a) Plain Finish

Three days after laying, the top layer must be evenly and smoothly machine ground with carborandum blocks of course, medium and the fine grades so as to ensure that all marble chipping are evenly exposed all over the surface. If marble chips are not evenly exposed, the Contractor shall remove the surface and relay it at his own cost. After the first grinding, the floor shall be thoroughly grouted with the same cement and colour composition as specified for the mosaic' mix. The grout shall be of the consistency of thick cream and shall be brushed over the floor to eliminate all depressions and thoroughly fill the surface for final grinding. The surface after grinding shall be left undisturbed and cured for 2 or 3 weeks, after which it shall be cleaned of dirt and dust by rubbing gently with pumice stone or washing soda in sufficient water. Three days after the surface has been cleaned it shall be rubbed hard with 1:10 solution of oxalic acid using felt. The surface shall then be cleaned and washed with plenty of water. After the surface has dried a final gloss shall be given by polishing the surface to the satisfaction of the. Engineer-in-Charge. The walls and all surfaces of the finished works of other trades shall be properly protected from damage and spoiling during the process of grinding and washing of the mosaic. After the finish grinding has been completed and the surface treatment and polish applied, the mosaic work shall be covered and protected with material approved by the Engineer-in-Charge until completion of the work of all other trades.

b) Washed Mosaic - Rough Finish

Before the mosaic is hardened the top surface shall be brushed down. Plenty of water being used in this process. The brushing shall continue till the matrix is removed and each piece of marble chips is clearly exposed. If brushing of surface does not produce desired results tooling process shall be carried out by kango Hammer. After whole of the area is evenly exposed the surface shall be sprayed with water and lightly brushed down cleaning all the adhering mortar and revealing the true colour of the marble chips.

14.12.7 MEASUREMENTS

Length and breadth shall be measured correct to a cm before laying skirting, dado or wall plaster. The area as laid shall be calculated in sqm correct to two decimal places. The thickness of the under layer shall be measured correct to a cm. The thickness of top layer shall not be less than that specified.

No deduction shall be made, nor extra paid for voids not exceeding 0.20 square metre. Deduction for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 square metre. Nothing extra shall be paid for laying the floor at different levels in the same room or courtyard.

Terrazo (Marble Chips) flooring laid as floor borders, margins and similar bands upto 30 cm width and on staircase treads shall be measured under the item of terrazo flooring but extra shall be paid for such work. This extra in the case of staircase treads shall include the cost of forming the nosing also. However, moulded nosing shall be paid for staircase treads etc. extra in running metres except where otherwise stated, returned moulded ends and angles to mouldings shall be included in the description. Extra shall also be paid for laying flooring in narrow bands not exceeding 7.5 cm in width and such bands shall be measured in running metres for this purpose.

Special surface finishes to treads, risers and the ends of concrete steps and the like shall be measured separately and given in square metres and shall include form work, if required.

14.12.8 TERRAZZO DADO & SKIRTING

The plastered surface over which the dado/skirting is to be applied shall be well roughened and watered; cement mortar of specified ratio shall then be plastered over this well roughened surface to. the indicated thickness. Before the base course has set the layer of mosaic mixture shall be well trowelled into the surface of the base to a thickness which after grinding shall result in the finished thickness. A layer of neat cement of the specified colour shall then be well trowelled into the surface leaving a plain smooth surface. The Contractor shall start finishing as specified for floors above. Mosaic skirting shall be provided around all mosaic floors unless shown otherwise. Skirting and dado shall' be straight, level and in plumb. Intersections at floors shall be straight and flush.

14.12.9 MEASUREMENT:

Same as 14.12.7

14.13 CONGLOMERATE FLOORING (CEMENT CONCRETE)

Unless otherwise specified, the conglomerate flooring shall be constructed in accordance with the following specifications.

14.13.1 MATERIALS

a) Cement shall conform to **ASTM C150 / C150M -09 Standard Specifications for Portland Cement**.

b) **Fine Aggregate**

Source:

Fine Aggregate shall be obtained from an approved source.

Grading:

Fine Aggregate shall consist of well graded sand, stone screening or other inert material of similar characteristics, or a combination of these. The whole of it shall pass through 3/16 inch sieve and 2 to 10 per cent through sieve No. 100.

Cleanliness:

Fine aggregate shall be clean and free from clay lumps, soft and flaky particles shale, alkali, organic matter, loam, mica and injurious amounts of deleterious substances. The sum of percentages of all deleterious substances shall not exceed 5 per cent by weight.

Quality:

Fine aggregate shall be sharp, cubical, hard dense and durable.

Storage:

Fine aggregate shall be stacked on a brick, wooden or other suitable platform so as to adequately protect it from dust and other impurities.

(c) **Coarse Aggregate**

Source:

Coarse aggregate shall be obtained from an approved source.

Grading:

Coarse aggregate shall be well graded within the range of 3/16 in to 3 in of any size or range of sizes within such limits as actually specified for any particular work. It shall consist of quarried or crushed stone or other inert material or combination of these as specified.

Cleanliness:

Coarse aggregate shall be clean and free from soft, friable, thin or elongated pieces, alkali, organ matter, or injurious amounts of deleterious substances. The sum of the percentage of all deleterious substances in any size shall not exceed 3 per cent by weight.

Quality:

Coarse aggregate shall consist of well-shaped, hard, dense, durable, uncoated rock fragments or brick bats.

Storage:

Coarse aggregate shall be stacked on a brick, wooden or other suitable platform so as to adequately protect it from dust and other admixtures. Each type and size of aggregate shall be stacked separately.

(d) **Water**

Source:

Water for construction shall be obtained from an approved source.

Quality:

Water shall be free from earth, vegetable, organic impurities and any other substance likely to cause efflorescence or interfere with setting of mortars or otherwise prove harmful to the work. Broadly speaking any water which does not show any intensive odour or brackish taste shall be considered suitable for building works, whereas water fit for drinking shall be accepted as suitable for all engineering works. PH value of water shall range between 6 & 8.

Storage:

Water shall be stored in watertight tanks or containers so as to be adequately protected from the admixture of dust and other foreign matter.

14.13.2 BASE

The base for ground and subsequent floors shall be laid as per Specifications 14.10.

14.13.3 OPERATION

Unless otherwise specified conglomerate flooring shall consist of laying a topping of cement concrete of specified thickness over the base.

14.13.4 RATIO OF CONCRETE

Unless otherwise specified cement concrete used for topping shall be of the ratio 1:2:4 by volume and shall conform to Section 5 – Plain & Reinforced Concrete.

14.13.5 DIVIDING INTO PANELS

Before laying the topping. the surface of the base shall be divided into symmetrical panels by wooden or iron screeds. Unless otherwise specified the area of panel shall not exceed 16 square feet. The top of the screed shall be adjusted to the specified level of the finished floor surface.

14.13.6 PREPARATION OF BASE

Before the laying of topping the surface of base concrete shall be washed and scrubbed with wire brushes so that topping and the base concrete are well bonded. Where topping is to be laid directly on roof slab, It shall be roughened while it is still green.

14.13.7 MIXING AND PLACING

Mixing and placing of concrete shall be in accordance with the Section 5 – Plain & Reinforced Concrete.

14.13.8 CONSOLIDATION

Placing operation shall be specifically timed. No sooner the concrete has been evenly spread in a panel, than it shall be beaten for about 5 to 10 minutes with "wooden thapies" (about 5 Ibs weight).

14.13.9 FINISHING

Immediately after consolidation, the surface shall be levelled with a wooden trowel. Excessive trowelling in the early stage shall be avoided. The surface shall be tested with a straight edge to detect undulations, which, if found, shall be eliminated. The fines in the concrete which has come to the surface with the stroking shall be quickly but carefully smoothed with the steel trowel. When the concrete has hardened sufficiently, trowelling shall be done with steel trowel. No dry cement or a mixture of dry cement with sand shall be sprinkled on the surface for hardening the surface.

14.13.10 CURING

The concrete for topping shall be cured in accordance with Section 5 – Plain & Reinforced Concrete.

14.13.11 PRESERVING PANELS ALREADY LAID

After 24 hours of laying, the screeds shall be removed and strips of non-absorbent paper placed against the exposed side and folded over the finished surface so as to prevent concrete of adjoining panels from adhering to the edge or spreading over the finished surface. Panels shall be laid alternately, where possible; the adjoining panels shall be laid at an interval of 24 hours.

14.14 CONGLOMERATE FLOORING (TWO COAT WORK)

Unless otherwise specified, the conglomerate flooring (two coat work) shall be constructed in accordance with Specifications 14.13 for Conglomerate Floor (Single coat) except with the following modifications:-

i) It shall be laid in two layers with a top layer half an inch thick, wearing surface composed of cement and fine aggregate conforming to the provisions of Sub-section 14.13.1 and a bottom layer of cement concrete conforming to Specifications as mentioned in Section 5 – Plain & Reinforced Concrete, of specified thickness.

ii) Unless otherwise specified, the cement concrete for the bottom layer shall be composed of one cubic foot of cement, 3 cubic feet of fine aggregate and 6 cubic feet of coarse aggregate by volume and shall conform to the applicable provisions of Section 5 – Plain & Reinforced Concrete.

iii) Unless otherwise specified, the surface layer shall compose of one part of cement and two parts of fine aggregate by volume. The pigment of approved shade and colour may be added to give the desired colour to the topping layer.

iv) The bottom layer shall be brought to a level so that top layer shall have a minimum thickness of half an inch. The bottom layer shall be thoroughly compacted by tamping but shall not be finished smooth. While the bottom layer Is still plastic, the top layer shall be placed over it and levelled with a steel float after light tapping for five minutes.

14.15 PVC TILES/SHEET FLOORING:-

a) General

Such flooring shall consist of PVC flexible sheet or tile of the colour as per drawings or directed by the Engineer-in-Charge. It shall conforms to the relevant Standards

ASTM-D 2859	Flammability of finished materials vinyl-asbestos tile or flooring.
ASTM-D 3564	Application of floor polishes to maintain vinyl- asbestos tile or flooring.
BSS 3260	PVC (vinyl) asbestos floor tiles.
BSS 3261	Unpacked flexible PVC flooring

b) Types of PVC Flooring/Tiles

PVC Tiles (Static): PVC tiles / sheet of requisite thickness shall be of best quality available in the Country. Size, colour, shade and adhesive shall be as per the sample which shall be submitted by the Contractor and approved by the Engineer.

PVC Tiles (Anti-static): PVC tiles / sheet of requisite thickness shall be of best quality available in the Country Size, colour, shade, import quality copper strips and conductive adhesive shall be as per the sample which shall be submitted by the Contractor and approved by the Engineer.

Following shall be the technical requirements;

For new floors between two dry contact electrodes no individual reading shall be greater than 5 x 106 Ω than 2x 104 Ω. The average of all readings shall remain between 2 x 106 Ω and 5 x 104 Ω.

For existing floors between two dry contact electrodes no individual reading shall be greater than 5 x 10 7Ω. The average of all readings shall be 2 x107Ω.

c) Installation Method

1) PVC Static Flooring Sheets/Tiles

The base shall be prepared as per thickness shown on drawings keeping the margin of tile thickness. After the base is cured, any irregularities found on the base shall be filled in and levelled before the application of tiles. Surface to receive tiles shall be thoroughly cleaned of all dirt, dust, oil and other objectionable matter. Approved manufacturer's recommended adhesive shall be applied as per specifications and in quantities recommended by him. Tiles/sheets shall be laid starting from one side of the room or as per the instructions of the Engineer and shall be so pressed that complete adhesion takes place.

Tiles/sheet shall be cut where required with suitable cutting tool and rough edges shall be rubbed smooth. Tiles shall be laid to straight edges as per approved pattern

2) PVC Anti-Static Flooring Sheets / Tiles

d) Preparation of Base

The base shall be prepared as per thickness shown on drawings keeping the margin of tile thickness and network of Copper Strips. After the base is cured, any irregularities found on the base shall be filled in and levelled before the application of sheets/ tiles. Surface to receive tiles / sheets shall be thoroughly cleaned-off all dirt, dust, oil and other objectionable matter. Approved manufacturer's recommended adhesive shall be applied as per specifications and in quantities recommended by him. Tiles/sheets shall be laid starting from one side of the room or as per the instructions of the Engineer and shall be so pressed that complete adhesion is ensured. Tiles/sheets shall be cut where required with suitable cutting tool and rough edges shall be rubbed smooth. Tiles shall be laid to straight edges as per approved pattern.

e) Fitting the Copper Mesh

Lay the full lengths of copper strips across the room on both sides cutting each other. Each strip must be at a distance of 12” from each other and 24” from the other. The joints of these sheets must be properly acid welded. Keep as many points of the copper strip as you require out from the ends for earthing purpose. Similarly the whole copper grid must be properly earthed. To do so one part of this grid shall be attached to the earthing point of the room. The non-static tiles shall then be laid on the floor. This grid shall only be necessary for assuring the continuity. The strip shall pass beneath of the tile to give proper resistance.

f) Fixing PVC Floor Tiles / Sheets (Anti-Static)

- Mark out the room area with chalk lines across length and width, positioned to allow for reasonably sized tile cuts on all sides.
- The new trowel blade enclosed with the adhesive shall be fitted when starting the pack and used for spreading one pack only.
- Stir the adhesive before use.
- Spread the adhesive evenly holding the blade at an angle of about 60 degrees.
- Good transfer is essential; the area spread with adhesive at any time shall be limited to ensure that all the tiles and cuts can be laid while the adhesive is still wet. Commence tiles laying at the point first spread so that the adhesive has been left open for approximately 15 minutes. The actual area spread and the open time shall depend on the absorbency of the sub-floor and ambient conditions. Do not spread more than one pack at a time.
- Ensure electrical conductivity by overlapping adjacent areas of adhesive application.
- Put tiles closely and press them firmly to the floor to give good contact over the whole tile area.
- Approximately 1-hour after laying the tiles apply suitable pressure on them to ensure overall good contact. Care shall be taken that adhesive shall not squeeze up between the tiles, and if it happens then immediate cleaning of it shall be necessary.
- Dried adhesive residue shall be removed with a slightly abrasive cloth.

g) Traffic

Electrical testing shall be carried out until at least 21-hours after completing the installation. The method shall be as laid down or as specified. The following summarizes the procedure recommended in NHS technical memorandum No. 2 (1977)

h) Equipment

An insulation testing ohm meter having an approximate open circuit voltage of 500 volts DC and capable of measuring resistance values of between 104 and 5 x 107Ω.

i) Method

The finished surface of concrete screed as floor base shall be washed thoroughly and then be allowed to dry (no test shall be carried out within 2-hours of floor being wetted) with subsequent wiping over it with a dry cloth. Place the electrodes approximately 12” apart and measure the resistance between them. In order to check the actual resistance the black bottom layer shall have to be checked, to do this either puncture a tiny hole on the surface of the tile or check the resistance from the left out copper strips on the ends of the floor.

14.16 REINFORCING STEEL / MESH

The work for procurement and placing of the reinforcing steel shall conform to the applicable provisions of Section 5 – Plain & Reinforced Concrete.

14.17 RUBBING AND POLISHING OLD MARBLE / MOSAIC FLOOR

14.17.1 SCOPE

The work shall include furnishing all materials, tools and plant, labour, equipment etc. as well as performing all operations to complete the work in workman like manner in accordance with the herein stated specifications, stipulations and requirements except when such stipulations and requirements are specially modified by the Engineer-in-Charge in connection therewith.

14.17.2 PREPARATION OF SURFACE

i) If the old marble/mosaic floor is firm and sound, grinding of the surface shall be done with a coarse Carborandum brick or disk, using water freely. The whole surface is then scrubbed using plenty of water, till all dirt, grease, projections and the grinding mud is removed.

ii) If the surface bears holes, cracks and other inequalities, these shall be raked out, squarely shaped and cut to a depth and then filled with a fine, identically tinted mix, well pressed in by a trowel, in accordance with specifications prescribed. Filling in of the squarely cut patches shall be kept a little above (generally 6mm or as specified or as directed by the Engineer-in-Charge) the rest of the floor. These patches shall be kept damp till the second grinding of the floor surface is done.

iii) The second grinding shall be done after a further five days using a finer grained Carborandum brick or disk and this shall complete the grinding unless there are still faulty patches, which must be filled as specified or as directed by the Engineer and a third grinding carried out.

iv) After each grinding, the floor shall be washed thoroughly, but after the final grinding, this washing shall be done with hot water and pure soft soap.

14.17.3 POLISHING

After the washed floor has dried, a final gloss shall be given by polishing the surface to the satisfaction of the Engineer-in-Charge.

14.17.4 FINISHING

The walls and all surfaces of the finished works of other trades shall be properly protected from damage and spoiling during the process of grinding and washing of the mosaic. After the finishing grinding has been completed and the surface treatment and polish applied, the floor shall be covered and protected with material approved by the Engineer-in-Charge until completion of the work of all trades.

14.18 FLAGGED FLOORING

14.18.1 SCOPE

Unless otherwise specified, flagged flooring shall be constructed in accordance with the following specifications.

14.18.2 STONE

The flags are the rectangular stone slabs of specified size. The specified stones from which the flags are made shall conform to Sub-section 12.1.2 for Stone of Stone Masonry.

14.18.3 MORTAR

Mortar shall be cement mortar complying with Sub-section 11.7.2 (ii) – Brickwork.

14.18.4 BASE

The base shall be laid as per Sub-section 14.10, Flooring.

14.18.5 SIZE OF FLAG

Flags shall not be less than one inch and a half in thickness. The length and breadth shall not be less than 14 inches and more than 30 inches. The size of flags shall be such as to give uniform parallel courses.

14.18.6 DRESSING

Flags shall be chisel dressed so as to have a flat surface, free from windings. All edges shall be accurately dressed, truly square to their full depth. Flags projecting over the edges of verandahs or steps shall have their outer edges bull-nosed.

14.18.7 SOAKING

Flags that be soaked in water for one hour before laying.

14.18.8 JOINTS

The thickness of joints shall not be more than 1/8 of an inch. Unless otherwise specified, the mortar in joints shall be made flush with a trowel.

14.18.9 POINTING

If pointing has been specified, the flags shall be laid against wood or iron strips of uniform thickness, so as to form joints not less than ¼ inch wide. When a row of flags is laid, the strips shall be removed and the open joints shall at once be filled with specified mortar, and shall then be flush pointed with specified mortar.

14.18.10 THICKNESS OF BEDDING MORTAR

Flags shall be laid over specified bedding mortar not more than ¾ inch thick.

14.18.11 LAYING OF FLAGS

Flags shall be placed in position and brought down to the required finished level and the joints shall then be filled with specified mortar.

14.18.12 PATTERN

Flags shall be laid in the specified pattern. The courses shall be of uniform width and, unless otherwise specified, parallel to the wall having the main entrance. Flags shall break joint in adjacent courses by not less than 8 inches.

14.18.13 PROTECTION AND CURING

The floor shall be protected from the effects of weather. During the progress of work and for 10 days after laying, the floor shall be kept watered. Three clear days shall be given for setting before anyone is allowed to walk over, but no weight shall be brought on the surface till 7 clear days have elapsed after the completion of laying.

14.19 MURUM FLOORING

14.19.1 SCOPE

The work shall include furnishing all labour, materials, equipment, and performing all operations specified herein to lay the murum floors in accordance with the drawings, or as directed by Engineer-in-charge.

14.19.2 MATERIALS

a) All murum used in construction murum flooring shall be in complete conformity with the applicable requirements set forth in this section
b) Rubble or broken bricks

14.19.3 PREPARING SURFACE

All filling up-to 30 cm below the proposed floor level shall be dug out and the hollow thus created shall be treated as specified hereunder:

14.19.4 LAYING

All murum floors shall be constructed in accordance with the detail shown on drawings, the Engineer-in-charge's instructions and the stipulations and requirements set forth herein, as follows:

a) The dug out surface as mentioned in 14.9.3 above shall be properly watered and rammed with hand rammers sufficiently to the entire satisfaction of Engineer-in-charge. The consolidated surface shall be such that a very faint impression can be made on it with the heel of boot or the blow of hammer.

b) Sub-base of broken bricks or hand packed rubble shall be laid to a template evenly and watered thoroughly and allow to dry. The surface shall be fairly levelled and beaten with rammers to produce one uniform level. Up-to the entire satisfaction of the Engineer-in-charge.

c) Then a layer of good hard murum, 150 mm thick, shall be added and water thoroughly for 2 days. When the whole mass has become too slushy, it shall be tempered over by coolies so as to form a one uniform mass. Then the surface shall be fairly levelled and beaten with hand rammers, to one uniform level. It shall be then allowed for dry for 2 to 3 days.

d) Finally, spread 25 mm layer of fine powder or flaky variety of murum, which shall be thoroughly beaten by hand rammers. As a check of good work, the surface shall not now crack on drying and the floor is complete.

14.19.5 MEASUREMENT:

Length and breadth shall be measured correct to a cm before laying skirting, dado or wall plaster and the area calculated in square metre correct to two places of decimal. Where coves are used at the junctions, the length and breadth shall be measured between the lower edges of the coves.

No deduction shall be made nor extra paid for voids not exceeding 0.20 square metre. Deductions for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 square metre.

14.20 GROUTING DRY BRICK WORK WITH CEMENT MORTAR

14.20.1 GENERAL

Unless otherwise specified, pure Portland cement and rich mixture of sand and cement with an excess of water, termed grout, shall be used in the form of a water paste of about the consistency of cream to grout in brick work or stone masonry, paving stones, sets and wood blocks laid dry. This grouting consists of the filling in of the cavities, cracks, joints etc. by pouring in, brushing in, or otherwise forcing such a liquid mixture of cement and water, and occasionally sand in to every joint. The amount of water to be used with the cement to make the grout will vary with the climatic conditions, and the absorptive nature of the material with which it is to be used. It is best to use as little water as possible, having regard to getting the grout to penetrate the required parts. The practice is condemned, where the conditions are unusual, as cement used in this way will never develop its full strength, unless otherwise specified, grouting dry brickwork with cement mortar of specified mix proportion and consistency or as directed by Engineer-in-charge, shall be done in accordance with the following specifications.

14.20.2 SCOPE

The work shall include furnishing all labour, materials, equipments, plants, instruments, accessories and services necessary to complete the work at the locations shown on the drawings or as directed by Engineer-in-charge in accordance with these specifications.

Materials

a) Brick shall conform to Specifications as mentioned in Section 11 for Clay Bricks.
b) Mortar shall conform to Specifications as mentioned in Section 11– Brickwork, Mortars.

14.20.3 LAYING

Grouting dry brickwork with cement mortar of specified mix proportion shall be done in accordance with the details shown on drawings, the Engineer-in-charge instructions and the stipulations and requirements set forth herein, as follow;

a) Grout shall be made by mixing specified cement: sand mix proportion with water to produce mortar with specified consistency or as directed by the Engineer-in-charge, so as to form a watery paste of about the consistency of cream to flow into the joints of dry brick work and filled the joints fully upto the surface subject to the approval of Engineer-in-charge. The surplus grout sticking to the surface of the dry brickwork shall be swept over and the surface shall be cleared.
b) Only so much should be mix in one time as can be used before it commences to set and any which has begun to stiffen should be rejected.

14.21 CARPET FLOORS/TILES

14.21.1 GENERAL

The Contractor will submit duplicate 3 foot square pieces of each type of carpet specified, for the approval of the Engineer-in-Charge.

14.21.2 MAINTENANCE DATA

Provide maintenance data for carpet maintenance for incorporation into Operation and Maintenance Manual.

14.21.3 MAINTENANCE MATERIALS

Provide maintenance materials as per manufacturer's recommendations for use of at least 1 year as per storage life of the said materials.

14.21.4 PRODUCTS

Maintenance material: deliver to the Engineer-in-Charge additional carpet equal to 5% of carpet used in the project and include a sufficient amount of adhesive in unopened containers to apply the carpet.

Identify each roll. Store where directed.

Maintenance materials to be full size piece of same production run as installed materials.

14.21.5 MATERIALS

Carpets as selected by the Engineer-in-Charge.

Carpet grippers: types recommended by carpet manufacturer.

Seaming tape: hot melt type as recommended by carpet manufacturer for purpose intended.

Binder bars: brass of type recommended by carpet manufacturer.

Adhesive: release type, water resistant, non-staining adhesive as recommended by carpet manufacturer.

Carpet protection: non-staining heavy duty kraft paper or 0.15 mm thick polyethylene film.

14.21.6 EXECUTION OF WORK

a) Workmanship:

Examine substrate by taping a rubber mat for 24 hours prior to commencement of work. Observe the underside of the mat and if the mat is damp, wait till slab is dry.

Repair minor holes, cracks, depressions and rough areas using material recommended by carpet adhesive manufacturer.

Clear away debris and scrape up cementations deposit from surfaces to receive carpet.

Vacuum clean surface to receive carpeting immediately prior to installation.

Check concrete surfaces to ensure no dusting is apparent. Apply sealer where required to prevent dusting.

Install glue-down carpet in accordance with manufacturer’s printed instructions.

Install carpeting after finishing work is completed but before demountable office partitions and telephone and electrical pedestal outlets are installed.

Finish installation to present smooth wearing surface free from conspicuous seams, burring and other faults.

Use material from same dye lot and ensure colour, pattern and texture match within any one area.

b) Binder Bars

Use metal binder bars at exposed carpet edges and centre under doors in door openings.

c) Carpet Installation

Install carpet in accordance with shop drawings. Hot melt seams and cross-joints. Maintain constant pile direction.

Fit sections of carpet into each space prior to application of adhesive. Trim edges and butt cuts with seaming cement.

Apply adhesive uniformly to substrate in accordance with manufacturer's instructions. Butt carpet edges tightly together to form seams without gaps.

Roll entire carpet area lightly to eliminate air pockets and ensure uniform bond.

Remove any adhesive promptly from the face of the carpet by a method that will not damage the carpet surface and in accordance with the manufacturer's recommendations.

d) Carpet Base Installation:

Install carpet base to match adjacent carpet flooring.

Attach carpet to wall with adhesive. Neatly fit against floor carpet and into the plaster recess.

e) Protection of Finished Work:

Vacuum carpets clean. Protect traffic areas of carpeted floors with carpet protection. Tape edges and joints to prevent shifting.

14.21.7 MEASUREMENT:

Length and breadth shall be measured correct to a cm before laying skirting, dado or wall plaster and the area calculated in square metre correct to two places of decimal. Where coves are used at the junctions, the length and breadth shall be measured between the lower edges of the coves.

No deduction shall be made nor extra paid for voids not exceeding 0.20 square metre. Deductions for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 square metre.

14.22 EPOXY FLOORING

a) General

Epoxies are polymer materials that begin life as liquids and are converted to the solid polymers by a chemical reaction. An epoxy based polymer is mechanically strong, chemically resistant to degradation of the chemical elements in the solid form and highly adhesive during conversion from liquid to solid. There are a wide range of basic epoxy chemicals from which an epoxy system can be formulated.

Epoxies are known for their excellent adhesion, chemical and heat resistance, good to excellent mechanical properties and very good electrical insulating properties. Almost any property can be modified. Epoxy is safe and there are no known harmful effects of the chemicals used in the mixture. It also has a high resistance to chemicals such as gasoline, salt, grease, oil and solvents.

b) Areas of Application of Epoxy Floors

Generally the epoxy flooring are preferred in the following building categories.

i)	Chemical plants	ii)	Pharmaceuticals Industries
iii)	Food Processing Areas	iv)	Bottling Plant
v)	Electric / Electronics Industries	vi)	Computer Rooms
vii)	Hospitals Operation Theaters & Corridors	viii)	Nuclear Power Plants
ix)	Dairies & Breweries	x)	Laboratories
xi)	Aerospace Industries	xii)	Airport Hangers
xiii)	Picture Tube Manufacturing Plants	xiv)	Automobiles Workshops
xv)	Fermentation Floor in tea Gardens	xvi)	Textile Mills
xvii)	Warehouse	xviii)	Hotels & Restaurant

c) Benefits of Epoxy Flooring

Impact Resistance: Epoxy floors are generally used in areas of industry where goods are handled in specific spaces, such as production lines, warehouses, loading bays, and where compressive loads are generated by the movement of goods on trucks, pallets etc.

Slip Resistance: Pedestrian traffic areas require varying degrees of slip resistance dependent on whether the environment is wet or dry.

Fire Resistance: Fire escape routes, explosive production and storage areas underground car park decks.

Hygiene: Pharmaceutical, Automotive, food, beverage, chemical and electronics industries have very demanding sanitary requirements. These industries often need totally dust free and easily cleanable floors, without cracks or angled Corners.

Chemical Resistant: Epoxy floor coverings provide an impermeable seal to protect floor from chemical attack.

Points to be Check Prior to Epoxy Flooring:-

Following points should be viewed before the application of epoxy flooring

Moisture: Moisture content less than 5%

Smooth Surface / New Casted Floor: Depending on surface we can provide the epoxy system for smooth floor epoxy coating from 500 micron 1mm system

Rough Floor: 1MM – 2MM SYSTEM

Damaged Floor: Using epoxy underlayment / requires repairing.

Cracks: Repairing / Filling of cracks

Oil / Grease: Checking of oil content on floor

Pot Holes: Checking & Filling of pot holes

Control Joints: Checking if joints / grooves are cut and filled with joint sealant.

d) Application Method:-

Surface preparation

Surface life of the sealer is primarily dependent on the good surface preparation. Sealers life will be extended by following few key points:

- The concrete must be cleaned free of old existing coatings, oils, grease, and dirt and wax solutions.
- Grind the floor to open the pores and remove dirt, debris and other containments.
- If there are any cracks, filling of cracks
- Filling of control joints.
- Remove all debris from working area.

Mixing Procedures

Epoxy penetrating sealer is a two component system. Mix component A “resin” with component B “Hardener” in the ratio of 1:1, mix with the help of power mixer @ 200rpm-300rpm until an even colour develops (2-3 minutes)

Application of Epoxy Coat

Penetrate epoxy sealer may be applied with roller, brush or air spray. Ensure that the concrete surface is dry, and at least 28 days old, having a moisture less than 5%. After application the minimum curing time for floors should be given as follows

Min Curing	12 hours
Foot Traffic	24 hours
Medium Traffic	48 hours
Full load	72 hours

e) Epoxy Floor Caring

DOs	DON’Ts
Clean Immediately with detergent and Warm water in the event of chemicals/Oil/grease spillage	Spill chemical / oil / grease on the floor
Vacuum clean regularly clean floor with detergent and warm water using soft Bristle to avoid scratch. Polish as per Manufacturer’s instructions.	Let sand inside use air lock or air curtain
Maintain reasonably constant temperature	Store react able solvent without proper instruction
Regular maintenance of trolleys and forklifts. Prevent locking of wheels.	Use imbalance wheels

Use Polyurethane or pneumatic wheels with wider contact area to reduce frictional stresses.	Use black rubber / metal wheels on trolleys and forklifts as it will lead to scoring and marking on the floor
Keep mats underneath before placing heavy weights on the floor.	Drag heavy objects on the floor as it will lead to scratches
Check the pallets and ensure that no nails or protruding in trolleys/ forklifts	Drop sharp and heavy objects on the floor as it will leave dents and marks
Repair leakage in water pipes, air ducts immediately to avoid pressure beneath the substrate which could lead to blisters on the floor.	

f) Relevant Code for Epoxy

ASTM C 109:90 for compressive strength
ASTM C 501 for abrasion resistance.

14.22.1 MEASUREMENT:

Length and breadth shall be measured correct to a cm before laying skirting, dado or wall plaster and the area calculated in square metre correct to two places of decimal. Where coves are used at the junctions, the length and breadth shall be measured between the lower edges of the coves.

No deduction shall be made nor extra paid for voids not exceeding 0.20 square metre. Deductions for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 square metre.

14.23 LAMINATE FLOORING

Laminate Flooring is considered a “floating” floor and is installed using a floating floor system. These floors are intended for indoor use only and can be installed over virtually any existing floor structure. Since these floors are composed of natural cellulose fibres, they will expand and contract with changes in relative humidity.

14.23.1 SUB FLOORS REQUIREMENTS FOR LAMINATE FLOORING

a) **For concrete floors**, it must be cured properly and allowed to dry as per instruction of Engineer-in-Charge and must be free from alkali elements. Moreover it must be proper levelled to avoid the kinks in the laminate flooring.

b) **Wood subfloors must be suspended and have a minimum of 18” (45.7 cm) of well-**ventilated crawl space. Regardless of grade level, do not install over wood subfloors applied directly to concrete or on sleepers over concrete. Installation of a polyethylene film vapour barrier such as Armstrong Moisture Barrier Sheeting over the ground in the crawl space is recommended. The polyethylene film acts as a moisture barrier when seams are taped together with polyethylene tape.

c) **Preparatory Work for Laminate Flooring**

Following points should be kept in view while the preparatory work for laminate flooring in progress

- Removal of existing wall base, millwork, or trim is optional.
- Door trims and doorjambs must be undercut to allow the floor to move freely. Use discarded piece of floor and foam underlayment to support the saw blade at the correct height for undercutting.
- Sweep the subfloor and remove all dust and debris.

- If the drywall (plaster board, wallboard, gypsum panel, or gypsum board) is slightly elevated at the floor and wall juncture, create a solid wall surface by fastening a 2" to 3" (5 cm to 7.6 cm) wide facing strip such as ¼" (6.35 mm) plywood to the wall at the stud location.
- New wall base or moulding must be installed at the end of the job to cover the 1/4″ (6.35 mm) to 1/2″ (12.7 mm) expansion zone around the perimeter of the floor.
- It may be necessary to plane or cut the bottom of the door to accommodate the change in floor height.
- While in layout of laminate floor special care must be taken for the natural light, layout must be done to the incoming light from any windows, if natural light not provided in the room layout must be done to the longest side of the room.
- The floors must be moist free, if some dampness is observed, then dry the dampness first.
- If the cabinets exist in the flooring , then the laminate around the cabinets leaving ¼" (6.35mm) to ½" (12.7mm) expansion zone.
- If installing cabinets after the laminate has been installed, most or all of the cabinet weight should be supported by the wall mountings. To secure the cabinets to the substrate with screws or nails, drill holes through the laminate 1/2″ (12.7 mm) diameter larger than the screw or nail to allow for expansion.
- Always check each laminate flooring panel for damage before installing.

d) Installation Method

- Avoid narrow pieces at the finish wall. Measure the distance between the starting wall and the finish wall.
- Divide this number by the width of the board.
- If the remainder is less than 2-1/2″ (6.35 cm), cut off 2-1/2″ (6.35 cm) from the width of the first row or to balance the room add the difference to the plank width and divide by two.
- Roll out the moisture control sheeting as per recommendation of manufacturer or as per instructions of Engineer-in-Charge then install the laminate flooring.

14.23.2 MEASUREMENT:

Length and breadth shall be measured correct to a cm before laying skirting, dado or wall plaster and the area calculated in square metre correct to two places of decimal. Where coves are used at the junctions, the length and breadth shall be measured between the lower edges of the coves.

No deduction shall be made nor extra paid for voids not exceeding 0.20 square metre. Deductions for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 square metre.

14.24 ASPHALT FLOORING

14.24.1 SCOPE

The work shall include furnishing all labour, materials, equipments, plants, instruments, accessories and services necessary to complete the work at the locations shown on the drawings or as directed by Engineer-in-charge in accordance with these specifications.

14.24.2 MATERIALS

Asphalt used in constructing the asphalt flooring shall be in complete conformity with the applicable requirements set forth in the specifications for asphalt or as approved by Engineer-in-charge

Bitumen used for mixing with the asphalt shall be refined cut-back bitumen having viscosity (Standard Tar Viscometer) of 110 to 150 seconds at 40 degree centigrade or as approved.

Clean sharp sand used for mixing with the asphalt shall confirm to specifications 5.3.1.3

14.24.3 BASE

The base should be prepared in conformity with specification 14.10.

14.24.4 LAYING

Asphalt flooring shall be done in accordance with the details shown on the drawings, the Engineer-in-charge instructions and the stipulations and requirements set forth herein as under;

All dust and sand shall be swept-off, and the asphalt having been mixed and melted in the following proportions, unless otherwise specified or as directed by Engineer-in-charge.

Asphalt	1 part
Bitumen	1/32 part
Clean sharp sand	½ parts

Shall be laid on smoothly and evenly of uniform thickness as specified and carefully and steadily rubbed with hand float until the surface shall be perfectly even and true.

14.24.5 FINISHING

The junction of the sections of the asphalting shall be carefully made, and before the surface becomes hard, it shall be worked perfectly level and smooth with fine clean sand and left of a uniformly dark colour.

14.24.6 MEASUREMENT

Length and breadth shall be measured correct to a cm before laying skirting, dado or wall plaster and the area calculated in square metre correct to two places of decimal. Where coves are used at the junctions, the length and breadth shall be measured between the lower edges of the coves.

No deduction shall be made nor extra paid for voids not exceeding 0.20 square metre. Deductions for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 square metre.

14.25 MEASUREMENT AND PAYMENT

14.25.1 COMPOSITE RATE

The measurement and payment for the items of the work of Flooring hereof shall be made corresponding to the applicable CSR items as provided in Contract Agreement and shall constitute full compensation, for procurement, transportation, performance in all respects and completion of work as specified including the site clearance as approved by the Engineer-in-Charge.

14.25.2 LABOUR RATE

The measurement and payment for the items of the work of Flooring hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurement transportation, performance in all respects and completion of work as specified including site clearance, as approved by the Engineer-in-Charge except the cost of materials to be provided by Department at designated location as defined in the Contract Agreement.

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15 . FINISHES

15.1 PLASTER

Plaster is a material used in a plastic state, which can be trowelled to form a hard covering for interior or exterior surfaces, walls, ceilings, etc., in any building or structure.

15.1.1 BASE

Plasters are applied to bases of bricks, stones, hollow tiles, or concrete masonry and to wood laths, metal laths and gypsum laths or similar materials finished in sheets.

15.1.2 SURFACE PREPARATION

A stiff wire brush is used to remove all loose dust from joints, and the surface is then thoroughly washed with water. Plastering should not be done' on too much wet walls, because the results will not be satisfactory.

A good key is essential to a successful rendering and to avoid cracking and crazing. All joints in masonry are raked to a depth of at least half an inch with a hooked tool specially made for the purpose and not with trowel or hammer. This is to be done while the mortar is still green and not later than 48 hours of the time of laying. After raking, the brickwork is brushed to remove all loose dust from the joints and thoroughly washed with water. (In case of old walls, it may sometimes be advisable to ensure a good key for the new rendering by destroying the smooth surface, of the brickwork with some tool.) If the walls are washed with a solution of 1 part hydrochloric acid to 10 parts water, it will bring the grains in brickwork to the surface. This solution is left on for about quarter of an hour and then washed off with water.

15.1.3 COATS

Plaster may be applied in one, two or three coats; two are usually sufficient, but three should be applied only on wood or metal lathing or on a very rough, uneven background. The thickness of the first coat has to be just sufficient to fill up all un-evenness in the surface. The second and subsequent coats are thinner than the first, and no single coat has more than half an inch of thickness, because thick coats shrink more and crack. Under-coats of coarse stuff are allowed to dry and shrink properly before subsequent coats are applied; otherwise cracking and crazing is bound to occur. *A good key for all stages of, plastering is essential*. The freshly plastered surface is scratched or roughened before it has fully hardened, to form a mechanical key for the second coat. The method of application of the mix influences the adhesion; the mix sticks better if thrown on than if applied by trowel.

15.1.4 MATERIALS

Various materials employed for plastering have been described here below. A rich mortar mix tends to develop large cracks; a weaker one develops finer and distributed cracks. A strong coat is never applied over a weaker one since the latter would be unable to restrain its movement.

Mortar is defined as a material composed of fine aggregate and cementing material which forms a hardened mass when mixed with a suitable proportion of water. It is used for plaster work and for bonding bricks and masonry solidly together so that stresses from super-Imposed loads are evenly distributed. The cementing material is clay and Portland cement for mud mortar and cement mortar respectively. Sand is the aggregate used for cement mortars. The constituents of all mortars should be mixed thoroughly to ensure a uniformity of composition.

Mortars are usually defined by their composition rather than properties, and the proportions of ingredients are generally taken by volume. The following are the different types of mortars commonly used.

15.1.4.1 Mud Mortars

Mud mortar is used in brickwork, masonry and plaster work, provided these works are not likely to remain under water. The mud mortar shall comply with the provisions of clause 11.7.2(i), Mud Mortar, Section11 – Brickwork.

15.1.4.2 Cement Mortar

Cement mortar is used in brickwork, masonry plaster work and concrete work. Its Ingredients are cement and sand whose proportions may be 1:2, 1:3, 1:4, 1:5, 1:6, 1:7,1:8 and so on by volume as specified and shall comply with the provisions of clause 11.7.2(ii), Cement Mortar, Section 11 - Brickwork.

15.1.4.3 Mortar of Fire Clay Brick Work

Fire-clay or alternatively fire-cement is suitable for setting firebricks. Generally the joints are the most vulnerable part of fire brickwork and when they crumble away, the arises of these bricks become vulnerable to heat. Fire-clay can be used just as it comes out of hearth but it tends to contract on cooling and again on exposure to heat; so the best way is to use tire-cement that is especially prepared to resist construction under heat. Burnt clay, made by crushing ordinary fire bricks does not expand or contract markedly and therefore constitute a suitable aggregate for fire brick mortar mixed with high alumina or other bauxite cement.

The proportion of alumina cement to crushed fire brick is 1:1. The mortar isprepared in the same manner as described for cement mortars.

15.1.4.4 Cement Mortar with Plasticizer/Additives

The proprietary plasticizer approved by the Engineer-in-Charge, shall be used with cement and sand to improve the workability and durability of cement mortar. The dosage and mixing of the plasticizer shall be in accordance with the recommendations of the manufacturer for plasticizer.

The other additives used could be pigments for the required color, water proofing agent and washing soda. The procurements shall be made and mixing done as approved by the Engineer-in-Charge.

15.1.5 CEMENT PLASTERING

15.1.5.1 General

a) Plastering or pointing shall not commence until all electric conduits, drainage and sanitary pipes, inlets to tanks, brackets, clamps, doors and window frames and all sorts of inserts and embedded items are fixed in position. It shall be the responsibility of the Contractor to make sure that all such work is carried out by other contractors before starting of plaster or pointing work, chiseling and repairing of cement plaster or pointing shall not be permitted without the approval of the Engineer-in-Charge.

b) Sample of materials shall be submitted to the Engineer-in-Charge for his approval prior to use in the works.

c) All internal/external plaster on concrete surfaces shall have an average 12mm thick plaster consisting of 1:3 cement sand mortar in gray cement finished smooth plaster, unless otherwise specified on the drawings and/or as directed by the Engineer.

d) All internal/external surface on brick/block masonry shall have an average 20mm thick plaster consisting of base coat of 1:5 cement sand mortar in gray cement and finished smooth unless otherwise specified on Drawings and/or as directed by the Engineer.

e) <u>Tolerances</u>

Surfaces of plaster work shall be finished with a true plane to correct line and level with all angle and corners to a right angle unless otherwise specified and with walls and reveals plumb and square.

The maximum permitted tolerances shall not exceed 3 mm in 2m variation from plumb or level in any exposed line or surface and 1.5 mm variation between planes of abutting edges or ends.

f) <u>Cleaning and Protection</u>

Rubbish and debris shall be removed as necessary to make way for work of other trades and as directed by the Engineer-in-Charge. As each room or space is completed, all rubbish, debris, scaffolding and tools shall be removed to leave the room clean.

15.1.5.2 Precautions in Plastering

Unless otherwise specified or directed by the Engineer-in-charge the following measures shall be adopted to remedy defects and faults incidental to plaster work.

- **i)** Fine aggregate (sand) shall be clean and free from all impurities. It shall be washed before use.
- **ii)** A proper key shall be provided between the plaster and the surface to be plastered.
- **iii)** The background shall be kept moist but excessive moisture shall be avoided.
- **iv)** Proper curing shall be done to eliminate excessive and rapid thermal changes.
- **v)** Each coat shall be allowed to dry before the next is applied.

15.1.5.3 Scaffolding

The scaffolding for plaster shall always be double.

15.1.5.4 Inspection of Plastering

Plastering shall be inspected by the Engineer-In-charge or his authorized representative when the work is in progress and after its completion. The following points will be kept in view while making the inspection.

- **i.** If wood skirting are specified, the plastering has been finished tight, on to them.
- **ii.** The surface checked by mean of straight edge and tips of the fingers is perfectly even.
- **iii.** All intricate places like soffits, cupboard and their recesses, specified to be plastered, have been properly plastered.
- **iv.** The work has been properly finished at the junction with other materials, such as woodwork at windows and door openings fireplaces and similar other places
- **v.** If wood angle-beads are specified they are of proper section under cut for key. Securely fixed and the plaster has been finished up to them in a proper manner.
- **vi.** Special care has been taken of cornices, and moulding sections. The templates shall be thoroughly checked and compared with the approved drawing.
- **vii.** All ornamental work and other details as specified are true to design and securely fixed and bonded.
- **viii.** In external stucco, rough cast, or pebble-dashing, the coats are of even thickness and are uniformly laid.
- **ix.** The plastered surface struck with the knuckles does not give hollow sound. If it rings hollow, it is an indication of insufficient adhesion between various coats of plaster.

15.1.6 PLASTERING

- **i)** Unless otherwise specified or directed by the Engineer-in-Charge or his authorized subordinate in writing, wooden screeds 8 cm wide and having a thickness equal to the plaster shall be fixed vertically 2.5 meter to 3 meter apart to act as gauges and guides in applying the plaster.

ii) The arises shall then be plastered for a space of 10 cm on each side and up to the ceiling, except in case of openings where it shall run around them. This plaster shall also serve as a guide for thickness etc. Unless otherwise specified or directed by the Engineer-in-Charge all corners and arises shall be rounded off to a radius of 20mm only and no more.

iii) The mortar shall be laid on the wall between the screeds, using a plasterer's float for the purpose and pressing mortar so that the raked joints are properlyfilled. The plaster shall then be finished off with a wooden straight-edge reaching across the screeds. The straight-edge shall be worked on the screeds with an upward and sideways motion, 5.5 cm or 7.5 cm at a time. Finally the surface shall be finished off with a plasterer's wooden float. Metal floats shall not be used.

iv) The plaster shall be laid to a true and plumb surface and tested frequently with a straight - edge and plumb-bob. The straight - edge shall not be less than 3 meters in length. As the work proceeds, all horizontal lines and surfaces shall be tested with a level, and all jambs and corners with a plumb-bob.

v) All moldings decorations details and finishes shall be worked true to template and shall be neat, clean, level, and parallel, or truly plumb, as the case may be.

vi) Unless otherwise specified, plaster shall not exceed 12 mm in thickness and shall not be less than 6 mm at the thinner part.

vii) Protection During Curing
After completion, plaster shall be kept wet for 10 days and shall be protected (during that period from extreme fluctuations of temperature and weather).

15.1.7 DEFECTS IN PLASTER

Various defects observed on plaster alongwith their causes are given below:

a) **Cracks:**
Cracks briefly occur on account of (i) Structural defects in building and discontinuity of surface. (ii) Plastering on very wet background. (iii) Old surface not properly prepared. (iv) Over-rapid drying. (v) Excessive shrinkage of the plaster owing to thick coats and richer mixes.

b) **Pitting And Blowing:**
These defects are noticed In case of faulty slaking -and hydration of the lime particles in the plaster.

c) **Falling Out:**
Plaster falls out mainly on account of (i) lack of adhesion for not having formed a proper "key" in the background (ii) Excessive moisture in the background (iii) Excessive thermal changes either in the background or in plaster itself. (iv) Rapid drying. (v) Insufficient drying between each coat of plaster.

15.1.8 REMEDIES OF DEFECTS

Hair-cracks on fresh plaster normally disappear after whitewashing. But wide cracks shall be filled in by forcing down mortar consisting of plaster of paris, cement and sand in the proportion of 1:2:7 unless otherwise specified or directed by the Engineer-in-charge. Surface areas showing pitting, blowing, popping and blister shall be remedied by cutting out patches in rectangular shape, under cutting the edges to form a dovetail key and making good on a portland cement ground.
All these remedial measures shall be carried out by the contractor at his own expense.

15.1.9 PLASTERING ON LATHING OR EXPANDED METAL

15.1.9.1 General

Lathing constitutes a convenient base in some form of construction for plastering on walls and ceilings. Metal lathing, the most commonly used, is fixed to timber support by galvanized wire nails or staples at short distance. It is also often used to bridge the junction of two dissimilar backgrounds, or to provide a suitable key for plastering over a wooden beam. Metal lathing may be of expanded metal or woven wire etc., which should weigh not less than 12 lbs. per 100 square feet, except when used to provide the key. Lathing is stretched tight with the help of some tension device such as mild steel rods since plaster would crack on a loose lathing. After cleaning the rust, if any the lathing is brushed with cement slurry. Most common defects in plaster on metal lathing are extensive cracking. Particularly along the line of fixing of the lathing to its support or unevenness of the finished plastered surface.

15.1.9.2 Preparation Of Surface

i) Expanded metal or similar metal fabric or lathing shall be free from all rust, grease or other surface impurities, before plastering can be done.

ii) When wooden lathing is used the wood shall be cleaned, slightly roughened and two coats of (creosote) or other wood preservative shall be given. Lathing shall be erected to break joints.

15.1.9.3 Mortar

Unless otherwise specified two coats of plaster shall be applied. The mortar for both the coats shall be 1:3 cement mortar prepared as per Specifications No. 15.1.4.2 except that for the first coat ¾ lb of fine chopped jute or hemp shall be added and thoroughly mixed with each cubic foot of mortar.

15.1.9.4 First Coat

The first coat shall be applied in such a way as to enclose the fabric completely or in the case of wooden lathing, to form a secure key between the lathes. The coat shall be worked to an even surface half an inch behind the screeds and kept wet for four days or till it sets.

15.1.9.5 Finishing Coat

Before the first coat has set the surface shall be scratched with a sharp tool both ways to give a key to the floated coat. All dust and loose plaster shall be washed off, the surface shall be cement-washed and floated coat shall then be applied and finished according to provisions of Clause 15.1.5 as approved by the Engineer-in-Charge.

15.1.9.6 Other Respect

In all other respects, it shall conform to relevant portions of Clauses 15.1.5 and before.

15.1.10 MORTARS FOR PLASTERING

The mixing proportion (by volume) of dry material for preparation of mortar shall be corresponding to relevant CSR item.

15.1.11 NIRU PLASTER

The niru plaster is a cement wash compressing a solution of cement & water in proportions as specified. The solution is freely applied on prepared surfaces by simple spraying or by application with brush.

15.1.12 MUD PLASTER

15.1.12.1 Preparation

Mud mortar for plastering shall be prepared as per Specifications No. 15.1.4.1.

15.1.12.2 Application of Plaster

The plaster shall be spread evenly over the wall so as to be not more than 3/4 inch thick. In case of roofs and floors, its thickness shall be 1 inch. After spreading, the plaster shall be floated with a straight-edge, till the surface is perfectly smooth, level and true. Any cracks that open out during drying shall be filled with liquid cow-dung.

15.1.12.3 Finish

i) When the surface has dried, it shall be *leeped* over and finished off with a trowel or float in the case of walls and roofs. In the case of floors, it shall be applied and finished by hand.

ii) The *leeping* shall be done with a preparation described below:-
Cow-dung is steeped in water to render it free from grass, straw, seeds and other impurities. If considered necessary, it shall be passed through a fine sieve. An equal part of finely-powdered clay shall then be mixed with it thoroughly in the tub.

15.1.12.4 Measurements

Length and breadth shall be measured correct to a cm and its area shall be calculated in square metres correct to two places of decimal. Thickness of the plaster shall be exclusive of the thickness of the key i.e. grooves, or open joints in brick work.

The measurement of wall plaster shall be taken between the walls or partitions (the dimensions before the plaster shall be taken) for the length and from the top of the floor or skirting to the ceiling for the height. Depth of coves or cornices if any shall be deducted.

The following shall be measured separately from wall plaster.

(a) Plaster bands 30 cm wide and under

(b) Cornice beadings and architraves or architraves moulded wholly in plaster.

(c) Circular work not exceeding 6 m in radius.

Plaster over masonry pilasters will be measured and paid for as plaster only. A coefficient of 1.63 shall be adopted for the measurement of one side plastering on honey comb work having 6 x 10 cm. opening. Moulded cornices and coves.

(a) Length shall be measured at the centre of the girth.

(b) Moulded cornices and coves shall be given in square metres the area being arrived at by multiplying length by the girth.

(c) Flat or weathered top to cornices when exceeding 15 cm in width shall not be included in the girth but measured with the general plaster work.

(d) Cornices which are curved in their length shall be measured separately.

Exterior plastering at a height greater than 10 m from average ground level shall be measured separately in each storey height. Patch plastering (in repairs) shall be measured as plastering new work, where the patch exceed 2.5 sqm. extra payment being made for preparing old wall, such as dismantling old plaster, raking out the joints and cleaning the surface. Where the patch does not exceed 2.5 sqm in area it shall be measured under the appropriate item.'

Deductions in measurements, for opening etc. will be regulated as follows:

(a) No deduction will be made for openings or ends of joists, beams, posts, girders, steps etc. upto 0.5 sqm in area and no additions shall be made either, for the jambs, soffits and sills of such openings. The above procedure will apply to both faces of wall.

(b) Deduction for opening exceeding 0.5 sqm but not exceeding 3 sqm each shall be made for reveals, jambs, soffits sills, etc. of these openings.

(i) When both faces of walls are plastered with same plaster, deductions shall be made for one face only.

(ii) When two faces of walls are plastered with different types of plaster or if one face is plastered and other is pointed or one face is plastered and other is unplastered, deduction shall be made from the plaster or pointing on the side of the frame for the doors, windows etc. on which width of reveals is less than that on the other side but no deduction shall be made on the other side.

Where width of reveals on both faces of wall are equal, deduction of 50% of area of opening on each face shall be made from area of plaster and/or pointing as the case may be.

(iii) For opening having door frame equal to or projecting beyond thickness of wall, full deduction for opening shall be made from each plastered face of wall.

(c) For opening exceeding 3 sqm in area, deduction will be made in the measurements for the full opening of the wall treatment on both faces, while at the same time, jambs, sills and soffits will be measured for payment.

In measuring jambs, sills and soffits, deduction shall not be made for the area in contact with the frame of doors, windows etc.

15.2 POINTING

15.2.1 GENERAL

The surface of the work is prepared as explained under "Plastering". When commencing masonry each day the first thing to be done if the surface is to be subsequently pointed, is to rake out the face joints of all masonry finished the previous day. The joints are properly wetted in old work before pointing; for the mortar will not stick to a dry surface. The work pointed is kept wet for at least three days.

15.2.2 MORTAR MIX

The mortar for pointing shall be cement sand mortar in proportion as specified and shall be prepared as per provisions of Clause 15.1.4.2.

15.2.3 PREPARATION OF SURFACE

i) Before pointing old brickwork or new brickwork in mud, the joints shall be raked out with a hook (not hammer) to a depth of half an inch. If, for any reason, the joints in new brickwork and stone masonry are not struck as the work proceeds they shall be raked out before the mortar sets.

ii) All earth and mortar dust coming out of the joints as a result of raking shall be washed off and the brickwork watered for 24 hours. The face shall once again be washed just before starting pointing.

iii) The surface prepared in the manner described above shall be inspected by the Engineer-in-charge or his authorized subordinate and shall be approved by one of them before actual pointing begins.

15.2.4 TYPES OF POINTING

Unless otherwise specified various types of pointing suitable for different situations shall be as follows:

a) Deep or Struck Cement Pointing

i) This type of pointing shall be done to all un-plastered faces of brickwork in mud where the brickwork is liable to be affected by dampness and saltpeter such as in plinths of buildings.

ii) The mortar shall be prepared as per Specifications Cement Mortar, Section 11 - Brickwork.

iii) The mortar shall be filled in the joints flush with stone masonry or brickwork with a pointing trowel and then pressed in with proper pointing tools. Lining with a spike on a mass of mortar shall not be allowed.

b) Flush Cement Pointing

i) This type of pointing shall be done to all brickwork and stone masonry with an exposed face when the finish of the face is not important or when a flush floor surface is required or when the floor or brickwork is subject to wear or to the effects of dampness and saltpeter.

ii) The mortar shall be prepared as per Specifications Cement Mortar, Section 11 - Brickwork.

iii) The mortar shall be filled and pressed into the joints with a pointing trowel and finished off level with the edges of the bricks to give the smoothest possible appearance to the work.

c) Ruled Pointing

i) This type of pointing shall be done when specified to brickwork and stone masonry not liable to be flushed with Water.

ii) The cement mortar as actually specified shall be used. These mortars shall be prepared as per Specifications Cement Mortar, Section 11 - Brickwork.

iii) The mortar shall be filled and pressed into the joints with a pointing trowel and finished off level with the edges of the bricks and shall then be ruled along the centre of all joints with a half round tool 1/2" wide.

d) Striking Joint

i) All new un-plastered faces of work in cement mortar shall be finished by striking joints as the work proceeds according to the relevant part of Section 11 contained under brickwork.

ii) In case of walls, joints shall be struck by raking out the green mortar after the brickwork has been laid and finished with a pointing tool.

15.2.5 POINTING TOOLS

The pointing tools for horizontal joint shall be such as to form weathered and struck joints, and for vertical joint, triangles so as to make a (V) notch in the joints care shall be taken not to develop a cutting edge in the tools since the idea is to compress the green mortar into the joints and not to cut it away.

15.2.6 EDGES OF BRICK

The mortar shall not be spread irregularly over the edges and corners of the bricks, which shall be left clearly visible. The practice of smearing mortar, over defects in bricks, to hide them, shall not be allowed and shall render the whole brick work liable to be rejected.

15.2.7 WASHING AFTER POINTING

After pointing, the face of the work shall be cleared off all surplus mortar sticking to the face. No washing shall be done till the pointing has set.

15.2.8 CURING

The cement pointed work shall be kept wet for 10 'days after completion. The work shall be protected during that period from extreme fluctuations of weather.

15.2.9 MEASUREMENT

Length and breadth shall be measured correct to a cm and its area shall be calculated in square metres upto two places of decimal. The various types of pointing for example, struck, keyed, flush, tuck, etc. shall each be measured separately. Pointing on different types of walls, floors, roofs etc. shall each be measured separately. The type and material of the surface to be pointed shall be described. Pointing in a single detached joint as for flashing shall be given in running metres.

For jambs, soffits, sills etc. for opening not exceeding 0.5 sqm each in area, ends of joists, beams, posts, girders, steps etc. not exceeding 0.5 sqm each in area and opening not exceeding 3 sqm each deductions and additions shall be made in the following way, in case of pointing on external face only.

(a) No deduction shall be made for ends of joists, beams, posts etc. and openings not exceeding 0.5 sqm each, and no addition shall be made for reveals, jambs, soffits, sills, etc. of these openings.

(b) Deductions for openings exceeding 0.5 sqm but not exceeding 3 sqm each shall be made as follows and no additions shall be made for reveals, jambs, soffits, sills, etc. for these openings.

(c) When both the faces of the wall are pointed with the same pointing deduction shall be made for one face only.

(d) When two faces of wall are pointed with different pointings or if one face is plastered and other is pointed or plastered, deduction shall be made from the plaster or pointing on the side of frames for doors, windows, etc. on which the width of the reveal is less than that on the other side, but no deduction shall be made from the other side.

(e) Where width of reveals on both faces of wall are equal, deduction of 50% of area of opening on each face shall be made from area of pointing or plaster as the case may be.

(f) For opening having door frame equal to or projecting beyond thickness of wall, full deduction for opening shall be made from each pointed face of wall.

In case of openings of area above 3 sqm each, deduction shall be made for the openings, but jambs, soffits and sills shall be measured.

The following shall be measured separately.

(a) Raking out joints for old work only shall be measured and given in square metres.

(b) Raking out joints of old work built in mud mortar, lime mortar and cement mortar shall each be measured separately.

(c) Raking out joints of different types of old walls, floors etc. shall each be measured separately.

(d) Raking single detached joints as for flashing old work shall be given in running metres.

15.3 WHITEWASH

15.3.1 PREPARATION

Whitewash, which is the cheapest water paint and has the desirable sanitary properties, is prepared from pure fat lime (white stone) or shell lime. Preferably, un-slaked lime is brought to the site of work and slaked there. After slaking it is kept in a tank of water for at least two days and then stirred up with a pole till it attains the consistency of a thin cream. Where necessary, gum or rice water (2 Ozs. of gum for1Cu.ft of lime) is added. Sometimes flour, skimmed milk, glue, molasses or other substances are mixed in the slaked lime to increase its adhesion. Preservatives such as salt or formaldehyde are added to keep these substances from spoiling. White ash may be tinted by using pigments and should be strained through a coarse cloth or a fine wire gauze before use.

15.3.2 PREPARATION OF SURFACE

All loose material and dirt on the surface must be removed with a brush. Holes and, irregularities of surface are repaired with lime putty, and the surface is allowed to dry before applying whitewash or color-wash. Similarly dusting and repair are done, to walls which have been whitewashed several times before. All greasy spots are given a coat of rice, water and sand. Surfaces discolored by smoke are washed with a mixture of wood ashes and water or yellow earth before being whitewashed.

15.3.3 APPLICATION

Each coat of whitewash comprises four strokes applied vertically and horizontally. One stroke is given from the top downwards and the other from the bottom upwards over the first stroke before it dries up, and similarly one stroke from the right and another from the left over the first brush. Each coat is allowed to dry up before the next is applied. Normally three coats are applied on the new surface.

Keeping in view the various principles on which the hydration of quicklime depends, the following methods are employed for slaking different types of lime:

a) Hand Slaking

i) By drowning: High calcium lime or fat lime is slaked by, drowning the particles in a tub containing enough quantity of water. The tub is covered to preserve the heat.

ii) By Immersion-Feeble hydraulic limes are slaked by immersion. They are put in a basket which is immersed in, a tub filled with water. The basket is withdrawn when the sound of the reaction becomes apparent. The exact period of immersion is a matter of experience.

iii) By sprinkling-Hydraulic limes are usually slaked by this manner. They are spread on a specially prepared non-ferrous platform and water is sprinkled by mean of a can with a rose. Simultaneously the limes are turned over with spades. The slaking operation is accelerated, if the limes are initially pulverized in grinding mills.

iv) Air Slaking-According to this method lime takes moisture from the air when kept in an exposed condition. This process of hydration is also accompanied by the formation of a certain proportion of calcium carbonate by taking carbon-dioxide from the air and in this way lime is spoiled. Besides, it is difficult to control this process.

b) Mechanical Slaking Or Hydrating:

Hydrated lime is produced on a large scale with the aid of various types of mechanical appliances. It may be produced in a specific quantity each time or the process kept continuous.

By whatever method, the hydration is done the following points must be observed:

- Only the necessary quantity of water should be added to the lime at a uniform rate.
- Lime and water must be thoroughly mixed. The temperature of hydration should be properly controlled by a suitable cooling method.

A hydrating plant essentially consists of a crusher and a hydrator with a suitable storage tank and silos, and contains devices for conveying the material from one unit to the other. Hydrated lime is then passed through a sieve of 20 to 30 meshes to an inch to yield a powder of the required fineness.

15.3.4 WHITEWASHING CEMENT CONCRETE

Cement concrete surface requires treatment prior to whitewashing. Surface is scraped off with a wire brush to remove greasy patches if any and washed with soap-suds. A coat of sodium silicate and water in the ratio of 1:5 is given to avoid any future scaling or flaking off.

Half to one part (by weight) of tallow in small lumps is added to 16 parts of quick lime, slaking it with only just sufficient water to form a thick paste stirring occasionally to assist in dispersing the tallow, and allowing it to stand till it cools down. The resultant paste is thinned down to a required consistency, is strained and applied on the surface in the usual manner. In the absence of tallow other oils or fats (for example, linseed oil or castor oil or some common vegetable oil) about 10% of the weight of dry lime are added to serve this purpose. If oil does not incorporate with the lime, the mixture is boiled a little till the oil disappears. In this way it becomes an insoluble soap which when once dry cannot be washed off even with heavy rains.

15.3.5 CEMENT WASH

Cement wash is simply a thin grout made of Portland cement and water and of such a consistency that it can be applied with a brush. Fine sand is sometimes added. This wash may be colored, if desired, but with certain tints it is desirable to use white Portland cement. Paints consisting of two parts of Portland cement to one part of lime are usually used.

15.3.6 MEASUREMENT

Length and breadth shall be measured correct to a cm. and area shall be calculated in sqm correct to two places of decimals. Measurements for Jambs, Soffits and Fills etc. for openings shall be as described in 15.1.12.4.

Cornices and other such wall or ceiling features, shall be measured along the girth and included in the measurements.

The number of coats of each treatment shall be stated. The item shall include removing nails, making good holes, cracks, patches etc. not exceeding 50 sq. cm. each with material similar in composition to the surface to be prepared. Work on old treated surfaces shall be measured separately and so described.

15.4 COLOR-WASHING

Color-washing is nothing more than a lime-wash colored with suitable pigments and treated to give a desired tint. It is applied exactly in the same fashion as the whitewash. The old paint is scraped off or a coat of whitewash is applied before the new color is given. Gum or rice water is added as in whitewashing.

15.4.1 PREPARATION

The surface to be color-washed shall be prepared according to the specifications No. 15.3.2 for Whitewashing.

15.4.2 PREPARATION OF COLOR-WASH

The color-wash shall be prepared by adding the necessary coloring pigment to the whitewash which has been strained. The mixture shall be stirred thoroughly and passed through a clean, fine cloth. Only such quantity of wash shall be prepared as can be consumed in a day's work.

15.4.3 APPLICATION

i) New or scraped surface shall be given a coat of whitewash, prior to color-wash.

ii) Old surface when the color-wash is satisfactory shall be given only one new coat of color-wash.

iii) When replacing one color with another of a lighter shade the old color - shall be thoroughly scraped and a coat of whitewash given before the new color is applied.

iv) Each coat color-wash shall be allowed to dry and shall be inspected by the Engineer-In-charge or his authorized subordinate. The next coat shall not be applied unless the previous one has been approved by either of them.

v) The completed wall shall be of a uniform color free from blots lines or cut shades and shall present a smooth regular surface which shall neither crack nor come off readily on figures when rubbed.

vi) Each room shall be finished in one operation and work shall not start in a room so late that it cannot be finished the same day.

15.4.4 OTHER RESPECTS

In all other respects not specified here, it shall strictly conform to Specifications No. 15.3 for Whitewashing.

15.4.5 MEASUREMENT

Length and breadth shall be measured correct to a cm. and area shall be calculated in sqm correct to two places of decimals. Measurements for Jambs, Soffits and Fills etc. for openings shall be as described 15.1.12.4.

Cornices and other such wall or ceiling features, shall be measured along the girth and included in the measurements.

The number of coats of each treatment shall be stated. The item shall include removing nails, making good holes, cracks, patches etc. not exceeding 50 sq. cm. each with material similar in composition to the surface to be prepared. Work on old treated surfaces shall be measured separately and so described.

15.5 DISTEMPERING

15.5.1 GENERAL

i) Unless otherwise specified or directed in writing, a newly plastered wall shall not be distempered earlier than 12 months after the plastering if distempered earlier the plaster shall be treated with damp proof compound.

ii) Distempering shall not be done in damp weather nor when the weather is excessively hot and dry.

15.5.2 PREPARATION OF SURFACE

i) Newly-plastered surface when absolutely dry shall be sand-papered to remove all irregularities, making good inequalities and holes with gypsum which shall be allowed to set hard. Unless the surface is perfectly clean and smooth, no pleasing effect shall result from distemper.

ii) Old plastered surfaces shall be thoroughly cleaned if it is whitewashed or color-washed, it shall be rubbed off with sand-paper or cocoanut fiber in case it is loose and then stopped and sized.

iii) After rubbing and cleaning, all plastered surface, old or new, shall be sized with a coat of equal parts of size and alum dissolved in hot water. Decomposed size shall not be used under any circumstances. Where the makers of the distemper recommend a special priming coat only that coat shall be applied.

iv) If the existing surface is cleanly distempered all the distemper shall not necessarily be removed. The surface shall be smooth down with glass paper or any firm distemper on the wall after such rubbing shall be-left.

15.5.3 PREPARATION OF DISTEMPER

i) Unless otherwise specified ready-made distempers as specified and approved by the Engineer-in-Charge shall be obtained from the market as they are easily available.

ii) Distempers shall be mixed strictly in accordance with the maker's instructions or as directed by the Engineer-In-charge, and the quantity shall be just sufficient for the day's work.

15.5.4 APPLICATION

i) Distemper shall be applied only with proper brushes as supplied or recommended by the maker. The brushes shall be washed in hot water after work each day and hung up to dry. Old brushes caked with dry distemper shall not be allowed to be used on the work.

ii) Distemper shall be applied quickly and boldly leaving no dry edges. The brush shall be dipped in distemper and stroked cross-wise on the wall, then immediately stroked up and down and stopped.

iii) Unless otherwise specified or directed two men shall work on a wall together, one working from the ceiling, downwards as far as he can reach and the other following him applying, the distemper from below. No patchy overlap shall be allowed under any circumstance. .

iv) Unless otherwise specified, the following number of coats of distempers shall be applied:

a) On newly plastered walls two coats over one coat of priming.

b) On old plastered walls covered with one or two coats of hard dry whitewash free from efflorescence or kalar, one coat without priming coat.

15.5.5 MEASUREMENT

Length and breadth shall be measured correct to a cm. and area shall be calculated in sqm correct to two places of decimals. Measurements for Jambs, Soffits and Fills etc. for openings shall be as described 15.1.12.4.

Cornices and other such wall or ceiling features, shall be measured along the girth and included in the measurements.

The number of coats of each treatment shall be stated. The item shall include removing nails, making good holes, cracks, patches etc. not exceeding 50 sq. cm. each with material similar in composition to the surface to be prepared. Work on old treated surfaces shall be measured separately and so described.

15.6 CEMENT RENDERING

15.6.1 PREPARATION OF SURFACE

i) The surface to be rendered shall be thoroughly cleaned and dust loose particles, grease and oil stains shall be removed by washing, using a wire brush, if necessary.

ii) Brickwork, stone masonry or concrete shall be prepared to receive the rendering by raking out joints to a small depth not more than ½”, or in the case of hardened concrete by beating a thoroughly saturated surface by 1:6 solution of hydrochloric acid and water, washing down within six hours and wire brushing so as to expose the aggregate. If the Engineer-in-charge thinks that the surface so prepared provides a good key, a single coat of rendering 3/8" to ½ " thick shall suffice.

iii) If, however, a good key is not obtained, a base coat of coarse sand and cement in the proportion of 1-1/2” parts sharp sand 1/4” down to 1 part cement, mixed in sufficient water, shall be applied. The mixture shall be dashed on to the wall in an uneven manner.

15.6.2 PREPARATION OF MORTAR FOR RENDERING

i) Fine Aggregate, Cement and water shall conform to Specifications of Cement Mortar referred in Clause 15.1.4.2.

ii) The grading of aggregate shall be ½” down for key coat and 1/8” down for finishing coat.

iii) The proportions of cement and aggregate for key coat shall be 1:3 and for backing or finishing coat 1:1-1/2”. A mortar of required consistency shall be prepared by adding water from 12 to 16 per cent of the total volume of aggregate and cement for backing coat and 14 to 18 per cent for finishing coat, unless otherwise specified or directed by the Engineer-In-Charge.

15.6.3 APPLICATION

i) Backing Coat:

It shall be laid to a uniform thickness of 3/8" and just, after the material has started to set, it shall be scored in wavy lines by a wire-nail comb to form a bond for the next coat, arid the work then allowed to set for at least 30 hours. It shall be kept damp for that period.

ii) Finishing Coat:

Unless otherwise specified or directed, the finishing coat shall be 1/8" thick. The backing coat (base coat) shall be washed clean and the finishing coat applied evenly with care.

15.6.4 CURING

The finishing coat shall be protected from the sun, hot winds or rain by wet screens till it has hardened sufficiently to remain unaffected by the external application of water. It shall then be watered and kept damp for a period of at least seven days and allowed to dry as slowly as possible.

15.6.5 PROTZECTION AGAINST CRACKING AND CRAZING

The surface shall be divided by joints to prevent cracking, and these joints shall be placed horizontally at the sill and Lintel level of windows and vertically at opening In wall angles and corners.

15.6.6 MEASUREMENT

Length and breadth shall be measured correct to a cm. and area shall be calculated in sqm correct to two places of decimals. Measurements for Jambs, Soffits and Fills etc. for openings shall be as described 15.1.12.4.

Cornices and other such wall or ceiling features, shall be measured along the girth and included in the measurements.

The number of coats of each treatment shall be stated. The item shall include removing nails, making good holes, cracks, patches etc. not exceeding 50 sq. cm. each with material similar in composition to the surface to be prepared. Work on old treated surfaces shall be measured separately and so described.

15.7 EMULSION PAINTING

15.7.1 SCOPE

The work include the provision of all materials, labour, plant and equipment and completion of work as specified and approved by Engineer-in-Charge

15.7.2 MATERIALS

Emulsion paints shall be of make and type as specified and approved by the Engineer-in-Charge.

15.7.3 EMULSION PAINT APPLICATION

For emulsion paint application the specifications laid for distempering under clause 15.5 shall apply.

15.8 SYNTHETIC FINISH

Synthetic finishes consist of application of synthetic finishes like Rockwall, Durock Graphic, Cemec or equivalent as specified and approved by the Engineer-in-Charge. The work shall be carried out according to supplier’s instructions.

15.8.1 MEASUREMENT

Length and breadth shall be measured correct to a cm. and area shall be calculated in sqm correct to two places of decimals. Measurements for Jambs, Soffits and Fills etc. for openings shall be as described 15.1.12.4..

Cornices and other such wall or ceiling features, shall be measured along the girth and included in the measurements.

The number of coats of each treatment shall be stated. The item shall include removing nails, making good holes, cracks, patches etc. not exceeding 50 sq. cm. each with material similar in composition to the surface to be prepared. Work on old treated surfaces shall be measured separately and so described.

15.9 STUCCO CEMENT PLASTER

15.9.1 SCOPE

It shall cover placing 1:2:4 (Cement, Sand and Shingle) mix, 51 mm thick, as a plaster including furnishing of all labor, materials, plant, equipment, accessories and services as required to complete the plastering item as shown on the Drawings, specified herein and/or as directed by the Engineer-in-Charge. The materials herein specified shall be proportioned, mixed, formed and placed in accordance with the herein stated requirements. The stipulations and requirements herein set forth shall apply except when such stipulations and requirements are specifically modified by the Engineer for this particular item of work.

15.9.2 MATERIALS

a) Cement

Portland cement shall conform to ASTM C 150-94 Type 1 or BSS – 12.

b) Sand

All sand required under these specifications shall be composed of particles with a maximum size of 5 mm. Sand shall be processed from natural deposits or manufactured from quarried rock.

The grading of sand for this item of work shall be as under:

100 % shall pass through sieve NO.4

2 to 10% shall pass through sieve NO.1 00

c) Aggregate

The aggregate shall comprise shingle having grading as shown on the Drawings and or as directed by the Engineer. Generally reasonable grading is as under:

5mm to 9mm size	upto 25%
9mm to 10mm size	upto 75%
Above 18mm	NIL

d) Water

Water required to be used shall conform to the stipulations and requirements set-forth Section 11 – Brickwork mortar.

15.9.3 MIX PREPARATION

The mix shall conform to the mix design specified in the Drawings. Mix used in Stucco Cement Plastering, as a general principle, shall be so mixed that it is firm enough to stay in place when plastered. The net water-cement ratio of the concrete (exclusive of water within or absorbed by the aggregates) shall range from 0.53 to 0.58 based on the climatic temperature. Temperature of mix when it is placed, shall not be more than 32 degree C and not less than 5 degree C. Tests of the mix shall be made by the Engineer-in-Charge and the mix proportions shall be changed, whenever necessary, for the purpose of securing the required workability, density, impermeability, durability or strength.

15.9.4 THICKNESS

Unless otherwise specified, the thickness of the plaster shall conform to the approved design/ drawings. Generally, the thickness of Stucco cement plaster is taken as 51 mm. The plaster having thickness less than the specified thickness shall be rejected.

15.9.5 APPLICATION OF PLASTER

The plaster shall be done in two coats. The surface of first coat shall be made rough before the second coat is applied

15.9.6 MEASUREMENT

Length and breadth shall be measured correct to a cm. and area shall be calculated in sqm correct to two places of decimals. Measurements for Jambs, Soffits and Fills etc. for openings shall be as described 15.1.12.4.

Cornices and other such wall or ceiling features, shall be measured along the girth and included in the measurements.

The item shall include removing nails, making good holes, cracks, patches etc. not exceeding 50 sq. cm. each with material similar in composition to the surface to be prepared. Work on old treated surfaces shall be measured separately and so described.

15.10 GYPSUM PLASTER

Gypsum Plaster shall be provided wherever shown on the Drawings or as directed by the Engineer-in-Charge. The work shall be carried out strictly in accordance with the manufacturer’s instructions.

Gypsum is naturally occurring material which is quarried or mined. When it is heated to a comparatively low temperature (150-170^{o}C), it is called plaster of Paris or calcium sulphate hemihydrates. When it is mixed with water it sets quickly to form a hard mass. This setting period is too short to permit the material to be used as plastering material. The setting time may be lengthened by adding retarders and the amount of retarders is adjusted by manufacturer’s instructions to suit the purpose of plaster.

Simple precaution which should be taken includes storing before use in a dry place. Calcium sulphate plasters in general are not suitable for use under persistently damp conditions because they will slowly dissolve in water. Plaster of Paris should not be applied to backgrounds containing large amounts of water, should not be used with clayey sand which tends to retain water and should be given adequate drying conditions once they have hardened.

15.10.1 GYPSUM PLASTER BOARD

Gypsum plaster board consists of a core of set gypsum enclosed between and firmly bonded to two stout lining papers. It is covered by British Standard, 1230:1955. This includes the following main type;

- Gypsum base board
- Gypsum wall board
- Gypsum lath
- Gypsum plank

Gypsum base board, Gypsum lath and Gypsum plank are used as a base for plaster. Gypsum wall board is designed to receive a direct decorative finish, but it may be plastered on its reverse side.

15.10.1.1 UNDERCOAT:

The undercoat of specified thickness and proportion shall be applied strictly in accordance with the specification of plaster as described in 15.1.5. The surface, however, needs not to be smooth.

15.10.1.2 APPLICATION:

Gypsum plaster board of specified thickness shall be fixed by nailing to wood joists or studs at 14” to 18” center or as directed by Engineer-In-charge.

15.10.1.3 Measurement:

Length and breadth of the Gypsum plaster board shall be measured correct to a cm and the surface area worked out in square metre of the finished work.

No deduction shall be made for openings of areas upto 40 square decimetre. No extra payment will be made for any extra material or labour involved in forming such openings. For openings exceeding 40 square decimetre in area, deduction for the full opening will be made, but no extra will be paid for any extra material or labour involved in forming such openings.

Boarding fixed to curved surfaces in narrow widths shall be measured and paid for separately. Circular cutting and waste shall be measured and paid for separately in running metres.

15.11 TILE FACING

The tile facing shall be as shown on drawings and approved by the Engineer-in-Charge. The work shall be carried in accordance with the applicable provisions of tile laying in Section 14.

15.12 ORNAMENTAL PLASTER

Ornamental plaster shall be provided wherever shown on the Drawings or as directed by the Engineer-in-Charge. It could be either original imported cement, or colored cement or cement mixed with coloring pigment as provided in the item of work. The work shall be carried out strictly in accordance with 15.1.5.

15.12.1 MEASUREMENT

Length and breadth shall be measured correct to a cm. and area shall be calculated in sqm correct to two places of decimals. Measurements for Jambs, Soffits and Fills etc. for openings shall be as described 15.1.12.4.

Cornices and other such wall or ceiling features, shall be measured along the girth and included in the measurements.

15.13 FALSE CEILINGS

15.13.1 GENERAL

A typical dropped ceiling consists of a grid-work of metal channels in the shape of an upside-down "T", suspended on wires from the overhead structure. These channels snap together in a regularly spaced pattern of cells.

15.13.2 MATERIALS

i) Gypsum Board False Ceiling

Standard Gypsum Board ½” thick unless otherwise indicated on the Drawings, ends square cut, tapered edges as manufactured by US Gypsum or approved equivalent and of approved pattern, size and thickness as per approved shop drawings.

ii) Lasani Board /MDF False Ceiling

Lasani Board / MDF false ceiling shall be of the approved manufacturer and of approved pattern, size and thickness as per approved shop drawings.

iii) Plaster of Paris False Ceiling

The Plaster of Paris false ceiling comprise of POP tiles 1/2" thick size 2'-0"x2'-O" or as shown on the Drawings, reinforce with hessian-mat.

iv) Dampa AL-15

Suspended aluminum false ceiling shall be standard products offered by the manufacturer / supplier DAMPA grid system shall be 0.5mm thick aluminum strips. They shall be profiled units available in standard foil and a pad of mineral wood 12mm thick. The approved manufacturers shall be DAMPA. The type of ceiling used shall be DAMPA AL-15 perforated.

v) Hangers

Hangers shall be of 5/8"x1/8" M.S. flat. It shall be the responsibility of the Contractor to get the sample of hanger approved by the Engineer-in-Charge.

vi) Angles and Tees

Angles and Tees shall be of Aluminum section 1.6mm of approved pattern as per shop drawings approved by the Engineer-in-Charge.

15.13.3 SUBMITTALS

The Contractor shall submit the following for approval of Engineer-in-Charge.

- The shop drawings showing reflected ceiling plan, locations of built-in products and access facilities, dimensions, layout arrangements, hanger locations, structural connection, details of level changes, direction of pattern and panel-joint details.
- Samples of false ceiling panels, suspension system, and accessories including sealant, furring and runner channel etc.

15.13.4 DELIVERY AND STORAGE

- Material shall be delivered in original, unopened, protective packaging, with manufacturer's labels indicating brand name, pattern, size, thickness and fire rating.
- Material shall be stored in original protective packaging to prevent soiling, physical damage or wetting.
- Cartons shall be stored in the installation area, opened at each end to stabilize moisture content and temperature, for 48 hours prior to installation.

15.13.5 QUALITY ASSURANCE

Installer Qualifications: Engage an experienced Installer who has successfully completed false ceilings similar in material, design and extent to those indicated for this Project

Fire Performance Characteristics: Provide these ceilings that are Identical to those tested for the following fire performance characteristics, per ASTM test method indicated below, by Underwriters Laboratories, Inc. (UL) or other testing and inspecting organizations acceptable to authorities having jurisdiction. Identify acoustical ceiling components with appropriate markings of acceptable testing and inspection organization.

Surface burning characteristics: tested per ASTM E84 and complying with ASTM E1264 for Class A products.

Flame spread: 25 or less

Some developed: 50 or less

Single Source Responsibility for Ceiling Panels: Obtain each type of acoustical ceiling unit from a single source with resources to provide products of consistent quality in appearance and physical properties without delaying progress of the Work.

Single Source Responsibility for Suspension System: Obtain each type of suspension system from a single source with resources to provide products of consistent quality in appearance and physical properties without delaying progress in the Work.

Coordination of Work: Coordinate layout and installation of acoustical ceiling units and suspension system components with other construction that penetrates ceilings or is supported by them, including lighting fixtures, HVAC equipment, fire-suppression system components, if any, and partition systems.

15.13.6 TOLERANCES:

Deflection:

Suspension system components, hangers and fastening devices supporting light fixtures, ceiling grilles, and acoustical panels, maximum deflection 1/360th of the span.

Deflection test: ASTMC635.

Allowable tolerance of finished acoustical ceiling system: level to within 1/8 inch in 12 feet.

Field Constructed Mock-Up: Install acoustical ceiling in designated area. Notify Engineer-in-Charge when installation is ready for inspection. After the acceptance of the Engineer-in-Charge, retain mock-up as a standard of quality for entire acoustical panel ceiling installation.

15.13.7 PROJECT CONDITIONS

a) Environmental Requirements:

- Maintain humidity level of 60% - 70% in areas where acoustical materials are being installed, 24 hours prior, during and 24 hours after installation.
- Maintain uniform temperature in range of 55°F to 70°F prior to and during installation.

b) Maintenance Materials

- Deliver to the Engineer-in-Charge additional acoustical units of each type used on Project. Provide units from same manufacturer's run as those installed on Project. Furnish units in manufacturer's original unopened cartons property labeled with designations of building area where used, date, and names of Contractor, supplier and installer. Deliver material to site and store in areas as directed by Engineer-in-Charge.
- Minimum quantity shall be not less than 100 square feet or one full box whichever is more of each type of acoustical unit used on the project.
- Furnish quantity of each exposed suspension system component equal to 2% of amount installed on Project.

15.13.8 ACOUSTICAL CEILING PANELS

Standard for Acoustical Ceiling Panels: Provide manufacturer's standard units of configuration indicated that comply with ASTM E1264 classifications as designated by types, patterns, acoustical ratings, and light reflectance, unless otherwise indicated.

Colors and Patterns: Provide products to match appearance characteristics indicated under each product type.

15.13.8.1 Mineral-Base Acoustical Panels - Modular Cast Or Molded

a) **Fine line Fire- Rated**

Fine Textured Units (ATC Type 1): Manufactured from mineral fibers bonded by organic and inorganic materials and molded (cast) on trays for heat curing; paint finish.

- Type, form and pattern: ASTM E1264, Type III, Form 1, Pattern E.
- Size: as shown on the Drawings.
- Edge detail: regular.
- Noise Reduction Coefficient NRC range 0.70 to 0.80.
- Ceiling Sound Transmission Class: CSTC range 40 to 44.
- Light Reflectance Coefficient: LR-1; 0.75 or more.
- Color: as approved by the Engineer-in-Charge.
- Flame spread classification: Class A.
- Product: as manufactured by Armstrong World Industries Inc. United States Gypsum or equal.
- Locations of specific type of tile as approved by the Engineer-in-Charge.

15.13.8.2 Metal Suspension Systems:

a) **Standard for Metal Suspension Systems**: Provide manufacturer's standard metal suspension systems of types, structural classifications and finishes indicated that comply with applicable ASTM C 635 requirements.

b) **Finishes and Colors**: Provide manufacturer's standard factory-applied finish for type of system indicated.

c) **High-humidity finish**: comply with ASTM C 635 requirements for "Coating Classification for Severe Environment Performance" where high-humidity finishes are indicated.

d) **Attachment Devices**: Size for 5 times design load indicated in ASTM C-635, Table 1, Direct Hung unless otherwise indicated.

e) **Cast-in-place and post-installed anchors in concrete**: provide anchors of type indicated below, fabricated from corrosive resistant materials, with holes or loops for attachment of hangers of type indicated and with capability to sustain, without failure, a load equal to 5 times that imposed by ceiling construction, as determined by testing per ASTM E 448, conducted by a qualified independent testing laboratory.

- Cast-in-place anchors
- Expansion anchors
- Chemical anchors

f) **Wire Hangers:** ASTM A614, Class 1 zinc coating, soft temper.

g) **Gauge**: provide wire sized so that stress at 3 times hanger design load (ASTM C635, Table 1, Direct-Hung), will be less than yield stress of wire, but provide not less than 0.106" diameter (18 gauge).

h) **Edge Molding and Trim**: Steel or extruded aluminum of type and profiles indicated or, if not indicated, manufacturer's standard moldings for edges and penetrations that fit type of edge detail and suspension system indicated

- For lay-in panels with reveal edge details, provide stepped edge molding that forms reveal of same depth and width as that formed between edge of panel and flange at exposed suspension member.
- For circular penetrations of ceiling, provide edge molding fabricated to diameter required to fit penetration exactly.
- For narrow faced suspension systems, provide suspension system manufacturer's standard edge moldings that match width and configuration of exposed runners.

i) **Hold-Down Clips for Non-Fire-Resistance-Rated Ceilings**: For interior ceilings composted of lay-in panels weighing less that 1 lb. per sq.ft.; provide hold-down clips spaced 2' - 0" o.c. on all cross tees.

15.13.8.3 Execution

a) Inspection

- Conditions of Surfaces: Examine surfaces to receive suspended acoustical units for unevenness, irregularities, and dampness that would affect quality and execution of work.
- Refer to Architectural ceiling plans for proper layouts. Notify Engineer-in-Charge of any discrepancies which preclude installation in pattern shown prior to execution of work.
- Do not proceed with installation until unsatisfactory conditions have been corrected.

b) Preparation

- Coordination: Furnish layouts for preset inserts, clips, and other ceiling anchors whose installation is specified in other Sections.

Furnish concrete inserts and similar devices to other trades for installation well in advance of time needed for coordination of other work.

c) Installation

- General: Install acoustical ceiling systems to comply with installation standard referenced below, and manufacturer's installation instructions.
- Standard for installation of ceiling suspension systems comply with ASTM C636.
- Arrange acoustical units and orient directionally patterned units in a manner shown by reflected ceiling plans.

Suspend ceiling hangers from building structural members and as follows:

- Install hangers in plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structural or ceiling suspension system. Splay hangers only where required to miss obstructions and offset resulting horizontal forces by bracing, counters playing, or other equally effective means.
- Where width of ducts and other construction within ceiling plenum produces hanger spacing that interfere with location of hangers at spacing required to support standard suspension system members, install supplemental suspension members and hangers in the form of trapezes or equivalent devices. Size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced standards.
- Secure wire hangers by looping and wire-tying, either directly to structure or to inserts, eye screws, or other devices that are secure and appropriate for substrate, and in a manner that will not cause them to deteriorate or otherwise fail due to age, corrosion, or elevated temperatures.
- Secure flat, angle, channel, and rod hangers to structure, including intermediate framing members, by attaching to inserts, eye screws, or other devices that are secure and appropriate for structure to which hangers are attached as well as for type of hanger involved, and in a manner that will not cause them to deteriorate or otherwise fail due to age, corrosion, or elevated temperatures.
- Do not support ceilings directly from permanent metal forms; provide cast-in place hanger inserts that extend through forms.
- Do not tie the hangers with HVAC ducts.

- Do not attach hangers to steel deck tabs.
- Do not attach hangers to steel roof deck. Attach hangers to structural members.
- Space hangers not more than 4' - 0" o.c. along each member supported directly from hangers, unless otherwise shown, and provide hangers not more than 6" from ends of each member.
- Install edge molding of type indicated at perimeter of acoustical ceiling area and where necessary to conceal edges of acoustical units. Attach molding to substrates at intervals not over 16" o.c. and not more than 3" from ends, leveling with ceiling suspension system to tolerance of 1/8" in 12' - 0". Miter corners accurately and connect securely.
- Install acoustical panels in coordination with suspension system, with edges concealed by support of suspension members. Scribe and cut panels to fit accurately at borders and at penetrations.
- Install hold-down clips in areas indicated and in areas where required by governing regulations or for fire-resistance ratings; space as recommended by panel manufacturer, unless otherwise indicated or required.
- The Contractor will not start fixing of the suspension system at any place before the inspection and approval of the Engineer. All the false ceiling will be fixed at same height from the finished floor unless otherwise specified. Furthermore, the Contractor is required to make shop drawings after verifying the measurement as per site for each room and suggest adjustments through shop drawings for the fixing of the acoustical units of the false ceilings. The Engineer will review the drawings as per the actual measurement of the finished rooms.

d) Clean-up

- Clean exposed surfaces of acoustical ceilings, including trim, edge moldings, and suspension members.
- Comply with manufacturer's instructions for cleaning and touch-up of minor scratches or abrasions on painted surfaces.
- Remove and replace any work that cannot be successfully cleaned and repaired to permanently eliminate evidence of damage.

15.13.9 MEASUREMENT:

Length and breadth of the False Ceiling shall be measured correct to a cm and the surface area worked out in square metre of the finished work.

No deduction shall be made for openings of areas upto 40 square decimetre. No extra payment will be made for any extra material or labour involved in forming such openings. For openings exceeding 40 square decimetre in area, deduction for the full opening will be made, but no extra will be paid for any extra material or labour involved in forming such openings.

Boarding fixed to curved surfaces in narrow widths shall be measured and paid for separately. Circular cutting and waste shall be measured and paid for separately in running metres.

15.14 PVC WALL PANELING

General

Decorative Wall Panels are made from precision extruded PVC and decorated with unique designs ranging from marble, onyx to wood grain patterns. Other colors are also available. The result is a product with durability and low maintenance. It has a safer fire rating than wood or other wood fiber products.

These plastic panels are resistant to color change or fading and warm to touch. These panels are perfect for installation vertically, horizontally or diagonally. Tongue-in-groove profiles are designed to allow easy installation, with recessed fastening by either stapling or nailing to conceal the fastener. Plastic wall panels can also be glued.

The benefits of plastic paneling are innovative, decorative patterns that are not available in other wall covering materials. They are safe, with the highest fire rating for any interior wall finish; flame spread, ASTM E-84, less than 15. Plastic panels also are waterproof; they will not rot, delaminate or absorb water, and are ideal for tub surrounds and high moisture areas. Plastic paneling are perfect for the DIY enthusiasts as they are easy to install, lightweight, and easy to handle, requiring no special tools. Plastic panels fit easily over existing surfaces, including tiles; and can be readily fastened using nails, staples, screws or glue.

15.14.1 SUBMITTALS

The contractor shall submit the required samples to the Engineer-in-Charge along with the technical guide of the manufacturer, the minimum warranty for the PVC paneling should not be less than 10 years.

15.14.1.1 Delivery, Storage, and Handling

- Deliver materials to site in manufacturer’s original, unopened containers and packaging, with labels clearly identifying product name and manufacturer.
- Store materials in clean, dry area indoors in accordance with manufacturer’s instructions. Store wall and ceiling panels flat.
- Protect materials during handling and installation to prevent damage.

15.14.1.2 Area of Application

The panels may be applied on the following areas

- Private residences, offices, warehouses.
- Places where dampness is prevailing.
- In areas where high concentration of sulphur.

15.14.1.3 Check Points

The panels should be laid flat for 48 hours in the area in which they will be installed with a minimum distance of 50 cm from the walls to adapt to the environmental conditions in the area. The ideal environmental temperature before and during installation is approximately 20°C.
Check each panel carefully in daylight before installation for scratches, dents, damage, difference in color and any other deviations to the standard quality. A plan installed that shows faults, is excluded from our guarantee.
Special panels must be installed when installing in places where high requirements are set on hygiene, e.g. in food processing industries. Please check on the insert sheet whether our panels are suitable for this application

15.14.1.4 Preparation

A sturdy support framework must be attached to uneven or damaged bases to ensure an even surface on which the panels may be installed.

- Usually wooden lattice work is chosen. Plastic lattice work is also possible.
- These supports are installed in the opposite direction to the panels (e.g. if the panels are installed horizontally, then the supports must be placed vertically)
- The supports may be a maximum of 30 cm distance from each other.
- Providing open spaces in the framework behind the panels is also recommended to allow some circulation of air.
- With an even base a simple (silicon) adhesive may be used and no framework is required. The panels may be glued directly onto existing tiling without removing it.
- This method is only suitable for dry surfaces free from dust and grease. For damp and uneven walls we recommend the use of lattice work.
- Apply the adhesive in a zigzag pattern onto the panel or the base.
- Use an adhesive on a MS-polymer base, or a two-component polyurethane adhesive. Please always check that the adhesive is also suitable for use on the base on which the panels will be installed.
- Take account of the fact that the panels might expand and contract in the event of major changes in temperature in an area and absorb this by leaving extra space in the support profiles.

15.14.1.5 Installation

- The panels may be cut or shortened easily using a hand saw, table saw, portable circular saw, a sabre jig saw or a sharp snap-off blade knife. Please take the necessary precautions when handling sharp tools.
- First attach the support profile with screws, nails, staples or adhesive so that it is securely attached. Standard support profiles are an end profile, H-profile, universal angle for inside and outside corners, ceiling profile, skirting board, multifunctional F-profile and a ainscoting profile. Skirting boards and crown moldings should be mitred in the corners.
- Remove the tooth from the left side of the first panel and cut the panel to the right length. Install the panel with the side with the sawn off tooth in the support profile.

- Then attach the panel to the side with the groove via the end lip using screws, nails or staples, or use adhesive to attach the entire back to the surface. Ensure that the screw, nail or staple is completely level with the end lip. Check whether the panel is actual attached securely before continuing the installation.
- Take the next panel, put the tooth in the groove of the previous panel until it connects perfectly and attach the new panel to the groove side in the same way as before. Repeat this step until you reach the end. Cut off the excess and use a support profile to complete the installation.
- If the rear of our 10 mm thick panels is cut open in the length, the panels may be bent to make inside and outside corners. The corner cannot then ever exceed 90°, and the panels must be fixed extremely securely to the base using screws. If the panel is less than 10 mm thick, this technique cannot be applied

15.14.1.6 Finishing and Maintenance

- Do not attach heavy accessories like coat hooks, light fittings, mirrors, etc. directly to the panels but drill holes through the panels and use screws and plugs to attach the accessories securely in the wall or ceiling behind.
- For installation in a shower room, around a bath or other very humid places a line of silicon must always be provided in the connection between the panels themselves and between the panels and support profiles to ensure a completely waterproof join. Also provide a silicon line between the panel and the edge of the shower or the bath. Making each join between the panels waterproof is the installer's responsibility.
- When installing halogen lamps holes may be drilled in the panels.
- The contact temperature with the halogen spot may not exceed 60°C. Ensure that a space is always left of at least 10 mm between the halogen lamp and the panels to prevent distortion of the panel. The halogen spot must never be aimed at the panels.
- Also pay attention that the light fittings conform to the legal regulations and that the fitting does not conduct the heat from the light bulb to prevent distortion to the panel.
- Use ordinary household products for maintenance.
- You can polish the panels to their original condition using a soft, nonabrasive cleaning agent. Usually you only need a damp cloth to clean the panels thoroughly
- Do not use abrasive, aggressive substances or cleaning products based on chloride. Solvents should also not be used.
- Adhesive residue or pen marks are best removed using isopropyl-alcohol.
- This product is made from PVC and is 100% recyclable. PVC does not contain any hazardous substances.

15.14.2 MEASUREMENT:

Length and breadth of the PVC Wall Panelling shall be measured correct to a cm and the surface area worked out in square metre of the finished work.

No deduction shall be made for openings of areas upto 40 square decimetre. No extra payment will be made for any extra material or labour involved in forming such openings. For openings exceeding 40 square decimetre in area, deduction for the full opening will be made, but no extra will be paid for any extra material or labour involved in forming such openings.

When fixed to curved surfaces in narrow widths shall be measured and paid for separately. Circular cutting and waste shall be measured and paid for separately.

15.15 GYPSUM DRY BOARD PARTITIONS

15.15.1 MATERIALS

15.15.1.1 Framing Materials

All framing material shall be of best quality available in the market..

15.15.1.2 Perimeter Framing

Perimeter of construction to be framed with "U" channels at head and base and “C" studs at abutments and openings (Refer Drawings). The studs should be designed for quick screw attachments of facing materials. The knurled surfaces on both stud faces shall ensure a minimum of screw riding when partition/drywall is installed. Knock outs for electrical conduits and plumbing shall be placed at every 1'-0" on center and 2" from ends of channels or studs. All framing size and gauge used to be as per manufacturers recommendation.

Vertical studs to be located in head and base, .U" channels at maximum 2'-0" on center and set to coincide centrally with board joints.

Studs to be "C" studs, size and gauge used to be as per manufacturers recommendation.
Vertical studs should be of continuous lengths where possible, and cut to ensure maximum penetration in to head and base channels.

15.15.1.3 Fasteners

Nails, Screws, Staples, Corner Beads, tapes, Resilient clips etc, should be as recommended by the manufacturer and should all be approved by the Architect.

15.15.1.4 Gypsum Board Material

Gypsum shall be Rigid Gypsum plasterboard as manufactured by U.s. Gypsum or approved equivalent (Wall Board/Sound Shield/Fire Shield/ Moisture Shield/Dense Shield. Fire and Moisture Shield/Plank) as recommended by the manufacturer and approved by the Architect in size 8’x4’, with 5/8” thickness unless otherwise indicated on drawing.

15.15.1.5 Support for Horizontal Joints In Facing

Fixing channels or flat Fixing Plate to be fitted across the face of all studs secured with 2 Water Head Jack point Screws or pop rivets per stud to back horizontal joints in outer board layers to both faces.

15.15.2 QUALITY ASSURANCE

15.15.2.1 Qualifications of Workmen

For erecting metal frame, cutting and fitting of gypsum panels (boards), use only skilled workers who are thoroughly trained and experienced for the work required, completely familiar with the requirements of this work.

15.15.2.2 Rejection

In the acceptance or rejection of finished partition walls, no allowance will be made for lack of skill on the part of workmen. Any rejected item shall be removed from the site immediately.
Submit data for each product and metal framework drawings along with all details prior to actually starting work and ensure quality control during fabrication, installation and finishing. Submit Mock-Up showing section of the partition wall for Architect's/Engineer Employer’s Representative's approval. Competent Supervisors from main suppliers is to be deputed to see the installation and quality of workmanship.

15.15.2.3 Samples and Submittals

The Contractor must submit the name of the manufacturer along with samples of all galvanized steel sections used for the metal stud frame work and sample of Gypsum Board for approval of Engineer-in-Charge prior to beginning the work at site, he must also submit detailed shop drawing, showing the locations of studs and openings for approval by the Engineer-in-Charge.

15.15.3 GYPSUM BOARD INSTALLATION

All boards to be secured at 1'-0" centers around edge and to intermediate studs with Drywall Screws Drywall Jack point Self-Drilling Screws of appropriate length to allow minimum penetration of 1/2" through steelwork. Fixing centers to be reduced to 8" at corners. At head, foot and abutments, board edges to be bedded onto continuous beads of Sealant.

In multi-layer facings, under layer to be started with half boards to stagger joints between layers.

15.15.4 GYPSUM BOARD FINISHING

Jointing	all joints to be taped filled and finished.
Skim plastering	all joints to be taped and the entire board surface finished with a 1/2” to 1/4” coat of gypsum plaster. Boards to be finished with edge boards, corner beads as shown on drawings and as recommended by manufacturer.
Priming Prior to Decorating	Apply one coat of Drywall manufacturer's recommended Primer by brush or roller.
Protection	Protect the materials of this section before, during, and after installation and protect installed work and materials of other trades.
Replacement	In the event of damage, immediately make repairs and replacements to approval, at no additional cost to the Employer.
Shop Drawing	Manufacturer/Installer to provide coordinated shop drawings for all Gypsum Dry Wall Installation.

15.15.5 MEASUREMENT:

Length and breadth of the Partition Wall shall be measured correct to a cm and the surface area worked out in square metre of the finished work.

No deduction shall be made for openings of areas upto 40 square decimetre. No extra payment will be made for any extra material or labour involved in forming such openings. For openings exceeding 40 square decimetre in area, deduction for the full opening will be made, but no extra will be paid for any extra material or labour involved in forming such openings.

15.16 CORIAN

15.16.1 GENERAL

Corian is an advance composite product used as a decorative, it is a solid surfaced material that prevent the penetration of water and have the ability to resist the chemical attack, and moreover it is also a scratch resistance material.

15.16.2 BASIC USES

- Counter Tops.
- Vanity Tops.
- Tub/Shower walls.
- Kitchen Sinks.
- Laboratory Bench Tops
- Tops in numerous markets including lodging, healthcare, banks, boutiques and restaurants etc.

15.16.3 COMPOSITION & SHEET DIMENSION

Corian is a solid, non-porous, homogeneous surfacing material, composed of ±1/3 acrylic resin (also known as Poly Methyl Meth-Acrylate or PMMA), and ± 2/3 natural minerals. These minerals are composed of Aluminium Tri-Hydrate (ATH) derived from bauxite, an ore from which aluminum is extracted.

Some standard dimensions of Corian sheets are

- 4 mm sheet — 930 x 2490 mm
- 6 mm sheet — 760 x 2490 mm , 930 x 2490 mm
- 12 mm sheet — 760 x 3658 mm , 930 x 2490 mm
- 19 mm sheet — 760 x 3658 mm

15.16.4 LIMITATIONS

Use of 4mm and 6mm sheets should be restricted to vertical applications or certain furniture applications only. The choice between 12mm and 19mm sheets is generally based on performance and cost consideration. In some hospitals and laboratories where strong disinfectants come in contact with corian, it is recommended to use solids colors and extended contact is avoided.

15.16.4.1 Properties Of Corian

PROPERTY	TEST METHOD	TYPICAL RESULTS		UNITS
		6mm sheet	12mm sheet	
Density	DIN ISO 1183	1.73 – 1.76	1.68 – 1.75	g/cm3
Flexural modulus	DIN EN ISO 178	8920 – 9770	8040 – 9220	MPa
Flexural strength	DIN EN ISO 178	49.1 – 76.4	57.1 – 74.0	MPa
Elongation at break	DIN EN ISO 178	0.58 – 0.94	0.76 – 0.93	%

Compressive strength	EN ISO 604	178 – 179	175 – 178	MPa
Resistance to impact (spring load)	DIN ISO 4586 T11	> 25	>25	N
Resistance to impact (ball drop)	DIN ISO 4586 T12	> 120	>120	cm
Surface hardness (Mohs index)	DIN EN 101	2-3	2-3	
Resistance to surface wear	DIN ISO 4586 T6	63 – 75	58 – 63	Lost weight mm3/100 rev.
Resistance to boiling water- increase in weight	DIN ISO 4586 T7	0.1 – 0.7	0.1 – 0.3	%
Resistance to boiling water- surface change	DIN ISO 4586 T7	No visible change	No visible change	
Dimensional stability at 20oC	DIN ISO 4586 T10	< 0.16	< 0.16	% change in length
Resistance to dry heat-180ºC	DIN ISO 4586 T8	4-5 slight change	4-5 slight change	
Light fastness (Xenon arc)	DIN ISO 4586 T16	> 6	> 6	Blue wool scale
Anti-slip properties- with 100 µm	DIN 51130:1992-11	5.8° – do not pass R9 requirement (6° min)		° angle
Anti-slip properties- with 120 µm	DIN 51130:1992-11	7.6° – pass R9 requirement (6° min)		° angle
Anti-slip properties- with 150 µm	DIN 51130:1992-11	8.1° – pass R9 requirement (6° min)		° angle
Resistance to bacteria and fungi	DIN EN ISO 846	Does not support microbial growth		
Electrostatic surface behavior	DIN IEC 61 340-4-1		> 1 x 1012	W

Surfaces in Corian are renewable, meaning they can be fully restored with ordinary mild abrasive cleansers and a scouring pad. Cigarette burns, for example, can be easily removed in this way. Damage caused by abuse can usually be repaired on site without having to completely replace the material.

Corian surfaces are hygienic. Because it is a non-porous material, bacteria and mould cannot be trapped and proliferate in its joints, nor underneath the surface.

Corian is an inert and non-toxic material. Under normal temperature conditions, it does not emit gases. When burned, it releases mainly Carbon Oxides and the smoke generated is optically light and does not contain toxic halogenated gases. Because of these properties, Corian is used in public spaces and delicate applications such as airport check-in counters, wall and work surfaces in hospitals and hotels.

15.16.4.2 Sealants and Adhesive

Corian is compatible with many commercially available caulks and sealants. Vertical panels of Corian may be installed over suitable substrates, including water-resistant gypsum board, marine-grade plywood and ceramic tiles. In case a support is needed, apply perimeter frame or full support direct to Corian using large beads of flexible adhesive leaving a space with a minimum thickness of 1.5mm.

15.16.4.3 Clearance

The minimum expansion Clarence for corian is 35 x 10^{-6} x (length of piece) x (biggest temperature range expected in C°) in mm. Joints to be approximately 1.5 mm wide to allow satisfactory caulk penetration and expansion.

15.16.4.4 Submittals

The contractor should submit the sample to Engineer-in-Charge along with the technical guide of the manufacturer of corian. The manufacturer shall give the warranty at least 10 years.

15.16.5 MEASUREMENT:

Length and breadth of the Corian shall be measured correct to a cm and the surface area worked out in square metre of the finished work.

No deduction shall be made for openings of areas upto 40 square decimetre. No extra payment will be made for any extra material or labour involved in forming such openings. For openings exceeding 40 square decimetre in area, deduction for the full opening will be made, but no extra will be paid for any extra material or labour involved in forming such openings.

Curved surfaces in narrow widths shall be measured and paid for separately. Circular cutting and waste shall be measured and paid for separately.

15.17 ALUCOBOND (FACE CLADDING)

Also commonly referred to as "Diabond" or "ACM", aluminum composite panels consist of two aluminum cover sheets and a core made of low density polyethylene.

The cladding system shall be installed complete by an approved specialist cladding subcontractor with a demonstrated experience of at least 10 years in the fabrication and installation of cladding systems. All work to be carried out in accordance with manufacturer's recommendations and approval of Engineer-in-Charge.

15.17.1 REFERENCES

A. Aluminum Association

AA-M12C22A41:	Anodized - Clear Coating
AA-M12C22A44:	Anodized - Color Coating

B. American Architectural Manufacturers Association

AAMA 508-05:	Voluntary Test Method and Specification for Pressure Equalized Rain Screen Wall Cladding Systems

C. American Society for Testing & Materials

E 330	Structural Performance of Exterior Windows, Curtain Walls, and Doors under the Influence of Wind Loads
E 283	Rate of Leakage through Exterior Windows, Curtain Walls, and Doors
D 1781	Climbing Drum Peel Test for Adhesives
E 84	Surface Burning Characteristics of Building Materials
D 1929	Standard Test for Ignition Properties of Plastics
D 3363	Method for Film Hardness by Pencil Test
D 2794	Resistance of Organic Coatings to the Effects of Rapid Deformation (Impact)
D 3359	Methods for Measuring Adhesion by Tape Test
D 2247	Practice for Testing Water Resistance of Coatings in 100% Relative Humidity
B 117	Method of Salt Spray (Fog) Testing
D 2244	Calculation of Color Differences from Instrumentally Measured Color Coordinates
D 4214	Evaluating the Degree of Chalking of Exterior Paint Films
D 822	Practice for Operating Light and Water Exposure Apparatus (Carbon-Arc Type) for Testing Paint, Varnish, Lacquer, and Related Products
D 1308	Effect of Household Chemicals on Clear and Pigmented Organic Finishes

D. International Conference of Building Officials

NFPA 285	Intermediate Scale Multi Story Test

15.17.2 SAMPLES SUBMITTAL

The contractor shall submit the technical guide, samples along with the construction drawing showing the panel arrangement to the Engineer-in-Charge. The samples shall fulfill the following criteria:

- Panel System Assembly: Two samples of each type of assembly. 304mm (12") x 304mm (12") minimum.
- Two samples of each color or finish selected, 76mm (3") x 102mm (4") minimum.

15.17.3 DELIVERY, STORAGE AND HANDLING

- Protect finish and edges in accordance with panel manufacturer's recommendations and as per directions of Engineer-in-Charge.
- Store material in accordance with panel manufacturer's recommendations and as per directions of Engineer-in-Charge.

15.17.4 EXECUTION OF WORKS

15.17.4.1 Inspection

- Surfaces to receive panels shall be even, smooth, sound, clean, dry and free from defects detrimental to work. The Engineer-in-Charge shall notify contractor in writing of conditions detrimental to proper and timely completion of the work. Do not proceed with erection until unsatisfactory conditions have been corrected.

- Surfaces to receive panels shall be structurally sound as determined by a registered
Architect / Engineer.

15.17.4.2 Installation

- Erect panels plumb, level, and true.

- Attachment system shall allow for the free and noiseless vertical and horizontal thermal movement due to expansion and contraction for a material temperature range of -20°F to +180°F (-29°C to +82°C). Buckling of panels, opening of joints, undue stress on fasteners, failure of sealants or any other detrimental effects due to thermal movement will not be permitted. Fabrication, assembly, and erection procedure shall account for the ambient temperature at the time of the respective operation.

- Panels shall be erected in accordance with an approved set of shop drawings.

- Anchor panels securely per engineering recommendations and in accordance with approved shop drawings to allow for necessary thermal movement and structural support.

- Conform to panel fabricator's instructions for installation of concealed fasteners.

- Do not install component parts that are observed to be defective, including warped, bowed, dented andbroken members.

- Do not cut, trim, weld, or braze component parts during erection in a manner which would damage the finish, decrease strength, or result in visual imperfection or a failure in performance. Return component parts which require alteration to shop for re-fabrication, if possible, or for replacement with new parts.

- Separate dissimilar metals and use gasketed fasteners where needed to eliminate the possibility of corrosive or electrolytic action between metals. Foreign

15.17.4.3 Adjusting and Cleaning

- Remove and replace panels damaged beyond repair as a direct result of the panel installation. After installation, panel repair and replacement shall become the responsibility of the General Contractor.
- Repair panels with minor damage.
- Remove masking (if used) as soon as possible after installation. Masking intentionally left in place after panel installation on an elevation, shall become the responsibility of the General Contractor.
- Any additional protection, after installation, shall be the responsibility of the General Contractor.
- Make sure weep holes and drainage channels are unobstructed and free of dirt and sealants.
- Final cleaning shall not be part of the work of this section.

15.17.5 MEASUREMENT:

Length and breadth of the Alcobond shall be measured correct to a cm and the surface area worked out in square metre of the finished work.

No deduction shall be made for openings of areas upto 40 square decimetre. No extra payment will be made for any extra material or labour involved in forming such openings. For openings exceeding 40 square decimetre in area, deduction for the full opening will be made, but no extra will be paid for any extra material or labour involved in forming such openings.

Boarding fixed to curved surfaces in narrow widths shall be measured and paid for separately. Circular cutting and waste shall be measured and paid for separately.

15.18 MEASUREMENT AND PAYMENT

15.18.1 COMPOSITE RATE

The measurement and payment for the items of the work of Finishes hereof shall be made corresponding to the applicable CSR items as provided in Contract Agreement and shall constitute full compensation, for procurement, transportation, performance in all respects and completion of work as specified including the site clearance as approved by the Engineer-in-Charge.

15.18.2 LABOUR RATE

The measurement and payment for the items of the work of Finishes hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurement transportation, performance in all respects and completion of work as specified including site clearance, as approved by the Engineer-in-Charge except the cost of materials to be provided by Department at designated location as defined in the Contract Agreement.

15.19 REFERENCES

The following standards and standard specifications, referred to thereafter by designation only, form a part of these Specifications:

- ASTM A446 / A446M-91, Specification for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process, Structural (Physical) Quality.
- ASTM A525-91b, Specification for General Requirements for Steel Sheet, Zinc-Coated (Galvanized) by the Hot-Dip Process.
- ASTM A641-92, Specification for Zinc-Coated (Galvanized) Carbon Steel Wire.
- C635-91, Specification for the Manufacture, Performance and Testing of Metal Suspension Systems for Acoustical Tile and Lay-In Panel Ceilings.
- C636-91, Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels.
- E84-91a, Test Method for Surface Burning Characteristics of Building Materials.
- E119-88, Method for Fire Tests of Building Construction Materials.
- E488-90, Test Method for Strength of Anchors in Concrete and Masonry Elements.
- E580-91 Practice for Application of Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels in Areas Requiring Seismic Restraint.
- E. 95-92, Practice for Mounting Test Specimens during Sound Absorption Tests.
- E1190-87, Test Methods for Strength of Powder Actuated Fasteners Installed in Structural Members.
- El 264-90, Classification of Acoustical Ceiling Products.

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16. WOODWORK

16.1 INTRODUCTION

16.1.1 DEFINITION

Woodwork is the process of converting timber into a desired shape and erecting it Into Its final position. It is mostly carpenter's and joiner's work.

16.1.2 CARPENTER’S WORK

Carpenter’s work includes all work on timber used in roofs, floors, verandas, staircases, doors and windows, frames, bridges, centering, shores, struts, large gates, and generally all wood work of which the scantling exceeds three-quarters of an inch, except in case of battens used in roof trellis-works which is specially mould or carved.

When the thickness of carpenter's work does not exceed two inches but its width exceeds twice the thickness, it is called "planking".

16.1.3 JOINER’S WORK

Joiner's work includes furniture, doors and windows, turned and carved, on molded work of all kinds.

16.2 SCOPE

The scope of work includes providing all labor materials, plants, equipment, accessories and services to complete the fabrication and installation of wood work consisting of but no limited to doors, windows, ventilators, gates, trusses stairs and all related work as specified and shown on drawings as approved by the Engineer-in-Charge.

16.3 MATERIALS

16.3.1 Timber

1. **Source:**

Timber to be used for woodwork shall consist of Deodar wood, Shisham and Kail wood as specified and shall be procured from an approved source. Brief description in their respect is as under;

Description	Uses
SHISHAM Weighs about 49 lbs, per cubic foot. It is a large tree of plain areas as well as the Sub-Himalayas forests growing at the altitude of about 3000 feet or less. Its sapwood is pale brownish white and heartwood is golden brown to dark brown with deeper brown streaks. The wood is dull with interlocked grain and medium coarse texture. It is easy to season but hard to work. It keeps its shape well if properly seasoned and takes on fine finish	It is chiefly used for flooring paneling furniture, sports goods, turnery and wheel-work; when peeled it can be made into beautifully grained plywood panels.
DEODAR Weight about 35 lbs per cubic foot. It is the most important soft wood of Pakistan found in the Himalyan ranges between 4000 to 7000 elevations. It is yellowish brown in colour. Its heartwood is strong and durable due to natural preservatives in it. It is easy to season and work and retains its shape well.	Being light and moderately strong, it is used for structure work, railway carriage wagons, planking, shingles, pattern making and cheap furniture etc.

KAIL An evergreen tree, moderately hard, durable and close-grained. It is found is the Himalayas. Weights about 32 lbs per cubic foot.	It is used for furniture house building are railway sleepers, etc.
FIR, PALUDAR, PARTAL An evergreen tree having light and soft wood with an average weight of 30 lbs per cubic foot (air dry) occurs naturally in North Western hilly areas from 2000 to 3000m elevation.	It is used for railway sleepers, planking for floors, ceiling, cheap type door and windows, house construction and paper pulp etc.
CHIR, CHILL An evergreen tree having durability when placed under cover but non-durable in exposed conditions. An average weight of 38 lbs per cubic foot (air dry) occurs naturally in North Western hilly areas from 450 to 2400 meter elevation.	It is used in building construction, roofing and flooring, furniture making and also used for fuel wood.

2. Quality:

General

i. Timber shall be of good quality in accordance with the requirements of BS:1186, felled not less than two years before use for carpentry and four years for joinery and shall be properly seasoned.

ii. Timber shall be uniform in texture, straight in fiber, free from open shakes, bore holes, fungus attack rots, dots, decay, warp, twist spring or crook and all other defects and blemishes.

Sapwood:

iii. Sapwood shall not be permissible in hard wood thresholds and projecting window sills.

iv. Sapwood shall not be permissible in hard wood joinery unless properly treated with a suitable preservative as approved by the Engineer-in-Charge..

v. In soft wood joinery which is ordered as 'selected for staining' discolored sap wood shall not be permissible in surfaces which are intended to receive the final decoration.

vi. In all other uses sap wood including discolored sap wood if sound shall be permitted.

Knots:

vii. Exposed surfaces of hard wood sills shall be free from knots other than isolated sound tight knots not exceeding ¾ inches in diameter.

viii. In joinery which is ordered as 'Selected for staining' all surfaces intended to receive final decoration shall be free from knots.

ix. Glazing bars shall be free from all knots other than sound knots appearing on one surface only and not exceeding ¾" diameter in the web and ½" diameter elsewhere.

x. Loose or decayed dead knots shall not be permissible in any joinery and shall be cut out and plugged properly.

xi. In all other cases sound and tight knots including knot clusters which appear on any surface shall be permitted subject, to a maximum of:

   a. One live knot measuring 1 ½" to 2" across the major diameter per 2 feet length, i.e. a Max of four 2" knots per 8 feet length and five such knots in 10 feet length. (Smaller live knots shall be tolerated provided they are not so numerous or on ground as to affect unduly the strength of the sawn out turn there-from).

b. One dead knot measuring ½" to 1"across the major diameter per 3 feet length, i.e. three such knots per nine feet length and four such knots in twelve feet length (Dead knots below ½" diameter shall, however, be considered as negligible).

Shakes

xii. Straight splits or shakes shall be permissible up to a total for both ends of ½ inch per foot of length at the time of passing.

xiii. Timber shall not be spongy or in brittle condition.

Storage

Timber shall be stacked on a raised wooden or paved platform to eliminate chances of white ant attack. It shall be stacked under a proper shelter where maximum aeration is possible without subjecting it to the direct sun, rain or other weathering agents.

3. Logs End Squares

Source

Logs or Squares shall be obtained from an approved source.

Size

i) Round logs shall not be of size less than 10 feet in length and 60 inches in girth.
ii) Logs shall not be longer than 35 feet in length. Tapered logs shall not be less than 54 inches in girth at the small end.
iii) Squares shall be of the size not less than 10 feet in length and 15"x15" in cross section.

Quality

Logs or squares shall conform to the specifications for Timber, Clause 16.3.1.

4. Seasoning

i) General

The object of seasoning timber is either to expel or to dry up the sap remaining in it, which otherwise putrefies and causes decay. The seasoned timber does not decay, or warp or bend due to temperature variations as in case of moist timber. The seasoned timber works easily under the saw and its shape and dimensions do not change with variations in temperature or with age. The seasoning also increases the strength of timber. The timber for carpentry is well seasoned when it has lost its weight by 1/5th. Timber for joinery is fit when it loses about 1/3rd of its weight after felling.

ii) Method of Seasoning

Wood can be seasoned in drying kilns or by air seasoning. Kiln seasoning though very helpful in our country, where the high humidity during certain part of the year, precludes effective air seasoning.

iii) Air Seasoning

For air seasoning there are two important points to be attended to. First is the proper pilling and stacking of timber and the second is the protection of wood from rain, sun and hot wind.

The wood pile should be on proper foundation of wood, masonry or concrete. Concrete of brickwork foundations are the best. One square foot pillars at 4 to 5 feet intervals and rising 1 foot above the level of the ground will do. The distance between the two rows of pillars forming the two sides of the stack should also be 4 to 5 feet. For protection against termites, termite guards are provided near the top of the pillars, with a bend down edges protruding all round.

The orientation of the stack foundation is also a matter of considerable importance. Generally, the length of the pile should be in the same direction as the prevailing dry wind. The main force of the hot dry wind is then met by the sides of the crossers and only one end of the planks is exposed to heat. Piling of timber is to be done in a systematic manner. Lack of care in proper piling results in wastage of timber through crack warp, rot, stain and termite attack. All these can be avoided with a little extra expense or trouble. Other important factor is protection of the stack from hot wind, sun and rain. The direct rays of the scorching sun can cause very rapid drying of wood on the exposed surfaces and consequent splitting and cracking.

Timber can be classified into six categories based on the seasoning behavior. They are;

i. Very easy to season but require quick seasoning,
ii. Easy to season,
iii. Season well with care,
iv. Crack in seasoning and so difficult to season,
v. Season well but take a long time to season and
vi. Crack badly in seasoning. In the para 16.3.1.1 giving individual description of wood of the seasoning behavior has been stated based on the above classification.

Timbers which crack in seasoning and so are difficult to season or crack badly in seasoning, should be dried so as to prevent rapid drying. Timbers which season well with care, or season well but take a long time to season, should be seasoned in shades open on the north with a sufficient overhang so that the pile is protected from the rain. In case of timbers which are easy to season or very easy to season but require quick seasoning, it is necessary, that the timber should be piled under a good weather-proof roof but the sides should be always exposed to air and the sun. In the cases of timbers which require quick seasoning it is a good practice to stand the planks up on the ends against a horizontal support for a week or two after conversion to prevent formation of mould and staining. After a short period of vertical stacking the planks should be pilled horizontally, as described.

5. Plywood and Veneer

a) Plywood

Plywood shall be an assembled product made up of plies and adhesives, the chief characteristic being the crossed plies which distribute the longitudinal wood strength. The term plywood in general sense shall include similar products such as laminated board, block board and batten board. Plywood shall conform to BS1455 whereas laminated, block and batten boards to BS 3444.

Three ply constructions shall include a “face” a “back” and a core or inner ply. Multi-ply shall include a face, a back and a core of three or more inner plies. With very few exceptions the grain of each veneer in the core shall run at right angles to that of the veneers on either side of it.

The construction of plywood may be balanced with an odd number of veneers arranged symmetrically or unbalanced. The tendency of the finished board to distort shall be reduced by adopting a balanced construction.

Plywood according to BS1455 shall be classified into two main types, viz interior and resin bonded.

Interior type plywood shall be suitable for most interior work including wall paneling, subflooring, kitchen filaments, and any location where resistance to moisture is not required. Adhesive used shall include casein, soya, blood albumen and animal glues as well as synthetic resin extended with other substances.

Synthetic resin bonded plywood shall have a much greater resistance to moisture. The more resistant types shall be suitable for external wall sheathing, shop front fascias, sign boards, shuttering and form work for concrete and for any purpose where it may be exposed to moisture. Adhesives used shall include urea, melamine phenol and resorcinol formaldehyde (arranged in order of increasing moisture resistance).

b) Veneers

Grade I Veneer shall be of one piece of firm smoothly cut veneer. The veneers shall be free from knots, worm and beetle holes, splits, dots, glue-stains, filling or In laying of any kind or other defects. No end joints shall be permissible.

Grade II Veneer shall present a solid surface free from open defects. Veneer may be in one or two pieces.

Veneers when jointed need not necessarily be matched for color or be of equal width. A few sound knots shall be permitted with occasional minor discoloration and slight glue stains, isolated pin holes not along the plane of the veneer.

Grade I veneered plywood shall only be used if not specified otherwise.

Grade II shall be used if specified and where subsequent painting and/or veneering is intended.

c) Laminated Veneered Board

It shall be built-up board, with narrow strip 3 to 7 mm wide, faced both sides with either one or two veneers from 1.2 mm to 3.7 mm thick. Where single or double face veneers are used, the grain shall usually run at right angles to the grain of the core strip. This type of board, conforming to B.S. 3444 and of a thickness between 13 mm to 25 mm, shall be the base for the highest class of veneered wood.

d) Block Veneered Board

Block board conforming to B.S. 3444 shall be of similar construction as of laminated board but the core shall be built-up of blocks up-to 25 mm wide. It shall be used as a base for veneering and for painted work.

e) Fiber Building & Chip Board

The term “board” in general sense shall include fiber building boards and the chip boards (or particle boards). The fiber building boards shall include hard boards, insulation boards and straw boards.

6. Fiber-Building Boards

a) Hard Board

Mass per unit volume of hard boards shall range from 480 to 800 Kg per cubic meter and shall be classified according to this density (mass per unit volume). Tempered hard board/standard hard board shall be treated to increase hardness and resistance to water.

b) Insulation Board

Insulation board shall have maximum density of 400 Kg/Cu meter, minimum thickness of 11 mm and maximum thermal conductivity (K) of 0.45. Insulation boards classified as homogeneous laminated, bitumen bonded, bitumen impregnated and acoustic shall have good qualities of thermal insulation and sound absorption. Acoustic boards shall be of low density and specially designed (Often with perforated surface) to increase sound absorption.

c) Straw Board

Straw boards shall be made of straw compressed and formed into slabs 50 mm thick by heat and pressure and with proprietary paper glued to the sides. Edges too shall be bound with paper. The slabs shall be fairly stiff and shall have thermal conductivity (k) of 0.6.

7. Chip Board (Particle Board)

Chip boards shall be made of wood particles in the form of chips or shavings of a controlled size combined with a thermo setting synthetic resin glue binder and formed into panels under the influence of mechanical pressure and heat. The process of adhesion shall be controlled resulting in a variety of boards with different but predictable physical properties. Chip Board, if specified, shall be used in sheathing, flooring and sub-flooring, wall paneling, partitions, shelves, furniture and veneered boards. It should not be affected dimensionally by changes in atmospheric humidity, though in wet conditions it shall have a limited resistance to moisture.

The surface finish of standard boards shall be comparatively rough and to support a good quality paint or varnish finish it shall require sanding and filling. Special grade of the board which have a paper surface permanently bonded to the board during manufacture shall be used for painting.

Chip boards shall be classified in grades of high, medium and low density mainly in thickness of 13 mm and 19 mm. The density range of this board is from 480 to 800 Kg per cubic meter as under:

High Density (HDF)	Above 800 kg/m^3
Light (LDF)	Below 650 kg/m^3
Ultra-Light (ULDF)	Below 550 kg/m^3

Due to variation between brands, the weight of chipboard is not constantly proportional to thickness. Typical weights, based on standard chipboard with average density 750 kg/m^3 are:

Thickness	Mass Per Unit Area
13.0 mm	09.0 kg/m^2
16.0 mm	11.0 kg/m^2
19.0 mm	14.0 kg/m^2

Chipboard is available in an extensive range of thicknesses, i.e. 1.8mm to 60mm. The most common sheet sizes are: widths 1220mm, 1525mm and 1850mm and in lengths up to 3660mm.

16.3.2 Adhesives

For joinery work, animal glues complying with B.S:745 or synthetic resin adhesive complying with B.S:1204 shall be used. For flush doors and other forms of construction that rely mainly upon the adhesive, and particularly where exposure conditions are severe and prolonged dampness is likely to occur, one of the more moisture resistant adhesive shall be employed, the choice depending upon the severity of the conditions to which the work will be exposed.

16.3.3 Hardware

i) Nails and Screws

For joining work, wire nails oval, chequered head, lost head round or panel-pins complying with BS:1202, or wood screws in accordance with BS: 1210 shall be used. The gauge of nail or screw used shall be suited to the woods being fixed and to which a fixing is being made, and the length shall be such as will give a sufficiently strong and secure fixing. CP:112 shall be followed which gives relationship between gauge amount of penetration and strength. All nails and screws used with reactive timber (becoming stained and disfigured by reaction with ferrous metals) shall be of non-ferrous metals or shall be given protective coating before use if the woodwork is likely to be subjected to moist conditions, e.g. external doors.

ii) Finish Hardware

Hinges, tower bolts, handles, locks catchers, stoppers, railings, supports, appurtenances, fixings, fittings and all other items metallic, plastic or wooden considered as finish hardware shall be as shown on the Drawings or required in the Specifications and approved by the Engineer-in-Change for the specific job.

16.4 WORKMANSHIP

A. General

i) All workmanship shall be of the best type and all joints shall fit accurately without wedging or filling. After the wood work has been erected, the contractor shall, if any undue shrinkage or bad workmanship is discovered, forthwith correct the defect without any extra charge.

ii) All Woodwork shall be fitted, hung and trimmed as indicated on the Drawings. One sample of each fitting to be used, shall be deposited by the contractor in the office of the Engineer-in-Charge. Hinges shall be counter sunk into the frames. The recess to be cut to the exact size and depth of the hinge. No subsequent packing shall be allowed. Brass screws shall be used with brass fittings unless otherwise specified. Hardware shall be fixed as specified in the Drawings. Locks and other hardware items shall be fixed at heights as shown on the Drawings or as directed by the Engineer-in-Charge.

iii) Items of hardware specified in the Drawings shall be carefully fitted and securely attached on completion of the work. Hardware shall be demonstrated to work freely, keys shall be fitted into their respective locks, and upon acceptance of the work, keys shall be tagged and delivered in duplicate to the Engineer-in-Charge.

iv) All wood work shall be neatly and truly finished to the exact dimensions specified.

B. Joints

Unless otherwise specified all joints shall be simple ten on and mortise joints with the end of the ten-on exposed to view. All mortise and ten-on joints or scarfs shall fit truly and fully without filling. Where specified in the case of special 'high class joinery the end of the ten-on shall not show. Joints shall be painted with specified lead paint before the frames are put together. Glue shall not be used in joints which are exposed to weather and in such exposed work any hard stopping shall be done with tight driven plugs.

C. Screws And Nails

All nails and screws shall be of an approved type. Holes of correct size shall be drilled before inserting screws. Hammer shall not be used at all for driving in or starting the screws. All screws shall be dipped in oil before they are inserted in the wood. The heads of nails or screws shall be sunk and puttied or dealt with as directed by the Engineer-In-charge.

D. Wood To Be Covered In Grounds Or Wall

The contractor shall give at least 7 days’ notice to the Engineer-in-charge in writing, when any timber is to be covered in the ground, or in the walls of a building, or otherwise. Failing this the Engineer-in-charge may order it to be uncovered at the contractor's expense, or measure and pay for only so much as is uncovered.

E. Fixing

All wood work shall be fixed in accordance with the drawings or the instructions of the Engineer-in-charge.

F. Bearing

All beams and girders shall be bedded on plates with not less than 9 inches bearing. All joists shall bear not less than 4-1/2 “inches on wall plates, and every purlin or batten supported on a wall shall have a bearing in the direction of its length equal to its own depth subject to a minimum of 4” inches.

G. Air Space

An air space of quarter of an inch shall be left along sides of battens and other wood work buried in masonry or brickwork.

H. Preservatives

All portions of timber built into or against or close to masonry or concrete, and all junctions or rafters, purlins, beams and wall plates shall be given two coats of hot solignum, creosote or other wood preservative approved by the Engineer-In-Charge.

I. Planks

All scantling planks etc. shall be sawn straight and shall have uniform thickness. They shall be sawn in the direction of the grain and shall have full measurement from end to end. All planks and scantlings shall be sawn 1/16 inch in excess of actual measurement to allow planning. They shall be supplied with straight square edge, or rebated, ploughed, tongued or dwelled, as may be directed.

J. Chimney Flue

As a precaution against fire no wood work shall be fixed within 2 feet of the interior face of a chimney flue.

K. Wood For Use

Unless otherwise specified the wood used in construction or joinery work shall be conform to the applicable provisions of Sub-Section 16.3.

L. Responsibility Of Contractor After Fixing

The contractor shall be responsible for the easing or otherwise of all doors etc. and the closing down of all open joints which may occur within six months of the completion of the work or as specified in the contract and which in the opinion of Engineer-in-charge required attention. Should any shrinkage or warping occur or any other defects appear in the joiner’s work before the end of the specified period, such defective work shall be taken down and replaced to the Engineer-in-Charge satisfaction and any other work disturbed shall be made good at the Contractor’s expense.

16.5 DOORS AND WINDOWS (GENERAL)

16.5.1 Quality

Unless otherwise specified timber shall conform to specifications as mentioned under 16.3.1.

16.5.2 Workmanship

Unless otherwise specified the workmanship for doors and windows shall conform to the provisions under clause 16.4 - Woodwork (General) in all respects, except those specified hereunder.

16.5.3 Size Of Door And Windows

The size of doors and windows shall be as specified.

16.5.4 Section Fitting

Unless otherwise specified or directed the particulars and dimensions of chowkats for doors and windows together with their fittings and furniture shall be as specified on drawings or as existing at site for repair works.

16.5.5 Chowkat Framing And Corners

Chowkats shall be properly framed and mortised together. Door and Window chowkats shall have 4-1/2 inches wide horns left on the heads (also on sills where these are provided) or the corners of the chowkats bound with 2-1/4 inches by 1/10 inch Iron straps bent into a right angle having legs of a length equal to the depth of the chowkat and fixed with four screws of 2 inches each. The cost of horns or straps is included in the rate. Unless otherwise specified, the latter method shall be adopted.

16.5.6 Rebates

Chowkats shall have a rebate cut to receive the leaves. The rebate shall be 1/2 inch deep and its width shall be equal to the thickness of the leaf. The other side shall be finished with a bead and quirk; or other simple moulding, unless wire gauze is to be fitted. Where the plaster butts against the chowkat 1/2 inch deep rebate with a slight cut back shall be given, to serve, as key to the plaster.

16.5.7 Position Of Chowkats In Jambs

Unless otherwise specified, doors and windows opening to another room, to a corridor or verandah shall have the chowkats so fixed that they project 3/8 of an inch from the plastered face of the wall.

The plaster shall stop against the chowkat which shall have the rebate mentioned in the above paragraph as key for the plaster.

Other doors and windows shall be set back 4-1/2 inches from the face of the wall.

16.5.8 Chowkat To Be Ready Before Starting Superstructure

No chowkat shall be painted or fixed before the Engineer-In-charge has inspected and approved it. All chowkats shall be ready before the work reaches the sill level so that they can be built in as brickwork or masonry proceeds.

16.5.9 Chowkat Painting With Preservatives

Before fixing, chowkat shall have the side in contact with the brickwork or masonry painted with two coats of hot solignum, creosote, coal tar or other wood preservatives approved by the Engineer-in-Charge. If doors and windows are to be subsequently painted, the priming coat shall be painted on the chowkats before they are fixed.

16.5.10 Hold Fast

Chowkats shall be secured to the brickwork or masonry by hold fasts which shall be built into the wall with specified mortar. Hold fasts shall be made 1 ½ x ¼ inches flat steel patti bent over at both ends leaving 13 ¾ inches clear length between bends one bend shall have two screwed holes to which the chowkat is secured by bolt ½inch in diameter. The head of the bolt shall be sunk into the chowkats and the hole plugged with wood. Where the chowkatis fixed at the extreme edges of the Jambs, the hold fasts shall be worked or bent as directed by the Engineer-in-charge. The number of hold fasts to each chowkat shall be as indicated on drawings. The feet of the chowkat shall, in this case, rest on the damp-proof course or floor as the case may be.

16.5.11 Seasoning

All door and window leaves shall be cut out and framed together, as soon as possible after the commencement of the work, and stacked in the shade to season. They shall not be wedged and glued for four months where possible and where the contract time permits. If it is not possible, they shall be wedged and glued just prior to being hung. Before final gluing, all portions in which defects appear shall be replaced.

16.5.12 Methods Of Framing Leaves

All stiles and rails shall be properly and accurately mortised and tenoned. The thickness of the tenon shall not exceed one-fourth the thickness of the plank and the width shall not exceed five times the thickness. All rails over 7 inches in depth shall have double tenons. All tenons shall pass completely rough stiles and shall be secured by 3/8 inch hard wood or bamboo pins. All rails shall be haunch to the depth of groove for panels.

16.5.13 Gluing

All tenons at the final assembly of the doors shall be glued and wedged at top and bottom of the tenon with glued wedges. Immediately after gluing, the frames shall be tightly clamped and so left till the glue has set.

16.5.14 Hinges

Unless otherwise specified, leaves shall be hung on hinges of the size and the number specified. These hinges are to be of an approved type and quality. They shall be counter sunk into the chowkat as well as to the leaf the recesses being cut to the exact size and depth of the hinge, no subsequent packing shall be allowed. Two inch screws shall be used with 5 inches to 6 inches hinges and 1 ½ inches for smaller sizes.

TYPES OF HINGES

1. PIANO HINGES

A. Materials Requirements

Sr. No	Name of Component	Material
1	Flap	Mild Steel
		Aluminum Alloy Sheet
		Cold rolled low carbon steel sheets
2	Pin	Mild Steel Sheet
		Aluminum Alloy Sheet

B. Knuckles

The sides of the knuckles shall be straight and at right angle to the flap. The movement of the hinge shall be free and easy and working shall not have any play or shake.

C. Pins

The hinge pin shall be of mild steel in the case of mild steel hinges. The hinge pin shall be of mild steel (galvanized) or aluminum alloy hinge. The aluminum alloy hinge pin shall be hard anodized to a minimum thickness of 0.025mm and sealed with oil wax or lanolin. The hinge pin shall fit in the knuckle firmly so as not to allow any play or shake and shall allow easy movement of hinge, but shall not cause looseness.

D. Screw Holes

All screw holes shall be clean and countersunk suitably for screws.

E. Finish

Mild steel hinges shall be protected with anti-corrosive treatment, such as bright polished chromium plated or oxidized finish. Aluminium hinges shall be anodized and have the best quality of finishing.

F. Sampling and Criteria for Conformity

The method of drawing representative samples of the material and the criteria for conformity is given as under:

i. Sampling

For this purpose at-least 10 % of the packages subjected to minimum of three packages shall be selected and equal number of hinge shall be selected from each such package.

ii. Criteria for Conformity

The selected samples shall be checked thoroughly and if the samples is fail to comply with the dimensional or quality finishing check then the lot will be ejected.

2. Stainless Steel Butt Hinges

A. General

Hinges shall be well made and free from any flaws and defects of any kind. All hinges shall be cut clean and square and shall be provided with stainless steel pin. The hole for the hinge pin shall be central and square to knuckles. All sharp edges and corners shall be removed.

B. Knuckles

The sides of knuckles shall be straight and at right angle to the flap. The movement of the hinges shall be free and easy and working shall not have any play or shake.

C. Pins

The hinge pin shall be of diameters as specified in the drawing or BOQ. Pin shall fit inside the knuckle firmly and riveted head shall be well formed so as not to allow any play or shake. It shall allow easy movement of the hinge, but shall not cause looseness.

D. Screw Holes

All screw holes shall be clean and suitable for countersunk head of wood screws of number as specified.

E. Position of Holes

The center line of the holes shall be parallel to the pin. In the heavy & medium weight hinges, when only two screws holes in each flap are provided they shall be in one line, but when more than two holes are provided in each flap they shall be distributed in zigzag manner.

F. Finish

Unless otherwise specified, hinges shall be naturally finished bright with smooth surface without chemical coating.

G. Sampling & Testing

Butt hinges for testing shall be selected at random from at-least 10% of the packages subject to minimum of 3 equal number of hinge being selected from each lot. All butt hinges shall be check for dimensions.

16.6 DOOR CLOSERS

A door closer is a mechanically device that close a door, in general after someone opens it, or after it was automatically opened. Choosing of door closer can involve the consolidation of a variety of criteria.

Choosing a door closer changes depending on many different as stated below

i) Size and weight of the door
ii) Location of the door
iii) Opening and closing frequency
iv) Mounting location
v) Affordability
vi) Backswing requirements

16.6.1 Traffic Volume Considerations

In general, overhead door closers are used typically for medium- to heavy-traffic locations, and they are extremely durable. There are options for interior or exterior doors, and they're one of the most common types that are used.

Floor-spring or overhead spring closers, on the other hand, are a bit more durable, and they work nicely for heavy traffic doors. Additionally, they are not visible like overhead closers, making them one of the most attractive options. Finally, concealed and frame-mounted closers are typically used for medium traffic, interior doors.

Deciding on a door closer depends on a variety of factors. It starts with understanding the various types, and the benefits that they have to offer. Then, matching the door to the type of door closer that you're using is the key. Heavier doors and doors with higher traffic require durable, strong door closers. Lighter doors do not.

16.6.2 Building Code Considerations

Each area can have slightly different building codes depending on the location of the building. Federal, state, and even local building codes can have an impact on determining the door closer required. The Builders Hardware Manufacturers Association (BHMA) and American National Standards Institute (ANSI) provide extensive standards for door closers. The full list can be found here. Generally, each door closer needs to meet different levels of performance broken up in 3 grades with 1 being the highest and 3 being the basic level. Performance is judged based on cycle testing as well as closing force and finish tests. The tests are done in a neutral air pressure laboratory at 60-85 degrees F.

Door closers have the following requirements:

- Grade 1: 2,000,000 cycles at 60% efficiency
- Grade 2: 1,000,000 cycles at 60% efficiency
- Grade 3: 500,000 cycles at 50% efficiency

If doors are being installed into a high volume area like a major office building or hospitals etc., it is crucial to only use door closers that have been rated as Grade 1 closers.

The American Disability Act also provides a list of clear requirements when looking at doors and door closers. The ADA states that interior doors should require no more than 5lbs of force to operate and exterior doors should have the minimum force possible. The ADA also states that the closing or swing speed shall not be faster than 5 seconds and the latching speed should be quick enough to latch the door, but not slam it.

16.6.3 Aesthetic Considerations

A door closer might be chosen for its appearance, as some are more attractive than others. The majority of door closer units are adjustable, allowing operators to set a specific closing rate and opening resistance.

16.6.4 Overhead Door Closers

Overhead door closers are the most common, and they're widely used throughout commercial properties. For example, interior doors within offices, like conference doors, are typically affixed with a door closer that automatically closes the door. Additionally, commercial front doors are also installed with a closer unit, and overhead units are a popular choice.

There are three common types of overhead door closers including:

A. Regular Arm

The regular arm, or standard arm, closer is a pull-side application, meaning it is located on the exterior of the door. In these applications, there are two arms, one attached to the frame and another to a spring-loaded box on the pull-side of the door. The arms, when closed, project out perpendicularly from the door, which is less attractive than other applications. This is the most power-efficient option available.

B. Top Jamb:

Top jamb door closers, like regular arm closers, have arms that project out from the door perpendicularly. Yet, the biggest difference is that the spring-loaded box is mounted on the face of the doorframe. These are often used for aluminum or glass storefront doors, because these doors generally have narrow top rails. Like regular arm closers, top jamb closers are fairly power efficient.

C. Parallel Arm:

With a parallel arm application, there are two arms that sit on top of the door when it is closed. They are attached to the door via a spring-loaded box, which sits at the top of the push-side of the door and powers the closing action. Parallel arm door closers are one of the most common applications, particularly in commercial properties and schools, because they reduce the risk of vandalism to the arm and they are more attractive than other overhead options. Due to the arm geometry, these are less power efficient than regular arm and top jamb closers.

16.6.5 Other Types Of Door Closers

Although overhead closers are the most common, there are other types that aren't mounted at the top of the door. Concealed closers, for example, are hidden within the jamb, offering a more appealing look. Similarly, floor closers are concealed within the floor and they aren't visible when the door is opened. Examples include:

A. Concealed: Concealed closers are fitted into recesses in the door and frame. Thus, they aren't visible when the door is closed. They are available as hydraulic or spring-loaded versions, and they are typically used for interior doors that are fairly light.

B. Surface-mounted: These types of door closers are fitted to the door frame, with a bar along the back of the door. Typically, these are fairly small in size, and they can be used to match the color of the door. They are a cost-effective option for automatically closing doors.

C. Floor-Spring: Floor-spring closers are typically used on glass storefront doors. They are mounted in the floor, and are concealed. A bar within the closer is fitted into the underside of the door, which controls the closing action. These provide one of the most appealing looks, and they are often used for upscale commercial properties.

Floor-spring closers typically have an open setting, so that they can be left open. Over-head spring closers are also available.

D. Installation and Adjustment

Installation and adjustment of the door closer must be done as per instructions of Engineer-in-Charge or as per manufacturer technical guide.

16.7 DOOR LOCK SYSTEM

External door locks shall be mortise locks complying with BS 12209, category A with the dimensions of 80mm case and 57mm backset.

The reversible latch bolt operated by lever handles shall have a strong return spring. The latch bolt shall project minimum 12mm. The latch bolt spring tension shall be strong enough to overcome the frictional forces of the lever handle. The lever handle shall have an independent spring mechanism and a properly designed stopper to eliminate transferring of forces to the latch bolt when the lever is depressed.

Dead bolt shall be reinforced with two hardened steel inserts or stainless steel and shall have a minimum projection of 14mm. The dead bolt shall be cylinder operated which can be opened by a key from either side of the door.

Internal door locks to all doors except WCs and bathroom shall be similar to details of the above external locks' specifications. However, dead bolt may not be strengthen with hardened steel inserts.

Locks for WCs and bathrooms shall be lever type mortise lock complying with BS 12209, category A with dimensions of 80mm case and 57mm backset. Operation mechanism of the reversible latch shall be similar to the above external locks. The dead bolt shall be operated by a turn button or thumb turn.

All locks shall be supplied with anodized aluminum lock furniture of an approved color along with suitable matching screws or solid stainless steel handles (Grade 316) approved finish compatible with other approved ironmongery.

16.7.1 Door Bolts

Door bolts shall be fixed top and bottom to one leaf in double door locations. They shall comprise two solid drawn, brass, aluminum or cast aluminum or stainless steel 150 mm long square profile bolts complete with keepers for head fixing and keepers for threshold fixing. The bolts shall incorporate keepers fixed into a screed to maintain the doors in an open position

16.7.2 Fitting

The Contractor shall deposit in the office of the Engineer-in-Charge one sample of each fitting to be used in the work. Unless otherwise specified, fittings shall be of the number size and type as specified.

16.7.3 Special Door Furniture

Where special ironmongery or door furniture is required, it shall be supplied by the department, or provided by the contractor at an extra cost. The cost of fixing or mounting such special furniture shall, however, be included in the rate.

16.7.4 Screws

Screws of such diameter shall be used as to fill completely the holes and cups in the fittings which they secure, and shall be oiled before being inserted. Unless the head can be counter-sunk flush with the fittings, round headed screws shall be used. Brass fittings of specified type shall be secured with brass screws.

16.7.5 Chocks

Hinged chocks shall invariably be fitted to all doors and windows to keep them open. Chocks shall be of hardwood and swung on 3 inches butt hinges and shall act on a sheet metal protector fixed to the door stile

16.7.6 Stops

Wooden stops of a size suitable for the leaf concerned shall be fixed to the door or window chowkats to prevent the leaf from damaging the plaster of the jamb when fully opened.

16.7.7 MEASUREMENT

Wood work wrought, framed and fixed shall be measured for finished dimension without any allowance for the wastage or for dimensions beyond specified dimension. However, in case of members having mouldings, roundings or rebates and members of circular or varying sections, finished dimensions shall be taken as the sides of the smallest square or rectangle from which such a section can be cut. Length of each member shall be measured over all to the nearest cm so as to include projection for tenons. Width and thickness shall be measured to the nearest mm and the quantity shall be worked out in unit of upto three places of decimal

16.8 PANELLED AND GLAZED DOORS AND WINDOWS

16.8.1 Design

Unless otherwise specified the paneled and glazed doors shall conform to the drawings.

16.8.2 Quality of Timber

Unless otherwise specified or directed by the Engineer-in-Charge the wood shall conform to specifications as mentioned above in 16.3.1.

16.8.3 Door Frame

1. the members shall be joined with close fitting mortise and tenon joints which shall be further pinned with corrosion resisting metal pins of not less than 8 mm (5/16"inch) diameter or with hard wood pins whose diameter shall not be less than 10 mm(3/8" inch). The framing shall be such as to ensure complete rigidity throughout.
2. The entire surface of frame coming in contact with masonry shall be treated with a preservative of an approved type and quality.
3. The frame shall be fixed to the masonry with at least four hold fasts. Two additional hold fasts shall be used if the chowkat is without a sill.

16.8.4 Shutter Frame

The stiles and rails of the frame shall be mortised and tenoned together. The thickness of each tenon shall be approximately 1/3 rd the thickness of the rail and the width of each tenon shall not exceed 5 times its own thickness.

16.8.5 Panel

1. Panels shall be made of solid wood or hard board or water resistant plywood or veneer having both sides properly finished. They shall be truly cut and framed into rebates to a depth not less than 3/8 inch. Their thickness shall not be less than 7.5 mm (5/16 inch) panels shall be in one piece up to 12 inches clear in case of deodar and 18 inches clear in case of teak. In the larger sizes they shall be jointed, but the joints shall be glued and dowelled together to prevent all possibilities of its opening out afterwards.

2. Panels shall be absolutely smooth so that no marks are visible. Unless otherwise specified, panels shall be splayed and fielded on both sides and the arises of the frame receiving the panels finished with a simple mould.

16.8.6 Sash Bars

Sash bars shall be of the same thickness on the leaf and shall be 1 inch to 1-1/4 inch wide, according to the size of the doors, and shall be twice moulded and twice rebated and mitred on the outside. The size of the rebate shall be 3/8 inch x1/2 inch to receive the glass and its fixing.

16.8.7 Glazing

All glazing shall be done in accordance with the provision of clause 16.14 for glazing. If specified, the doors and windows of bedrooms shall be glazed with blind glass up to full eye level. The glass panels of appropriate sizes shall be fitted into (3/8 inch) rebates and shall be retained in position with a thin layer of putty which shall be covered with wood beading.

16.8.8 Measurement:

Length and width of the shutters shall be measured to the nearest cm in closed position covering the rebates of the frames but excluding the gap between the shutter and the frame. Overlap of two shutters shall not be measured.

Frames shall be measured in cubic metres to nearest three place of decimal until and otherwise mentioned in description of item of work.

All work shall be measured net as fixed and area calculated in square metres to nearest two places of decimal. No deduction shall be made for providing venetian opening and opening for glazing.

16.9 FRAMED AND BRACED DOORS AND WINDOWS

16.9.1 Frame Of Leaf

Framed and braced doors shall consist of two stiles, three rails and two braces forming the frame of each leaf to which the battens (planks) shall be fixed. In case of doors opening outside, where it is necessary to admit light, the Engineer-in-Charge may direct the addition of a frieze rail. In this case the space between the frieze rail and the top rail shall be glazed by the contractor without any extra charge.

16.9.2 Framing And Bracing

The framing shall be made with mortise and tenon joints as per Specification No. 16.4. The top rail (or frieze rail when the door has been glazed) and bottom rails shall be chamfered or stop chamfered. The exposed edges of stiles and rails shall be chamfered or stop chamfered. Unless otherwise specified framing and batten shall be of the sizes as shown on drawings.

16.9.3 Batten

Batten shall butt into rebates in the top (or frieze) rail and the bottom rail and shall pass over the braces and the lock rail. Batten shall not be more than 5 inches wide and shall all be parallel and uniform in width. The joints shall be ploughed and tongued and finished with a bead and quirk on the outside. Battens shall be secured with two screws at each end and with one screw over each brace and the lock rail.

16.9.4 Other Respect

A framed and braced door/window shall conform to the provisions of Clause 16.5 In all respects.

16.9.5 Measurement:

Length and width of the shutters shall be measured to the nearest cm in closed position covering the rebates of the frames but excluding the gap between the shutter and the frame. Overlap of two shutters shall not be measured.

Frames shall be measured in cubic metres to nearest three place of decimal until and otherwise mentioned in description of item of work.

All work shall be measured net as fixed and area calculated in square metres to nearest two places of decimal. No deduction shall be made for providing venetian opening and opening for glazing.

16.10 LEDGED AND BRACED DOOR AND WINDOWS

16.10.1 Frame Of Leaf

Ledged and braced door leaf shall be formed with battens secured to three ledges, with two braces between the ledges. Windows shall have only two ledges and one brace.
The top edges and ends of ledges and braces shall be chamfered. Battens (planks) shall have rebated joints finished with a “V” on one side and shall be of uniform width of not more than 5 inches. The battens shall be screwed, with two screws at each end and one over each brace and the middle ledge. The size of ledges, braces and battens shall be as shown on drawings.

16.10.2 Double Leaves

In the case of double doors a 3” x 1” cover bar shall be screwed on to the edge of one leaf so as to make it a master leaf.

16.10.3 Hanging

The chowkat shall be rebated to a depth equal to the full thickness of the door, i.e the batten plus ledges. The doors shall be hung with the battens inside and the ledges outside. Hinges shall be fixed to the ledges.

16.10.4 Other Respect

In all other respect it shall conform to provisions of clause 16.5 for Doors and Windows (General).

16.10.5 Measurement

Length and width of the shutters shall be measured to the nearest cm in closed position covering the rebates of the frames but excluding the gap between the shutter and the frame. Overlap of two shutters shall not be measured.

Frames shall be measured in cubic metres to nearest three place of decimal until and otherwise mentioned in description of item of work.

All work shall be measured net as fixed and area calculated in square metres to nearest two places of decimal. No deduction shall be made for providing venetian opening and opening for glazing.

16.11 LEDGED DOORS AND WINDOWS

16.11.1 Frame Of Leaf

Ledged type also called country doors and windows, shall be formed by fixing battens on to three ledges. The battens shall be of uniform width, not more than 9 inches, and shall have rebated joints. The thickness of battens and the size of ledges shall be as specified on drawings.

16.11.2 Erection

Country doors shall be hung on pivot with the battens outside and ledges inside

16.11.3 Other Respects

In all other respect the ledged doors and windows shall conform to the Specifications No.16.8 for Ledged, Braced and Battened Doors

16.11.4 Measurement

Length and width of the shutters shall be measured to the nearest cm in closed position covering the rebates of the frames but excluding the gap between the shutter and the frame. Overlap of two shutters shall not be measured.

Frames shall be measured in cubic metres to nearest three place of decimal until and otherwise mentioned in description of item of work.

All work shall be measured net as fixed and area calculated in square metres to nearest two places of decimal. No deduction shall be made for providing venetian opening and opening for glazing.

16.12 WIRE GAUZED DOORS

16.12.1 Material

Unless otherwise specified leaves of wire gauze doors shall be made from deodar, irrespective of the wood used in making the chowkat or the other leaves hung from the same chowkat.

16.12.2 Chowkat

Wire gauzed door shall normally be hung on the same chowkat as other doors, and the rate shall include the provision of extra depth in the chowkat to take the rebate for the wire gauze leaf. Where wire gauze doors are hung on a separate chowkat a special rate shall be settled.

16.12.3 Wire Gauze

Unless otherwise specified, wire gauze shall be of best quality and uniformly woven wire webbing 12 x 12 meshes to the square inch made from 22 gauge galvanized iron wire. All wire gauze panels shall be in one piece, on joints being allowed in the gauze.
Whereas specified expanded metal or plastic or aluminum wire mesh could be used.

16.12.4 Fixing

Wire gauze shall be fixed to the frame of the leaf after being stretched from out to out of rebate and nailed down taut by nails spaced at not more than 2 inches and then fixed that by a fillet of ¾ inch x ¾ inch screwed into a rebate of that size. The screws shall not be less than 1-1/4 inches in length, nor spaced further than 9 inches. All exposed arises of the fillet shall be finished with a small neat mould.

16.12.5 Spring Hinges

Unless otherwise specified all wire gauze doors shall be hung on self-closing spring hinges which shall be of an approved quality.

16.12.6 Double Doors To Project

All Double Leaf Wire Gauze doors shall close with the meeting stiles butting, against each other, a felt being fixed to one leaf to close the joint. The leaves shall close to such an extent that the junction projects from the face of the chowkat, the protection being one inch for each foot width of leaf. The top of the chowkat (and sill when it has been provided) shall be enlarged to a corresponding wedge shape, the cost of this being included in the rate.

16.12.7 Matching Inner Leaves

Unless otherwise specified the width and position of lock and bottom rails on wire gauze doors shall be the same type as those of the other leaves hung on the same chowkat.

16.12.8 Measurement

Length and width of the shutters shall be measured to the nearest cm in closed position covering the rebates of the frames but excluding the gap between the shutter and the frame. Overlap of two shutters shall not be measured.

Frames shall be measured in cubic metres to nearest three place of decimal until and otherwise mentioned in description of item of work.

All work shall be measured net as fixed and area calculated in square metres to nearest two places of decimal.

16.13 WIRE GAUZED WINDOWS

Where moveable wire gauze flaps or leaves are provided to windows, the provisions of Clause 16.10 for wire gauzed doors shall be followed with the following modifications.
Wire gauze windows shall not be provided with springs or spring hinges.
Double hung wire gauze windows shall close flush with the chowkat without the meeting stiles projecting in any way. Unless otherwise specified wire gauzed windows shall open outwards and shall be provided with hinged chocks to keep them in the open position, and with stops to prevent damage to plaster.

16.14 CLERESTORY WINDOWS

16.14.1 Chowkat

Unless otherwise specified the chowkat of clerestory windows shall be so fixed as to project 3/8” inch from the inner face of the wall.

16.14.2 Cleat

Unless otherwise specified brass cleats of the slanting single button type approved by the Engineer-in-Charge shall be fixed by two brass screws to the polished wooden teak blocks with chamfered edges. The wooden blocks shall 2” x 3-½”x ¾” and shall be firmly fixed to the wall by means of plugs and screws of an approved type.

16.14.3 Leaves

The leaves shall be hung 1 inch off centre so as to make them self-closing. In order to open them, a cord (stout, non-twisting picture cord) shall be provided with a hard wood weight at one end (to keep the cord in position over the cleat).

16.14.4 Other Respect

In all other respects it shall conform to the provisions of Clause 16.6.

16.14.5 Measurement

Length and width shall be measured to the nearest cm in closed position. All work shall be measured net as fixed and area calculated in square metres to nearest two places of decimal.

16.15 FIXED WIRE GAUZE

16.15.1 Wire Gauze

Unless otherwise specified, the wire gauze shall be of an approved quality, uniformly woven, wire webbing of 12x12 meshes to a square inch made from 22 gauge galvanized Iron wire. All panels shall be in one piece and no joints shall be allowed in the gauze. Where specified aluminium or expanded metal wire guaze shall be used.

16.15.2 Methods Of Fixing

Wire gauze shall be fixed to the outside of the chowkat. This shall be drawn taut to the full width of the chowkat and nailed down by nails spaced not more than 2 inches and a cover strip, 3/4 inch in thickness and of the same width as the chowkat so at to seem a part of the chowkat, bed all round with 1-1/4 inches screws fixed not more than 9”inches apart.

16.15.3 Alternate Finishing

If specially required by the Engineer-In-charge, the wire gauze shall be fixed to the chowkat by a fillet, ¾ inch x ¾ inch, screwed into a rebate of the same size. The wire gauze shall be stretched taut and nailed down by nails spaced not more than 2 inches to the chowkat, and then the fillet screwed down with one-inch screws spaced not more than 9” inches apart.,

16.15.4 Finishing Rate

Exposed arises shall be finished with a small but neat mould in each case. The rate shall be the same for either method of fixing.

16.15.5 Measurements

The length and breadth shall be measured correct to a cm, the area from outside to outside of beading shall be calculated in square metre nearest to two places of decimal.

16.16 GLAZING

16.16.1 Glass Thickness And Quality

Unless otherwise specified, all glass shall be flat sheet glass of fine quality known as "seconds". Glass shall be of the following weights per square foot for the various sizes mentioned below:-

Not exceeding 12"x14" - 16 oz (about 1/14" thick)
Exceeding 12"x14" but not exceeding 24”x24”-21 oz (1/10” thick)
Exceeding 24"x24" but not exceeding 30”x30" -26 oz (1/9" thick)
Exceeding 30”x30” but not exceeding 36”x36”-32 oz (1/7" thick)
Exceeding 36”x36” plate glass- (1/4" thick)

Glass shall be free from specks, bubbles, distortion and flaws of every kind, and shall be properly cut to fit the rebates, so as to leave a uniform space of 1/16 inch all-round the panes between the edge of the glass and the rebate.

16.16.2 Putty (Method Of Preparing)

Putty shall be prepared from pure raw linseed oil and best whiting, specially dry and ground fine to pass a sieve of 45x45 meshes to a square inch. The two shall be well mixed by hand and kneaded into a stiff paste. It shall then be left for 12 hours and worked up in small pieces till it becomes quite smooth. If the putty becomes dry; it shall be restored by heating and working it up again while hot. Where the rebate is small a little white lead shall be added in making the putty. Putty required for glazing large panes or for bedding plate glass shall be made with a mixture of linseed oil and tallow with whiting so as to make it pliable and capable of standing expansion of the panes. Where required, putty shall be coloured to match the wood work.

16.16.3 Painting Or Priming Rebates

If rebates have not been painted, they shall be well primed with boiled linseed oil to prevent the wood from drawing oil out of the putty. Putty shall be painted at the same time and the same number of coats as wood work.

16.16.4 Fixing Glass With Putty

Each pane of glass shall be bedded on a thin layer of putty called "back putty" and secured into position with proper glazing springs or nail. "Front Putty" shall then be applied chamfered and finished off neatly so as to ensure that the depth of the putty is exactly equal to the rebate.

16.16.5 Fixing Glass with Wood Fillets

In the case of all panes exceeding 12 inches in width, front putty shall not be used but the glass secured with fillets of wood, without extra charge. The fillets shall be plain or moulded and of a size depending on the type of door being glazed. The glass shall be protected from contact with the wood by putty made with tallow to act as a cushion.

16.16.6 Blind Glass

Where blind glass is fixed the frosted face shall be away from the putty.

16.16.7 Putty (Coming Off)

All glass that has been fixed by the contractor shall if it becomes loose during the period specified in the contract, be re-fixed and puttied by him at his own expense.

16.16.8 Cleaning And Finishing

No glazing shall be considered complete until all paint and other stains have been removed from the surface of the glass. Glass shall be cleaned and polished with pads of damp newspaper, and then with a clean dry soft cloth. Cleaning shall be done by two men working on opposite sides of the same pane at the same time. The contractor shall make good all glass broken by his workers while cleaning the glass. On completion of the work all doors and windows shall be cleaned, damaged putty or glazing repaired and the whole work left perfect with a workmanlike finish.

16.17 MISCELLANEOUS

Fitting shall be of mild steel brass, aluminium or as specified. Some mild steel fittings may have components of cast iron. These shall be well made, reasonably smooth, and free from sharp edges and corners, flaws and other defects. Screw holes shall be counter sunk to suit the head of specified wood screws. These shall be of the following types according to the material used.

(a) **Mild Steel Fittings :** These shall be bright finish black stone enamelled or copper oxidized (black finish), nickel chromium plated or as specified.

(b) **Brass Fittings :** These shall be finished bright satin finish or nickel chromium plated or copper oxidised or as specified.

(c) **Aluminium Fittings :** These shall be anodized to natural matt finish or dyed anodic coating as per ASTM B580 - 79.

Screws used for fittings shall be of the same metal, and finish as the fittings. However, chromium plated brass screws or stainless steel screws shall be used for fixing aluminium fittings. These shall be of the size as indicated in respective figures.

Fittings shall be fixed in proper position as shown in the drawings or as directed by the Engineer-in- Charge. These shall be truly vertical or horizontal as the case may be. Screws shall be driven home with screw driver and not hammered in. Recesses shall be cut to the exact size and depth for the counter sunking of hinges.

16.17.1 BUTT HINGES

These shall be of the following types according to the material used.

(a) Mild steel butt hinges (Medium).

(b) Cast brass butt hinges light/ordinary or heavy.

(c) Extruded aluminium alloy butt hinges.

16.17.2 MILD STEEL (MEDIUM)

These shall be medium type manufactured from M.S. sheet. These shall be well made and shall be free from flaws and defects of all kinds. All hinges shall be cut clean and square and all sharp edges and corners shall be removed. These shall generally conform to ASTM standards.

Hinge Pin : Hinge pin shall be made of mild steel wire. It shall fit inside the knuckles firmly and rivetted head shall be well formed so as not to allow any play or shake, and shall allow easy movement of the hinge, but shall not cause looseness.

Knuckles : The number of knuckles in the hinges of different sizes shall be as per standards. The size of knuckles shall be straight and at right angle to the flap. The movement of the hinges shall be free and easy and working shall not have any play or shake.

Screw Holes : The screw holes shall be clean and counter sunk. These shall be suitable for counter sunk head wood screws and of the specified size for different types, and sizes of hinges. The size of the holes shall be such that when it is counter sunk it shall be able to accommodate the full depth of counter sunk head of the wood screws.

16.17.3 CAST BRASS :

These shall be light/ordinary or heavy as specified. These shall be well made and shall be free from flaws and defects of all kinds. These shall be finished bright or chromium plated or oxidised or as specified.

Hinge Pin : Hinge pin shall be made of brass or of stainless steel. The hinge pins shall be firmly rivetted and shall be properly finished. The movement of the hinge pin shall be free, easy and square and shall not have any play or shake.

Knuckles : The number of knuckles in each hinge shall not be less than five. The number of knuckles in case of sizes less than 40 mm shall be three. The sides of the knuckles shall be straight and at right angle to the flap. The movement of the hinge pin shall be free and easy and working shall not have any play or shake.

Screw Holes : The screw holes shall be clean and counter sunk and of the specified size for different types and size of hinges. The size of the holes shall be such that when it is counter sunk it shall be able to accommodate the full depth of counter sunk head of wood screw specified.

16.17.4 EXTRUDED ALUMINIUM ALLOY :

These shall be manufactured from extruded sections. These shall be well made and free from flaws and defects of all kinds.

Hinge Pin : Hinge pin shall be made of mild steel (galvanized or aluminium alloy). The aluminium alloy hinge pin shall be anodized. The hinge pin shall be finally rivetted and shall be properly finished. The movement of hinges shall be free easy and square and shall not have any play or shake.

Knuckles : Number of knuckles in each hinge pin shall not be less than 5. The number of knuckles in case of sizes less than 40 mm be straight and at right angle to the flap. The movement of the hinge pin shall be free and easy and working shall not have any play or shake.

Screw Holes : The screw holes shall be suitable for counter sunk head wood screws, and of specified sizes for different type of hinges. The size of the holes shall be such that when it is counter sunk it shall be able to accommodate the full depth of counter sunk head of wood screw specified.

16.17.5 PARLIAMENT HINGES

These shall be of mild steel cast brass or as specified. The size of parliament hinges shall be taken as the width between open flanges. Mild steel parliament hinges shall be copper oxidized (thick finish) or as specified. The brass parliament hinges shall be finished bright, chromium plated or oxidized or as specified.

The hinge pin shall be made of mild steel in the case of brass hinges. The hinge pin shall be mild steel (galvanized) in the case of aluminium alloy hinges. The hinge pin shall be firmly rivetted and shall be properly finished. The movement of the hinges shall be free, easy and square, and shall not have any play or shake.

All screw holes shall be clean and counter sunk to suit the counter sunk head of wood screws specified.

16.17.6 SPRING HINGES (SINGLE OR DOUBLE ACTING)

These shall be single acting when the shutter is to open on one side only or double acting when the shutter opens on both sides. These shall be made of M.S. or brass as specified.

Hinges shall work smoothly and shall hold the door shutter truly vertical in closed position. Each double-acting spring hinge shall withstand the following tests which shall be carried out after fixing it to a swing door in the normal manner.

(a) When the door is pushed through 90° and released 2000 times on each side in quick succession the hinge shall show no sign of damage or any appreciable deterioration of the components during or on completion of the test.

(b) The door shall require a force of 2.0 ± 0.5 kg for 100 mm hinges and 3.0 ± 0.5 kg for 125 mm and 150 mm hinges at a distance of 45 cm from the hinge pin to move the door through 90º. The size of spring hinge shall be taken as the length of the plate.

These shall be of the following type:

(a) *Mild Steel :* The cylindrical casing shall be made either from M.S. sheet of 1.60 mm thickness, lap jointed and brazed, welded and rivetted, or from solid drawn tube of thickness not less than

1.60 mm; or from mild sheet of 1.60 mm thickness pressed to from the two casing and the distance piece. It shall be stove enamelled black or copper oxidized or as specified.

(b) *Cast Brass :* The cylindrical casing shall be made either from brass sheet of 1.60 mm thickness, lap jointed and brazed, or from solid drawn brass tube of not less than 1.60 mm thickness. It shall be satin, bright nickle plated or copper oxidized or as specified.

16.17.7 CONTINUOUS PIANO HINGES

These shall be made from mild steel or aluminium alloy sheet, these shall generally conform to IS 3818. All screw holes shall be clean and counter sunk. Piano hinges shall be fixed in the entire length of the cup board shutters. Its size will be the width of the two flaps when open.

M.S. Piano Hinges : These shall be made from 1 mm or 0.80 mm thick M.S. sheets and shall be protected with anti-corrosive treatment, such as bright polished, chromium plated or oxidised finish.

Hinge pin shall be of galvanized mild steel. It shall fit in the knuckle firmly so as not to allow any play or shake and shall allow easy movement of hinge but shall not cause looseness.

The sides of the knuckles shall be straight and at right angles to the flap. The movement of the hinge shall be free and easy and working shall not have any play and shake.

Aluminium ***Piano Hinges :*** These shall be made of aluminium alloy sheet and shall be anodized. as per ASTM B580 - 79.

The hinge pin shall fit in the knuckle firmly so as not to allow any play or shake and shall allow easy movement of hinge but shall not cause looseness. The sides of the knuckles shall be straight and at right angles to the flap. The movement of the hinge shall be free and easy, and working shall not have any play and shake.

16.17.8 TEE HINGES

These shall be made from M.S. sheets and shall be either bright finished or stove enamelled black or as specified. These shall generally conform to IS 206 (Tee hinges shall be well made, free from burrs, flaws, and defects of any kind. The movement shall be square, and the working shall be free and easy without any play or shake. The hole for the hinge shall be central to the bore and shall be square.

The hinge pin shall be firm and rivetted over, so that the heads are well formed. All screw holes shall be clear and counter sunk and shall be suitable for the counter sunk head of wood screws.

16.17.9 SLIDING DOOR BOLTS

These shall be of mild steel, cast brass, aluminium or as specified, and shall be capable of smooth sliding action.

M.S. Sliding Door Bolts : These shall be made of M.S. sheets and M.S. rods. M.S. sliding door bolts shall be copper oxidized (black finish) or as specified.

Cast Brass Sliding Door Bolts : These shall be made from rolled brass and shall generally conform to BS Standards. The hasp shall be of cast brass and secured to the bolt. Alter- natively, the hasp and the bolt may be cast in one piece. The fixing and staple bolts shall be cast with 6 mm studs. Bolts shall be finished to shape and have threaded ends and provided with robs washers and nuts of square or hexagon type. All components shall be finished smooth and polished before assembly. Cast brass sliding bolts shall be finished bright or chromium plated or oxidised or as specified.

Aluminium Sliding Door Bolts : These shall be made of aluminium alloy. Aluminium sliding door bolts shall be anodized. All screw holes shall be counter sunk to suit the counter sunk head of screws of specified sizes. All edges and corners shall be finished smooth. In case of single leaf door, when iron socket plate or a brass or aluminium fixing bolts (or sliding door bolt) cannot be fixed, hole of suitable size shall be drilled in the door frame and an iron or brass plate cut to shape shall be fixed at the face of the hole. The leading dimensions of the sliding door bolts are illustrated.

16.17.10 TOWER BOLTS

These shall generally conform to IS 204 (Part. I) & IS 204 (Part. II). Tower bolts shall be well made and shall be free from defects. The bolts shall be finished to the correct shape and shall have a smooth action. All tower bolts made with sheet of 1.2 mm thickness and above shall have counter sunk screw holes to suit counter sunk head of wood screws. All sharp edges and corners shall be removed and finished smooth.

The height of knob of tower bolt when the door, window etc. is in closed position from the floor level shall be not more than 1.9 metre. Tower bolts shall be of the following types:

(a) Aluminium barrel tower bolts with barrel and bolt of extruded sections of aluminium alloy. The knob shall be properly screwed to the bolt and rivetted at the back.

(b) Brass tower bolts with cast brass barrel and rolled or cast brass bolt. Or Brass tower bolts with barrel of extruded sections of brass and rolled or drawn brass bolt. The knobs of brass tower bolts shall be cast and the bolt fixed with knob, steel spring and ball shall be provided between the bolt and the barrel.

(c) Mild steel barrel tower bolts with mild steel barrel and mild steel bolt. Or Mild steel tower bolts with mild steel barrel and castiron bolts.

The plates and straps after assembly shall be firmly rivetted or spot welded. The rivet head shall be properly formed and the rivet back shall be flush with the plate. These shall be made in one piece.

Unless otherwise specified bolt shall have finish as given below :

(a) Mild steel tower bolts (Types 1 and 2) Bolts bright finished or plated as specified and barrel and socket stove enameled black.

(b) Brass tower bolts (type 3 to 5) Bolt and barrel polished or plated as

specified.

(c) Aluminium alloy tower bolts (type 6) Bolt and barrel anodized.

The anodic film may be either transparent or dyed as specified.

This shall be of mild steel polished bright or copper oxidized batch electrogalvanized or stove enameled. In case of stove enameled locking bolts, the bolt may be finished bright.

16.17.11 PULL BOLT LOCKS

These shall be of M.S. cast brass or aluminium as specified. M.S. pull bolt locks shall be copper oxidized (black finish) or as specified.

Brass pull bolt locks shall be finished bright, chromium plated or oxidized as specified. Aluminium pull bolt locks shall be anodized. The bolt shall be 10 mm in diameter and the fixing plate 3 mm thick. The stop block shall be screwed to the fixing plate by a small ball and spring over which the bolt shall slide. The fixing plate shall have four holes for fixing it to the door leaf, two of which shall be square to receive 6 mm dia. bolts with round heads, the remaining two shall receive machine screwed with lock nuts. The receiving plate shall be of the same width and thickness as the fixing plate and shall have 3 counter sunk holes.

Where the bolt slides into wooden members, like the chowkhat, which have a rebate, the receiving plate shall also be correspondingly shaped so as to fit into the rebate. The screws and bolts shall have the same finish as the main bolt. The leading dimensions of pull bolt locks are given in the drawing. The denominating size of the pull bolt locks shall be length of the fixing plate between guides plus the thickness of the guides.

16.17.12 DOOR LATCH

This shall be of mild steel, cast brass, or as specified and shall be capable of smooth sliding action. In case, of mild steel latch, it shall be copper oxidized (black finish) or as specified and in case of brass, it shall be finished bright, chromium plated or oxidized or as specified. The size of door latch shall be taken as the length of the latch.

16.17.13 INDICATING BOLT (VACANT/ENGAGED*)*

These shall be of cast brass finished bright chromium plated,or oxidized or as specified. The shape and pattern shall be approved by the Engineer-in-Charge.

16.17.14 MORTICE LOCK AND LATCH

The size of the mortice lock shall be denoted by the length of the body towards the face and it shall be 65 mm, 75 mm and 100 mm as specified. The measured length shall not vary more than 3 mm from the length specified.

The clear depth of the body shall not be more than 15 mm. The fore end shall be firmly fitted to the body suitably by counter sunk head screw. The latch bolt shall be of specified material and of section not less than 12 x 16 mm for all sizes of locks. If made of two piece construction both parts shall be rivetted. Ordinary lever mechanism with not less than two levers shall be provided. False levers shall not be used. Lever shall be fitted with one spring of phosphor bronze or steel wire.

Keys : Each lock shall be provided with two keys.

16.17.15 MORTICE LATCH (WITH LOCKING BOLT)

These are generally used in doors of bath rooms, WC's and private rooms. Mortice latch shall, in respect of shape, design and mechanism of the latch and its components parts, generally conform to IS 5930. The material used for the different component parts of the latch shall comply with Tables 1 and 2 of IS 5930, unless otherwise specified.

The size of the latch shall be denoted by the length of the body towards the face and shall be 65 mm, 75 mm or 100 mm as specified. The depth of the body shall not be more than 15 mm. The latch shall be of size 10 × 18 mm of shape as shown in Fig. 1 of IS 5930. The locking bolt shall be of section not less than 8 x 25 mm for all size of locks. The mechanism of the latch bolt, its spring, striking plate etc. shall be as described in IS 5930.

16.17.16 MORTICE LOCK AND LATCH (REBATED)

These are slightly different from mortice lock described in above and are designed for use in double leaved doors.

16.17.17 MORTICE NIGHT LATCH

This is a mortice lock having a single spring bolt withdrawn from the outside by using the key and from inside by turning the knob and with an arrangement whereby the lock can be prevented from being opened by its key from outside while the night latch is used from inside the room.

It shall be cast or sheet brass, cast or sheet aluminium alloy or Mild steel as specified and of best quality of approved make. These shall be bright finished or copper oxidized (black) finish as specified. Nominal size of the latch shall be denoted by the length of the face over the body in milli- metres. These shall have not less than two levers. False (Dummy) levers shall not be allowed.

Keys : Each latch shall be provided with two keys which should work smoothly and without any appreciable friction in the lock.

16.17.18 CUPBOARD OR WARDROBE LOCK

The size of the cupboard lock shall be 40, 50, 65 & 75 mm or other described in item of work. This shall be made of cast brass and shall be of the best make of approved quality. These shall be finished bright or chromium plated or oxidized or as specified. The size of the lock shall be denoted by the length of the face across the body in mm.

These locks shall be fitted with four, five or six levers as specified. False (dummy) levers shall not be used.

16.17.19 KICKING PLATES

This shall be of brass (finished bright or chromium plated or oxidized) bronze, stainless steel, aluminium or as specified. Aluminium kicking plates shall be anodized. It shall be made from a plate of minimum thickness 3.0 mm & 1.5 mm in case of stainless steel. Shape of the plate shall be as specified. This shall have bevelled or straight edges and shall be fixed by means of counter sunk or rounded screws of the same material and finish as that of the plate. The shape and pattern shall be according to the drawings and as approved by the Engineer-in-Charge.

16.17.20 DOOR HANDLES (DOORS AND WINDOWS)

The door handles shall be well made and free from defects. These shall be finished correct to shape and dimensions. All edges and corners shall be removed and finished smooth so as to facilitate easy handling. Cast handle shall be free from casting defects. Where the grip portion of the handle is joined with the base piece by mechanical means, the arrangement shall be such that the assembled handle shall have adequate strength comparable to that of integrally cast type handles. Door handles shall be of the following types according to the material used:

(a) ***Cast or Sheet Aluminium Alloy Handles:*** These shall be of aluminium of specified size, and of shape and pattern as approved by the Engineer-in-Charge. The size of the handle shall be determined by the inside grip of the handle. Door handles shall be of 100 mm size and window handles of 75 mm size unless, otherwise specified. These shall be fixed with 25 mm long wood screws of designation No. 6. Aluminium handles, shall be anodized. The finish can be bright natural, matt or satin or dyed as specified.

(b) ***Cast Brass Handles:*** These shall be of cast brass of specified size and of the shape and pattern as approved by the Engineer-in-Charge. The size of the handle shall be determined by the inside grip of the handle. Door handles shall be of 100 mm size and window handles of 75 mm size, unless otherwise specified. These shall be fixed with 25 mm long wood screws of designation No 6. Brass handles shall be finished bright satin or nickel chromium plated or copper oxidized or as specified.

(c) ***Mild Steel Handles:*** These shall be of mild steel sheet, pressed into oval section. The size of the handles will be determined by the inside grip of the handle. Door handles shall be 10 mm size and window handles of 75 mm size unless otherwise specified. These shall be fixed with 25 mm long wood screws of designation No. 6., Iron handles shall be copper oxidized (black finish) or stove enameled black or as specified.

16.17.21 FLOOR DOOR STOPPER

This shall be made of cast brass of overall size as specified and shall have rubber cushion. The shape and pattern of stopper shall be approved by the Engineer-in-Charge. It shall be of brass finished bright, chromium plated or oxidized or as specified. The size of floor stopper shall be determined by the length of its plate. It shall be well made and shall have four counter sunk holes for fixing the door stoppers to the floor by means of wood screws. The body for housing of the door stopper shall be cast in one piece and it shall be fixed to the cover plate by means of brass or mild steel screws and cover plate shall be of casting or of sheet metal. The spring shall be fixed firmly to the pin. Tongue which would be pressed while closing or opening of the door shall be connected to the lower part by means of copper pin. On the extreme end a rubber piece shall be attached to absorb shock. All parts of the door stopper shall be of good workmanship and finish, burrs and sharp edges removed. It shall be free from surface and casting defects. Aluminium stopper shall be anodized.

All the floor stoppers selected shall be checked for dimensional requirement, material, manufacture and finish. Any of door stopper which fails to satisfy any one or more of these requirement shall be considered as defective door stopper

16.17.22 HANGING RUBBER DOOR STOPPER

These shall be of cast brass, finished bright, chromium plated or as specified. Aluminium stopper shall be anodized. The size and pattern of the door stopper shall be approved by the Engineer-in-Charge. The size shall be determined by its length.

16.17.23 UNIVERSAL HYDRAULIC DOOR CLOSER (EXPOSED TYPE)

These shall be made of cast iron/aluminium alloy/zinc alloy and of shape and pattern as approved by the Engineer-in-Charge.

The door closers may be polished or painted and finished with lacquer to desired colour. Aluminium alloy door closer shall be anodized. All dents, burrs and sharp edges shall be removed from various components and they shall be pickled, scrubbed and rinsed to remove greese, rust, scale or any other foreign elements.

The nominal size of door closers in relation to the weight and the width of the door size to which it is intended to be fitted.

Performance Requirements: After being fitted in its position when the door is opened through 90°, the same should swing back to angle of 20° ± 5° with nominal speed but thereafter, the speed should get automatically retarded and in case of doors with latches, it should be so regulated that in its final position the door smoothly negotiates with the latch.

16.17.24 HASP AND STAPLE SAFETY TYPE

This shall be made of mild steel, cast brass or aluminium as specified. M.S. Hasp and staples shall be finished black enamelled, or copper oxidized (black finish) or as specified. Brass hasp and staples shall be finished bright chromium plated or oxidized or as specified. Aluminium hasp and staples shall be anodized and the anodic coating shall not be less than grade AC 15 of IS 1868.

M.S. hasp and staples shall be manufactured from M.S. sheet and brass hasp and staples by casting and Aluminium hasp and staples shall be made from dye section. The hinge pin which in all cases shall be of mild steel, shall be firm and its rivetted heads well formed. The movement of hasp shall be free, easy and square and shall not have any play or shake.

The hasp shall fit, in the staple correctly. The size shall be determined by the length of the bigger of the hasp.

The staple except in the case of cast one, shall be rivetted properly to its plate. The ends of the hinge pin for the safety type hasp shall be rivetted and properly finished. All screw holes shall be clean and counter sunk to suit counter sunk wood screw. All edges and corners shall be rounded.

16.18 MEASUREMENTS:

Length and width of the shutter shall be measured to the nearest centimetre in closed position covering the rebates of the frames but excluding the gap between the shutter and the frame. Overlap of the two shutters shall not be measured. All work shall be measured net as fixed and area calculated in square metres to nearest two places of decimal. No deduction shall be made to form panel opening, louver Venetian opening and opening for glazing. No extra payment shall be made for shape, joints and labour involved in operations described above.

16.19 WOODEN STAIRS

16.19.1 General

The wooden stairs shall be constructed where specified according to drawings with deodar wood complying with the provisions of Clause 16.3.1.

16.19.2 Workmanship

The quality of materials and workmanship shall conform with the provision of Clauses 16.3 & 16.4 or as specified. The glazing where specified shall conform with the provisions of Clause 16.14. The stairs shall be firmly anchored at floor and with walls as specified.

16.20 WOODEN ROOF

The wooden roofs shall be constructed according to Drawings and as specified. The timber and materials shall conform to the provisions of Clause 16.3. The work shall be carried out in accordance with Clause 16.4. The roofing work shall comply with applicable provisions of Section 13 – Roofing.

16.21 SOUND PROOFING

i) Where specified shutter and frames of the doors, windows shall be affixed with sound proofing material sheets. The sound proofing sheets shall include cork sheet, rubber sheet and namdaas specified.

ii) The sheets shall be cut precisely for the size of panels and frames on which they are to be affixed. The cut sheets shall be neatly fixed on the surface by means of screws/adhesive specified in Clause 16.3 as approved by Engineer-in-Charge.

16.22 WALL LINING

Specified timber shall be used, and it shall be sawn in the direction of the grains. Sawing shall be truly straight and square. The timber shall be planed smooth and accurate to the full dimensions, rebates, roundings, and mouldings as shown in the drawings made, before assembly. Patching or plugging of, any kind shall not be permitted except as provided.

16.22.1 MEASUREMENTS

Length and breadth of superficial area of the finished work shall be measured correct to a cm. Area shall be calculated in square meter correct to two places of decimal. No deduction will be made of openings of areas upto 0.40 sqm nor shall extra payment be made either for any extra material or labour involved in forming such openings

16.22.2 Grounds

Grounds shall be provided where so specified. These shall consist of first class hard wood plugs or the class of wood used for fabricating the frames, of trapezoidal shape having base of 50 × 50 mm and top 35 × 35 mm with depth of 5.0 cm and embedded in the wall with cement mortar 1:3 (1 cement: 3 fine sand) and batten of first class hard wood or as specified of size 50 × 25 mm or as specified, fixed over the plugs with 50 mm long wood screws. The plugs shall be spaced at 45 to 60 centimeters center to center, depending upon the nature of work. The battens shall be painted with priming coat, of approved wood primer before fixing.

16.22.3 Paneling

1. Material

This paneling shall be decorative or non-decorative (Paintable) type as per design and thickness specified by the Engineer-in-Charge, of 2nd class teak wood, or graded wood pre-laminated particle board or as specified in item.

2. Ornamental Work

The ornamental wood work shall be painted on the back with priming coat of approved wood primer before fixing the same to the grounds with screws, which shall be sunk into the wood work and their tops covered with putty. The ornamental work shall be made true and accurate to the dimensions shown in the working drawings. The fixing shall be done true to lines and levels. The planks for wall lining shall be tongued and grooved, unless otherwise specified.

16.23 U-PVC DOORS AND WINDOWS

UPVC doors, panels, frames, windows, louvers, screens shall be complete in all respect including sashes, glazing beads, mullions, panels, hardware, fasteners etc and procured from reputed manufacturers approved by the Engineer-in-Charge.

- Allowable Tolerance: - ±2 mm.
- All doors and frame components will be inspected, before installation.
- All components, which are abraded, dented, bent, bowed or show any other structural damage or distortion will be rejected, marked and shall be removed from the site. No component will be allowed to straightened and then incorporated in the work.

A) Delivery, Storage and Protection

Protect factory finished u-PVC surface with wrapping strippable finish. Do not use adhesive papers or sprayed coatings that bond when exposed to sunlight or weather.

B) Environmental Requirements

Do not install sealant when ambient temperature is less than 5°C during 48 hours after installation.

16.23.1 MEASUREMENTS

The outer length of the vertical and horizontal members of UPVC door frame shall be measured in running metres including embedded length in floor corrected upto a cm.

Length and width of the shutters shall be measured to the nearest cm in closed position covering the rebates of the frames but excluding the gap between the shutter and the frame. Area is calculated to the nearest 0.01 sqm.

16.24 KITCHEN CABINET

All wooden kitchen cabinet works shall be fabricated by approved sub-contractor/manufacturer and shall be of best quality.

A) Shop Drawings

The details of these items shown on the drawing are tentative and show basic configuration and design of these items.

The contractor shall submit detailed shop drawings of these items on the basis of tentative detail shown on the drawings including all fitting, fixtures and hardware for the proper execution of kitchen cabinet for the approval of the Engineer before fabrication.

B) Installation

All the works shall be installed in position by the manufacturer's skilled workmen specialized in the job. Works shall be executed in accordance with approved shop drawings and or as directed by the Engineer.

All work shall be thoroughly protected from the damage at all times by suitable methods approved by the Engineer. Adjacent works shall similarly be protected from damage. Any damage or disfigurement shall immediately made good at contractor's expense.

16.24.1 MEASUREMENTS:

Length and width of the cabinet shall be measured to the nearest cm in closed position covering the rebates of the frames but excluding the gap between the shutter and the frame. Area is calculated to the nearest 0.01 sqm.

16.25 MEASUREMENT AND PAYMENT

16.25.1 Composite Rate

The measurement and payment for the items of the work of Woodwork hereof shall be made corresponding to the applicable CSR items as provided in Contract Agreement and shall constitute full compensation, for procurement, transportation, performance in all respects and completion of work as specified including the site clearance as approved by the Engineer-in-Charge.

16.25.2 Labor Rate

The measurement and payment for the items of the work of Woodwork hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurement transportation, performance in all respects and completion of work as specified including site clearance, as approved by the Engineer-in-Charge except the cost of materials to be provided by Department at designated location as defined in the Contract Agreement.

16.25.3 Quantification

The unit of measurement shall be as mentioned below in accordance with corresponding CSR items.

1. For Volumetric items, the unit of measurement shall be cubic meter or cubic foot.
   Following items of CSR are measured in the above mentioned criteria;
   Item No.: 16-1 to 16-6 and 16-82
2. Following items shall be measured as % age increase;
   Item No.: 16-87
3. For surface area items, the quantity of work shall be measured by surface area. The unit of measurement shall be Square meter or Square foot. Following item of CSR are measured according to this criteria;
   Item No.: 16-7 to 16-43,16-48, 16-50 to 16-53, 16-55 to 16-58, 16-85 and 16-86
4. For linear items, the quantity of work shall be measured linearly along center line of structure. The unit of measurement shall be running meter or running foot. Following items of CSR are measured according to this criteria;
   Item No.: 16-44 to 16-47,16-49,16-54,16-59 to 16-61 and 16-71
5. The following items shall be measured as Each
   Item No.: 16-62 to 16-70, 16-72 to 16-81,16-83 and 16-84

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17. PAINTING AND VARNISHING

17.1 INTRODUCTION

Painting is meant the application of paint, varnish, enamel and other protective coating in a liquid form to the surface of wood, metal, brick, or other materials to form a thin coating or film which solidifies and sticks to the surface. This coating is applied for one or more of the following reasons:

To protect the surface from the elements and from wear;

To improve its appearance and give it the desired color and finish;

To facilitate cleaning: To improve the lighting of interiors of buildings, stains are applied to wood surface to produce the desired color.

To emphasize the grain or to protect the wood, metal surfaces may also be galvanized, sherardized, tin-plated, tern-plated, chrome-plated, or nickel-plated for their protection or improving their appearance.

17.1.1 PAINTING NEW WOODEN SURFACE

The surface to be painted must be properly prepared because a large number of defects, appearing afterwards can be attributed either to faulty preparations or to the improper seasoning of wood.

17.1.2 PREPARATION OF SURFACE

Assuming the wood to be properly seasoned, the surface is prepared by carrying out following operations in succession.

a) RUBBING WITH PUMICE OR MEDIUM & FINE GRADE SAND PAPER:
This rubbing is continued till the surface becomes perfectly smooth.

b) KNOTTING:
This is done before the application of a priming coat to cover all knots in wood so as to prevent any exudation of resin or any mark from showing, through the three common methods of knotting:

   i. Lime knotting
   ii. Ordinary size knotting and
   iii. Patent knotting. Knots in deodar or other resinous woods are painted over with hot lime and scraped off after 24 hours. The knots are primed with red lead and glue is laid hot on them. A coat of knotting varnish is then applied and the surface is rubbed smooth with pumice stone or sand paper.

Ordinary size knotting is applied in two coats. The first is made by grinding red lead in water and mixing it with strong glue size used hot. The coat dries in about ten minutes. The second coat consists of red lead ground in oil and thinned with boiled linseed oil and turpentine.

Patent knotting consists of two coats of a varnish made by dissolving shellac in methylated spirit or naphtha. Knotting may be composed of 5 oz. of pure shell as dissolved in a pint of methylated sprit. After it has been thoroughly dissolved 1/2 oz. of red lead is put into it and stirred. This is suitable for general purpose.

c) PRIMING:
Priming coat is the first coat applied to fill the pores of wood and prepare a smooth base for the subsequent coats, of paints. It also quickens their drying. It should be done before the woodwork is fixed in place. A priming coat may be of red lead or red and white lead mixed in double boiled linseed oil (7 Lbs.. of red lead or 7 Lbs.. of red and white lead mixed with 3/4 of a gallon of oil) and may be applied with a brush or spraying machine.

The following are the alternatives for priming:

   1. For Inside Woodwork
      1/2 Lb. of red lead
      8 Lbs. of white lead
      2 points boiled linseed oil

1-1/2Lbs. patent driers.
1 pint raw linseed oil

2. for Outside Woodwork
10 Lbs. of white lead
4 pints raw linseed oil
1 ounce red lead
2 ounce litharge or patent driers

And left for 12 hours and then it will be worked up-till quite soft and smooth.

d) STOPPING:

This means the tilling up of nail holes cracks and other inequalities to level the surface. Stopping is done as soon as the priming coat dries up, with ordinary putty made of 2 parts of whiting, 1part of white lead mixed together in linseed oil and kneaded (3 oz. linseed oil to 1 Lb. of whiting). High class interior work can be stopped with a mixture of 1/3 of white lead and 2/3 of ordinary putty. In the case of varnishing the wood surface is usually stopped with hot weak glue size (one Lb. of glue making about one gallon of size). When the surface dries up ,it is thoroughly sand papered. Stopping out wax is also a very useful preparation for concealing defects in wooden surfaces to be polished. It is applied hot and sets quite hard. As it does not take stains after setting it should be colored during its preparation to suit the finished work.

17.1.3 PAINTING

After having prepared the surface in the manner described above a second coat of paint of the desired quality and color is applied exactly in the same fashion as the priming coat. As soon as it dries up the surface is rubbed with pumice stone or glass paper. This is followed by second and subsequent coats. Each coat is allowed to dry completely before the next is applied. Thin coats of paint are preferable for thick coats not only take longer time to dry up but also scale off after some time in the form of blisters. .

Turpentine instead of oil is used for the surface which is exposed to strong sunlight because oil paints show up all defects. The proportions used are 2Lbs. of white zinc, 1 Lb. of turpentine and 1/2Ib of boiled linseed oil. For painting white, white lead is used for the surface exposed to weather and white zinc for interior works. If lead paint has been used, dry rubbing of surface should not be done on any account, since it causes lead poisoning among painters. Instead, waterproof sand papers or flint paper and cloth should be used.

Note: Woods having an excess of resin or oils are unsuitable for polished or painted work e.g. the resin of deodar shows itself up in the discolored patches even through a number of coats of paint.

17.1.4 REPAINTING WOOD WORK

Repainting of wooden surface is done in the same manner as the original painting; the difference lies only in the preparation of the surface.

17.1.5 PREPARATION OF SURFACE FOR REPAINTING

If the old surface is firm and sound, it is rubbed with pumice or soap stone and washed thoroughly with soap, washing soda and water. Afterwards all those processes like knotting, priming stopping and rubbing are carried out to obtain a properly prepared surface for second and subsequent coats of repainting. If the old paint is in a blistered, cracked or perished condition it has to be completely removed and the surface prepared afresh for painting. Surface marked with smoke or otherwise dirty is cleaned by applying a coat of 3 Lbs..glue and 3 oz un-slaked lime boiled in one gallon of water. Greasy places are brushed over with turpentine and then washed with lime/soap and water.

17.1.6 PAINT REMOVERS

There are a number of ready-made paint removers. If none is available, anyone of the following methods can be used for removing the old paint.

a) A coat of caustic soda (2Lbs. of caustic soda to a gallon of water) may be applied very carefully with a piece of cloth securely tied on one end of a long wooden stick. It is very dangerous and harmful to the eyes and skin, and, therefore, should never be touched by hand. A few hours after it has been applied the surface is thoroughly washed with clean water and neutralized with a weak acid solution or vinegar.

b) Old paint may be softened by repeated application of naphtha. The surface can be then rubbed and cleaned.

c) One Lb. of country soda (saji) may be dissolved in hot water and mixed with stone lime to make a creamy paste. The surface to be cleaned is well coated with it and kept moist for at least 3 hours. The paint would become soft and can be easily rubbed off. To quicken the action un-slaked lime may be used and the mixture applied hot.

d) One part of soft soap may be mixed to two parts of potash and the mixture dissolved in boiling water. Then lime is added to It. This mixture may be applied while it is still hot, with a brush on the surface of the old paint and left on for 12 to 18 hours. It would soften the paint which can be easily removed by washing with hot water.

e) Sodium carbonate or washing soda diluted with water would clean greases and fats from the old painted surface. (One Ib of washing soda is sufficient for one gallon of water) Hot water would quicken the action of washing soda.

f) Two parts of quicklime may be mixed with one part of washing soda and made to the consistency of a cream. A coat of this cream would soften the old paint very quickly.

g) Burning the paint preferably with a blow pump and scraping.

17.1.7 NOTES FOR GUIDANCE

Thick layers of old paints are generally burnt with a blow lamp and scraped. Flame of blow lamp cracks window glasses for which proper precautions must be taken:

Painting should be avoided during wet season.

No painting should be done on a stormy or rainy day on outside open surfaces.

Painted surface should not have any brush marks, runs or specks.

If the wet painted surface is spoiled by any weathering action It should be rubbed and painted afresh. The paint should have a proper consistency. It should not be thinned down so much that it flows off the brush when it is being applied.

If defects like bleeding, blistering, brush marking, chalking etc. shall be rectified at contractor’s own cost and rectified work shall be approved by Engineer-in-charge

17.1.8 FIRE PROOF PAINTS FOR WOOD WORK

A coating of paint of insulating and non-combustible type sodium silicate or ammonium phosphate acts as an efficient fire retardant. These chemicals decompose on painting and give out non-combustible gases and water-vapors which dilute the inflammable gasses and retard the combustion of wood. They also form readily a dense layer of charcoal and a fused viscous mass and protect the wood from radiant heat. The surface of wood is thus cut off from the supply of oxygen.

17.1.9 VARNISHING

Varnishing and painting are similar operations; painting is generally prescribed for exterior works and varnishing for Interior works. In both the cases, the surface is prepared in almost the same way. Woodwork when prepared is sized with a coat of thin clean glue. If the wood is of oily nature a little brown earth and ochre is added. That is why varnish does not dry up readily. This is applied hot and rubbed smooth. A second coat of thin clean glue with necessary quantity of staining color having equal parts of burnt umber and burnt sienna is then applied, and rubbed smooth with fine sand paper when it dries up. Two coats of boiled linseed oil can be given instead of glue size. Varnishes are applied in thin coats over the surface prepared in the above fashion as soon as it dries up. Of all the varnishes available English Copal varnish is considered the best. Normally for an old work a single coat would do, but for a new wood work a second coat is applied after the first has completely dried and rubbed with fine sand paper. Rubbing is done before and after each coat of varnish except the last. One pint of varnish covers about 150 square feet of surface in a single coat. Wood varnish dries up and is free from stickiness within two days.

17.1.10 FRENCH POLISH (SPIRIT POLISH)

It is a spirit varnish applied to the prepared wood surface with a polishing pad of soft cloth and not with a brush with quick and light strokes along the grain. The cloth contains absorbent cotton filling. Several coats will be necessary before the desired shine and finish is achieved. The pad may be dabbed with a drop of olive or mustard oil after each coat to allow a smooth working and finish. The wood to be polished is first painted with a filler composed of 5 Lb. of whiting mixed with 1/2 gallon of methylated spirit and then sand papered, when dried. Fillers can also be made in any of the following ways:

i) Whiting mixed with water.
ii) Linseed oil and bee's wax (3:1) boiled.
ii) Plaster of Paris either in water or raw linseed oil.

French polish is worked upon the surface of hard wood to obviate the effect of grain.

17.1.11 WAX POLISH

The surface of wood work is smeared with wax polish and rubbed with a soft flannel to a fine polish after 24 hours of its application. Wax polishing is mostly used for polishing the cement concrete floors.

17.1.12 WHITENING

Whiting mixed with zinc and water is used for whitening ceilings and walls. Whiting is made by reducing pure white chalk to a fine powder.

17.1.13 PAINTING IRON WORK (NOT UNDER WATER)

In order to protect metallic products from corrosion, surface treatment is extremely essential, and painting is one of the many methods employed for this purpose. In addition, it improves the appearance of the article or structure.

PREPARING IRON WORK FOR PAINTING-

It is essential to remove all rust, scale and dirt and have the surface absolutely cleaned before painting. Special attention is paid to the cleaning of corners and re-entrant angle. Usually anyone of the following methods is employed depending upon the nature of surface to be cleaned:-

1) Loose dust is removed by bristle or wood fiber.
2) Rust scale and perished old paints are burnt off by the application of flat oxy-acetylene flame and then rubbed off with wire brushes and scrapers,
3) Oil and grease can be removed by gasoline (petrol) or benzene, excess of which shall be wiped off from the surface.
4) Old paint can be loosened by applying a solution of country soda and fresh slaked lime in equal parts.

No chemical of any kind will be allowed to be used for cleaning the metal.

PRIMING OR UNDER COAT:

Priming coat can be a mixture of pure linseed oil and dry red lead in the proportions of 1 gallon of oil to 33 Lbs. of red lead. It is applied by brush or spraying machine immediately after cleaning the surface of the metal when it has completely dried up. If this coat is spoiled by rain within 24 hours of its application, it is removed and another coat is applied.

SECOND AND SUBSEQUENT COATS:

The second coat is applied when the priming or first coat has thoroughly dried and set i.e. after about four days. It may be red oxide paint or paint with aluminum or graphite base (red oxide paint may consist of 6 Lbs. of red oxide paint, 1lb of lamp black and 1 gallon of boiled linseed oil). The third coat is applied when the second coat has dried completely. It may consist of 7 Lbs. of red oxide paint, and 1 gallon of boiled linseed oil. For less important iron works or for roof coverings red oxide paint can be made up of the following constituents.

a)	Red oxide powder dry	10 parts by weight
b)	Raw linseed oil	4 parts by weight
c)	Boiled linseed oil	1 parts by weight
d)	Turpentine	1 parts by weight

One gallon of this paint will cover about 400 square feet of surface in two coats. Standard paints available in market should be used as specified and approved by the Engineer-in-Charge.

17.1.14 GUARDING RUSTING OF STEEL WORK

All structural steel work is primed and preferably given a coat of red oxide paint before erection, except the surfaces to be riveted in contact and the surfaces which have to remain in contact with concrete. Iron and steel work can be protected from rust as a temporary measure by means of a coat of whitewash or by covering it with slaked lime. Iron exposed to weather can be protected temporarily by a coat of paint made with pulverized oxide of Iron, linseed oil, and a drier. A coat of cement wash is also beneficial.

Painting Galvanized Iron

Paint does not adhere to the new galvanized iron surface. It is exposed to weather for at least one year before painting. If it is necessary to paint it earlier the galvanized surface is treated with anyone of chemical mixtures mentioned below.

The mixture will turn the surface black. The compositions of these chemical mixtures are:-

i)	Copper acetate	6-8 Ounces
ii)	Water	1 Gallon
	or	
i)	Muriatic Acid	2 Ounces
ii)	Copper Chloride	2 Ounces
iii)	Copper Nitrate	2 Ounces
iv)	Sal-Ammonia	2 Ounces
v)	Hydrochloric Acid	Small quantity
vi)	Soft Water	1 Gallon

Besides, the galvanized surface can be treated by washing it with vinegar or slaked lime and washing soda. .

The surface treated by any of the above methods can be painted with a priming coat after about 12 hours. The paint may either be obtained ready-made specified paint from the market or prepared by mixing red lead with linseed oil and turpentine in equal proportions.

17.1.15 PAINTING IRON WORK (UNDER WATER)

Unprotected Iron work suffers an average reduction in thickness of face by 0.003 inch per, year if it is submerged in sea water and 0.002 inches per year if it is submerged in fresh water. From these figures it is obvious that painting of Iron work under water is essential to safeguard against this recurring waste.

Iron or lead oxide paint is sometimes satisfactory but Khankl mixture is the most durable paint known so far for Iron work under water. The mixture is applied hot, and two to three coats are sufficient. Subsequent coats are given only after the previous ones have dried up. Anti-corrosive black enamel paints and asphalt paint (asphaltum dissolved in naptha or benzine) are also used for this purpose.

17.1.16 COAL TARRING

Tar is applied as hot as possible. If practicable, the article is dipped into the tar. Preferably the Iron article to be painted is heated red hot and then tar is brushed over. One Lb. of tar would cover 10 square feet. Tar paints are prepared in the following manner: For every gallon of tar 2 Lbs. of un-slaked lime is added and the mixture heated till it begins to boll. It is removed from-the fire and kerosene oil equivalent to 1/4th of its volume is added very slowly. Instead of kerosene oil, country spirit can be added in a proportion of 1/2 pint of country spirit to 1 gallon of tar. Solignum or creosote is also used sometimes. These too are also .to be applied very hot.

17.1.17 PAINTING WALLS AND OTHER CEMENT SURFACES

For painting walls, Ceiling etc., rubber paints or alkali resisting primers and plastic emulsions or cement paints are usually employed. A brief description of their application is, given below:-

i) The free alkali in new lime and cement plaster rapidly destroys the oil in paint and prevents it from drying. For this reason, it may not be possible to paint a plastered wall till after 12 months of its completion. In such cases the walls whitewashed in the first instance.

ii) All loose and flaking material is removed from old walls by scraping or wire brushing. All dust, dirt, oil, grease or efflorescence are carefully removed.

iii) The walls are primed with boiled linseed oil or glue size (glue mixed with water); glue size is not used if the walls have been whitewashed.

iv) First two coats normally consist of white lead and boiled linseed oil. The third coat can be of white lead tinted to approach the desired color and mixed with raw linseed oil and a small proportion of turpentine.

v) The finishing coat should contain a large proportion of turpentine with a little varnish to serve as a binder and applied when the previous coat is still sticky. This will give a flat finish as a glossy finish coat shows up the irregularities in the plaster.

vi) If a wall is to be painted immediately after it is cement plastered, without waiting for a period of 12 months as mentioned in No. (i) above, a solution of 5 Lbs of zinc sulphate in a gallon of water should be applied on it and when it dries up a coat of pure raw linseed oil should be given Alternatively the surface can be treated with dilute sulphuric or hydrochloric acid (1 part acid to 50 parts water) and then washed with water. Two coats of paint thinned with turpentine and having a little varnish as a binder are then applied in succession. For the third coat, paint is thinned with a mixture of 3 parts of boiled linseed oil to 1 part of turpentine.

A few varieties of ready-made paints are available in the market which need no such formalities of surface treatment or waiting for 12 months and can be applied directly on newly-plastered walls. The paints shall be as specified and approved by the Engineer-in-Charge.

17.1.18 PAINTING DAMP WALLS

Before painting damp walls they should be treated as described below, since otherwise the paints would not stick to them.

Take paraffin 2-1/2 gallons, benzoline 2 gallons, pale resin 14 Lbs. in a vessel and shake them well. When completely dissolved add 24 Lbs whiting and grind the whole mixture thoroughly. This mixture is kept airtight to prevent drying and 1 or 2 coats, depending upon the dampness of the wall, are applied as ordinary paint. It will dry up hard and then any suitable variety of paint can be applied, which will stick to it.

17.1.19 PAINTING BRUSHES

The brushes should be of bristle and not horse hair. Bristles can be distinguished by the fact that each bristle is split at end. A good brush has springiness in the bristles, and usually following sizes of brushes are employed:

1.	12 to 14 inches	For dusting large flat surface
2.	8 inches	For greater work
3.	6 inches	For wood work
4.	2 to 4 inches	For fine work

A round brush is considered the best for painting. New brushes should be placed in water for 2 to3 hours and then allowed to dry for 1 hour before use. When a brush is used for another color or is no longer required, it should be cleaned at once by dipping into kerosene oil. Old brushes should be kept in water or raw linseed oil (covering the bristle only) when not in use.

17.1.20 PAINTING WITH BRUSH

The paint should be applied by the end of the hair, and not by the sides. Application by the sides is not satisfactory, and the brush wears out more rapidly. Brush should be reversed at frequent intervals so that it wears down evenly. A free easy stroke should be cultivated. Short and jerky strokes result in uneven surface. Stretching the stroke too far also results in uneven surface.

17.1.21 PAINTING WITH SPRAYING MACHINE

When spraying machines are being used for painting the instructions given below should be followed.

a) The gun should be held 6 to 10 inches from the object to be painted. Gun should be moved across the surface with steady and even strokes made with a free arm action. The gun should be kept perpendicular to and at an equal distance from the surface throughout the operation. Before actual work, gun should be tried on a cardboard surface, etc.
b) The adjusting screw on the gun should be closed while starting and opened gradually till the spray runs right. A distorted spray indicates dirty air caps in which case it should be taken off and washed carefully in a clean solvent.
c) Spray painting should not be employed for paints containing lead or for painting joinery work which should be done invariably by brush to obtain proper penetration into joints, cracks. etc.

17.1.22 MEASUREMENTS:

The length and breadth shall be measured correct to a cm. The area shall be calculated in sqm (correct to two places of decimal), except otherwise stated. Small articles not exceeding 10 sq. decimetre (0.1 sqm) of painted surfaces where not in conjunction with similar painted work shall be enumerated.

Note : Components of trusses, compound girders, stanchions, lattices and similar work shall, however, be given in sq. metres irrespective of the size or girth of members. Priming coat of painting shall be included in the work of fabrication.

In measuring painting, varnishing, oiling etc. of joinery and steel work etc. The factors as indicated in 17.16.3 shall be used to obtain the area payable. The factors shall be applied to the areas measured flat and not girthed.

17.2 PAINTING AND VARNISHING (GENERAL)

17.2.1 GENERAL

For painting and varnishing the provisions of Clause 17.1 as pertinent shall apply.

17.2.2 WEATHER

Unless otherwise specified, no painting shall be done during wet, foggy or dusty weather or in the direct rays of the hot sun.

Paint or finish to any surface shall be applied when ambient temperature is 10 degrees centigrade or above and less than 43 degrees centigrade unless otherwise recommended by manufacturer of paint. No painting shall be done above 90% humidity.

17.2.3 NUMBER OF COATS

Unless otherwise specified all wood and iron work shall be given three coats including the priming coat. Color of priming coat shall be lighter than finish coat. All paints shall be of make where specified and as approved by the Engineer-in-Charge.

17.2.4 CLEANING AND PREPARATION OF SURFACE

Surface shall be thoroughly cleaned of all dust, rust, dirt, oil, grease, etc., and rendered smooth and dried before preparing it for painting or varnishing.

17.2.5 PRIMING KNOTTING AND STOPPING

A priming coat without coloring matter shall first be applied, after which all holes, cracks, knots, etc., shall be stopped with the specified putty.

17.2.6 PAINT

Paint and varnish shall be of an approved make and quality, ICI, Berger, Nippon or equivalent as approved by the Engineer-in-Charge.

17.2.7 PAINTING

i) Paints shall be applied with proper brushes of approved quality or spraying machine as specified..

ii) Paint shall be constantly stirred, while it is being applied. It shall be stirred with a smooth stick and under no circumstances with a brush.

iii) When more than one coat has to be given, every coat must be completely dry, rubbed and all dust removed before the next is applied.

iv) Each coat shall differ slightly in tint from the preceding one, to distinguish quickly between each coat. The last coat shall be of the tint required for the finished work.

v) Each coat shall be approved by the Engineer-in-charge before the next is applied.

vi) All coats shall be applied evenly and properly so that the work does not show any hair or brush marks or drops of paints. The method of crossing and laying off shall be normal applied, the latter in the direction of grains in the case of wood work.

vii) Paints, when not in use, shall be kept away from the air. The surface of the kegs of ground and mixed paints which have been partly used shall be covered.

viii) Drop cloths shall be placed to adequately protect all finished work.

17.2.8 MEASUREMENTS

The length and breadth shall be measured correct to a cm. The area shall be calculated in sqm (correct to two places of decimal), except otherwise stated. Small articles not exceeding 10 sq. decimetre (0.1 sqm) of painted surfaces where not in conjunction with similar painted work shall be enumerated.

Note : Components of trusses, compound girders, stanchions, lattices and similar work shall, however, be given in sq. metres irrespective of the size or girth of members. Priming coat of painting shall be included in the work of fabrication.

In measuring painting, varnishing, oiling etc. of joinery and steel work etc. The factors as indicated in 17.16.3 shall be used to obtain the area payable. The factors shall be applied to the areas measured flat and not girthed.

17.3 PAINTING NEW WOOD WORK

17.3.1 PREPARATION OF SURFACE

i) PLANING AND RUBBING:

Unless otherwise specified wood work to be painted shall be finished smooth with the plane, but free from plane marks of every kind and rubbed smooth with sand paper, first with 2-1/2 grade and then with 1-1/2 grade or pumice stone.

ii) KNOTTING:

After rubbing all knots in the wood it shall be killed or covered with:-

a) Two coats of patent knotting (shellac dissolved in naptha) or

b) Shellac varnish (5 oz shellac mixed with 1 pint of methylated spirit of vine thoroughly dissolved and stirred with 1/2oz red lead) or

c) A preparation of red lead and glue size in equal weight applied hot. Knots in deodar or other resinous wood shall be painted over with hot lime. This paint shall be scraped off after 24 hours, the knots primed with red lead and glue laid hot. Then one coat of knotting varnish shall be applied.

iii) RUBBING:

After knotting, the surface shall be rubbed again with pumice stone, or fine sand paper before the priming coat is applied.

iv) PRIMING OR FIRST COAT OF PAINT:

All new wood work shall be properly primed before being fixed in position. The priming paint shall be of type and make as specified. Alternatively it shall be prepared by mixing the following ingredients:-

a) For inside work (except in white and very pale shade):

1.	White lead	10 Lbs.
2.	Red lead	¼ Lbs.
3.	Boiled linseed oil	4 pints
4.	Raw linseed oil	2 pints
5.	Turpentine	1 pint

b) For outside work:

1.	White lead	10 Lbs.
2.	Red lead	¼ Lbs.
3.	Balled linseed oil	4 pints
4.	Raw linseed oil	2 pints
5.	Turpentine	1 pint

c) For white or light shade:

1.	White lead	16 Lbs.
2.	Lamp black	½ Lbs.
3.	Raw linseed oil	5 pints
4.	Turpentine	1 pint

d) Genuine white lead:

1.	Genuine red lead	7 Lbs.
2.	Boiled linseed oil	7 Lbs.
	or	
1.	White lead	15 Lbs.
2.	Red lead	0.30 Lbs.
3.	Litharge (Drier)	0.30 Lbs.
4.	Linseed oil	6.50 pints

The priming paints shall be applied either by brushes or by spraying machines as specified.

v) STOPPING:

After priming, all holes, cracks, gapping joints and similar other defects shall be stopped with approved putty made from pure whiting mixed to the proper consistency with raw linseed oil. A little white lead shall be worked in after mixing to help the hardening of the putty.

17.3.2 SECOND AND SUBSEQUENT COATS

Unless otherwise specified, second and subsequent coats shall be applied as per Specifications No. 17.2 for Painting (General).

17.3.3 MEASUREMENTS

The length and breadth shall be measured correct to a cm. The area shall be calculated in sqm (correct to two places of decimal), except otherwise stated. Small articles not exceeding 10 sq. decimetre (0.1 sqm) of painted surfaces where not in conjunction with similar painted work shall be enumerated.

Components of trusses, compound girders, stanchions, lattices and similar work shall, however, be given in sq. metres irrespective of the size or girth of members. Priming coat of painting shall be included in the work of fabrication.

In measuring painting, varnishing, oiling etc. of joinery and steel work etc. The factors as indicated in 17.16.3 shall be used to obtain the area payable. The factors shall be applied to the areas measured flat and not girthed.

17.4 REPAINTING WOODWORK

17.4.1 PREPARATION OF SURFACE

i) If the old paint is firm and sound the surface shall be rubbed with pumice stone and washed thoroughly with soap washing soda and water till all dirt grease projections and blisters, if any are removed and the surface is rendered smooth.

ii) Surfaces spoiled by smoke shall be cleaned by the application of a coat of 3 Lbs. Glue and 3 ozun slaked lime boiled in one gallon of water, unless otherwise specified.

iii) Greasy surfaces shall be cleaned by applying a coat of turpentine over them and then washing them with soap and water.

iv) When the old paint is in blistered cracked or perished condition, it shall be completely removed by burning off with a blow lamp or by means of a paint remover as specified or directed by the Engineer-In-charge. The blow lamp shall not be used on curved surfaces or surfaces adjoining glass, such as sashes etc. Care shall be taken that the wood surfaces are not charred.

v) When a ready-made paint remover of an approved quality is not available anyone of the following recipes shall be used, unless otherwise specified.

   a) Naptha shall be applied repeatedly till the paint has softened. The surface shall then be rubbed and cleaned.

   b) A coat of caustic soda (2 Lbs. of caustic soda to a gallon of water) shall be applied very carefully by means of a piece of cloth securely tied on one end of a long wooden stick. After a few hours of its application the surface shall be thoroughly washed with clean water and neutralized with a weak acid solution or vinegar. This paint remover shall be applied only when particularly specified and permitted by the Engineer-In-charge and shall not be touched by hand or allowed to come in direct contact with the wood.

c) One Lb. of country soda (sajji) shall be dissolved in hot water and mixed with lime stone reducing the whole to a creamy paste. The surface shall be coated with it and kept moist for at least 3 hours. If the lime used is un-slaked and the mixture is applied hot, the action shall be quickened.

d) One part of soft soap shall be mixed to two parts of potash and the mixture dissolved in boiling water. Four parts of lime shall then be added to it and applied (while it is hot) with a brush on the surface of the paint and left on for 12 to 18 hours.

e) Sodium carbonate or washing soda diluted with water cleans grease and fat from the old painted surface. One Lb. of washing soda shall be sufficient for one gallon of water. Hot water quickens the action of washing soda.

f) Two parts of quick lime shall be mixed with one part of washing soda and made to the consistency of a cream. A coat of this cream shall soften the painted surface.

g) A coat of this cream shall soften the surface.

1.	Palmatic acid (vegetable)	25 parts by weight
2.	Benzine	35 parts by weight
3.	Amyleaccerate	40 parts by weight

h) This solution shall be applied by brush.

1.	Caustic Soda	14 Lbs.
2.	Whiting	9 Lbs.
3.	Flour	2-1/2 Lbs.
4.	Petroluem	2-1/2 gallons
5.	Water	7 gallons

The solution shall be applied by any approved method on the surface.

(vi) After the paint has been removed the surface shall be rubbed smooth with sand paper, washed down and allowed to dry completely. It shall be wiped clean before paint is applied.

(vii) After rubbing all holes, cracks and other inequalities, the surface shall be properly stopped in the manner specified under “Painting New Wood Work”.

17.4.2 PAINTING

After preparing and treating the surface it shall be painted according to Specifications No. 17.3 for Painting New Wood Work.

17.4.3 OTHER RESPECTS

In all other respects it shall conform to Specifications No. 17.3 for Painting New Wood Work.

17.4.4 MEASUREMENTS

The length and breadth shall be measured correct to a cm. The area shall be calculated in sqm (correct to two places of decimal), except otherwise stated. Small articles not exceeding 10 sq. decimetre (0.1 sqm) of painted surfaces where not in conjunction with similar painted work shall be enumerated.

Components of trusses, compound girders, stanchions, lattices and similar work shall, however, be given in sq. metres irrespective of the size or girth of members. Priming coat of painting shall be included in the work of fabrication.

In measuring painting, varnishing, oiling etc. of joinery and steel work etc. The factors as indicated in 17.16.3 shall be used to obtain the area payable. The factors shall be applied to the areas measured flat and not girthed.

17.5 VARNISHING

17.5.1 PREPARATION OF SURFACE

i) New wood work to be varnished shall be finished smooth with the plane making sure that no marks are visible on the finished surface. It shall be rubbed perfectly smooth with sand paper or pumice stone.

ii) Knotting shall be done as specified under Clause 17.2 – Painting & Varnishing.

iii) STOPPING:

The surface of the wood shall be then stopped, with hot weak glue size (1 Lb. of glue making about 1 gallon of size) so as to close up the holes. The surface when it dries up shall be again thoroughly sand papered. After rubbing the surfaces another coat of the same glue size shall be applied cold.

iv) If the wood work is to be stained, the staining color shall be mixed with second coat of size which shall be applied regularly, evenly and quickly keeping the color on the flow.

v) If the wood work is of an oily nature, a little 'Multani Mitti' and ochre shall be added to the first coat of size (otherwise varnish would not dry readily)

vi) The sized wood shall then be rubbed with sand paper leaving the color even and rubbing, with the grain.

Varnish shall then be applied in very thin coats with a special fine-haired varnishing brush, and not with an ordinary paint brush. Unless otherwise specified, the best Copal varnish shall be used. If more than one coat have been specified the first coat shall be rubbed with the fine sand paper. Other coats shall be applied as directed by the Engineer-In-charge.

17.5.2 MEASUREMENTS

The length and breadth shall be measured correct to a cm. The area shall be calculated in sqm (correct to two places of decimal), except otherwise stated. Small articles not exceeding 10 sq. decimetre (0.1 sqm) of painted surfaces where not in conjunction with similar painted work shall be enumerated.

Components of trusses, compound girders, stanchions, lattices and similar work shall, however, be given in sq. metres irrespective of the size or girth of members. Priming coat of painting shall be included in the work of fabrication.

In measuring painting, varnishing, oiling etc. of joinery and steel work etc. The factors as indicated in 17.16.3 shall be used to obtain the area payable. The factors shall be applied to the areas measured flat and not girthed.

17.6 WAX POLISHING

17.6.1 SCOPE

Wax polishing shall be done where a dull polish, which shall not destroy the natural color and graining of teak or shisham, is required.

17.6.2 PREPARATION OF SURFACE

i) New wood work to be polished shall be finished smooth with the plane making sure that no plane marks are left after finishing.

ii) The surface shall be made perfectly smooth by rubbing it with sand paper or pumice stone.

iii) It shall then be stopped and rubbed perfectly smooth first with medium grained sand paper and then with fine sand paper. The final rubbing shall be done with sandpaper which has been slightly moistened with linseed oil and rubbed up-to required smoothness of surface.

17.6.3 PREPARATION FOR WAX POLISHING

The bee's wax polish shall be prepared by mixing two parts of bee's wax with two parts of boiled linseed oil over a slow fire. When it is dissolved, but is still warm, one part of turpentine shall be added.

17.6.4 FIRST COAT

Bee's wax polish as prepared above shall be applied with a clean cloth pad and rubbed continuously for at least half an hour.

17.6.5 SECOND COAT

When the surface is quite dry, the second coat shall be applied in the same manner and rubbed continuously for one hour, or till the surface has dried.

17.6.6 FINAL COAT

The final coat shall then be applied and rubbed for two hours (more if necessary), till the surface has assumed a uniform gloss and Is quite dry, showing no signs of stickiness when touched. The final polish depends largely on the amount of rubbing which shall be done continuously with uniform pressure and with frequent change in direction.

17.6.7 OTHER RESPECT

In all other respects it shall conform to Specifications No. 17.5for Varnishing.

17.7 FRENCH POLISHING (SPIRIT POLISH)

17.7.1 PREPARATION

Unless otherwise specified, the wooden surface to be polished shall be prepared according to the Specification 17.5.1 for Varnishing.

17.7.2 POLISHING

i) After the surface has been prepared it shall be first painted with filler composed of 5 Lbs. of whiting mixed with 1/3 of a gallon of methylated spirit and then rubbed with sand paper. A thin coat of the polish shall then be applied. The surface shall then be rubbed with sand paper before the second and subsequent coats are applied.

ii) Alternatively, plaster of Paris, red ochre (sufficient to tint it), and linseed oil are mixed together to form a stiff paste which shall be applied sparingly and rubbed hard on the surface to fill up the pores of the wood. Prior to this a piece of rag moistened with linseed oil shall be rubbed on the surface.

iii) The surface shall be rubbed smooth with fine glass paper a few hours later and then polished. .

iv) Unless otherwise specified, two coats of French polish of an approved type shall be applied.

v) To finish off, the surface shall be rubbed lightly and quickly with a circular motion by means of a piece of flannel rolled into the form of a rubber, covered with a piece of rag slightly damp with methylated spirit. If the rag sticks, the surface shall be touched with linseed oil.

17.7.3 OTHER RESPECT

In all other respects, it shall conform to Clause 17.5 for Varnishing.

17.8 OILING WOOD WORK

17.8.1 SCOPE

Wood work not exposed to weather shall be oiled with linseed oil or sweet oil preparations as specified.

17.8.2 LINSEED OIL PREPARATIONS

One Lb. of bee's wax shall be mixed with 3 Lbs. of boiled linseed oil and heated over a slow fire till the wax is melted. After the mixture has cooled one Lb. of turpentine oil shall be added.

17.8.3 SWEET OIL PREPARATION

Country sweet oil shall be mixed with equal parts of vinegar and turpentine oil and shaIl be employed where a darker effect is required or when particularly specified.

17.8.4 OILING

The specified oil preparation shall be applied after cleaning and allowed to soak

17.9 PAINTING WOOD WORK WITH SOLIGNUM OR CREOSOTE OR COAL TAR

17.9.1 QUALITY

Solignum, creosote or tar, whichever has been specified shall be of an approved quality.

17.9.2 HEATING AND PREPARING PAINT

i) Before applying Solignum /creosote/tar shall be heated to just short of boiling.

ii) If tar is specified it shall be thinned with kerosene oil or common country spirit in the following proportions:-

4 parts tar to 1 part kerosene or 1 gallon tar to 1/2 pint country spirit;

2 Lbs. un-slaked lime shall be mixed with 1 gallon of tar to, prevent its running

The mixture shall then be heated to a near boiling point.

iii) It shall be then applied with a stiff flat brush or a spraying machine as specified and approved by Engineer-in-Charge.

iv) The paint shall be stirred occasionally while it is being applied.

v) The ends of the timber pieces shall be liberally coated and, where possible dipped in the hot solignum or creosote.

vi) Where more than one coat has to be applied subsequent coats shall be applied when the previous one has dried.

17.9.3 MEASUREMENTS

The length and breadth shall be measured correct to a cm. The area shall be calculated in sqm (correct to two places of decimal), except otherwise stated. Small articles not exceeding 10 sq. decimetre (0.1 sqm) of painted surfaces where not in conjunction with similar painted work shall be enumerated.

Components of trusses, compound girders, stanchions, lattices and similar work shall, however, be given in sq. metres irrespective of the size or girth of members. Priming coat of painting shall be included in the work of fabrication.

In measuring painting, varnishing, oiling etc. of joinery and steel work etc. The factors as indicated in 17.16.3 shall be used to obtain the area payable. The factors shall be applied to the areas measured flat and not girthed.

17.10 PAINTING IRON WORK ABOVE WATER

17.10.1 WEATHER

i) Painting of iron work shall not be done in damp wet, stormy or extremely hot weather.

ii) Too quick drying in the baking heat of a summer sun shall also be avoided.

17.10.2 PREPARATION OF SURFACE AND APPLICATION OF PAINT

i) If the iron has not been painted previously it shall be thoroughly cleaned of all rust and scale by means of steel scrapers, chisels, or steel wire brushes till the bright shining surface of the iron appears.

ii) The surface shall then be cleaned with dry cotton waste and the paint applied immediately.

iii) Each small patch shall be painted as soon as cleaned if the painting is being done in damp weather since Iron begins to rust within a few minutes after it has been cleaned.

iv) In repainting Iron work whose old paint is sound, the surface shall be rubbed with wire brushes and scrapers and all loose paint that comes away shall be taken off. If the paint in a bad condition it shall be burnt off with a blow lamp or by other means as specified.

vi) If it is necessary to paint galvanized iron, a coat composed of eight ounces of copper acetate added to a gallon of water shall be applied first. Unless otherwise specified the first coat of paint shall be composed of genuine red lead mixed with raw linseed oil and turpentine in equal proportion.

vi) Second and subsequent coats shall be applied more uniformly with the paintbrush in long strokes evenly drawn or with a spraying machine as specified.

vii) Sufficient time shall be allowed between the coats to allow the paint to dry up. Unless otherwise specified an interval of 24 hours shall be sufficient.

17.10.3 NUMBER OF COATS

i) On new work three coats shall be applied but on old work it is sufficient to have two coats only.

ii) Each coat shall preferably vary slightly from the preceding one in shade, in order to ascertain that full number of coats has actually been applied.

17.10.4 PAINTS

The paint used shall be as given in BOQ or approved by the Engineer-in-Charge.

17.10.5 MEASUREMENTS

The length and breadth shall be measured correct to a cm. The area shall be calculated in sqm (correct to two places of decimal), except otherwise stated. Small articles not exceeding 10 sq. decimetre (0.1 sqm) of painted surfaces where not in conjunction with similar painted work shall be enumerated.

Components of trusses, compound girders, stanchions, lattices and similar work shall, however, be given in sq. metres irrespective of the size or girth of members. Priming coat of painting shall be included in the work of fabrication.

In measuring painting, varnishing, oiling etc. of joinery and steel work etc. The factors as indicated in 17.16.3 shall be used to obtain the area payable. The factors shall be applied to the areas measured flat and not girthed.

17.11 PAINTING IRON WORK WHICH REMAINS UNDER WATER

17.11.1 SCOPE

i) Unless otherwise specified, the surface shall be prepared according to Clause 17.10.2 for Painting Iron Work above Water.

ii) The paint shall be applied hot as soon as the surface is cleaned;

ii) Subsequent coats shall be applied only after the previous one has dried.

17.11.2 PAINTING MATERIAL

Unless otherwise specified, khanki mixture or any other approved paint shall be used.

17.11.3 NUMBER OF COATS

Two to three coats as actually specified shall be given

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17.11.4 PROTECTION

Work thus painted shall not be immersed in water until it has dried up; one week shall be generally sufficient for this purpose depending upon the weather.

17.11.5 OTHER RESPECT

In all other respects not specified here it shall conform to Clause 17.10for Painting Iron Work Above Water.

17.12 COAL TARRING IRON WORK

17.12.1 PREPARATION OF SURFACE

i) The surface to be coal-tarred shall be cleaned off all dust, rust, scale and grease, etc.

ii) It shall be dry and clean.

17.12.2 HEATING AND PREPARING TAR

To each gallon of tar 2 Lbs. of un-slaked lime shall be added and the mixture heated till it begins to boil. Then it shall be taken off the fire and kerosene oil added to it slowly in the proportion of 1part of kerosene to 4 parts of tar.

17.12.3 APPLICATION

i) Tar shall be applied as hot as possible with a brush. On no account rags shall be used for applying tar.

ii) Where possible the article to be tarred shall be dipped in the hot tar.

17.12.4 OTHER RESPECTS

In all other respects the painting shall conform to the relevant parts of the Clauses 17.10 & 17.11 for Painting Iron Work.

17.13 PAINTING PLASTER

17.13.1 GENERAL

i) Unless otherwise specified or directed in writing by the Engineer-in-charge, a plastered wall shall not be painted till 12 months, have elapsed since plastering work was completed.

ii) In the absence of special primers and wall paints, the plastered surfaces shall be prepared, and painted as specified below:

17.13.2 PREPARATION OF SURFACE

i) All loose and flaking material shall be removed from old walls by scraping or wire brushing and the surface shall be carefully smoothed and cleared.

ii) All dust, dirt, oil grease or efflorescence shall be carefully removed.

17.13.3 PRIMING COAT

i) Having prepared the surface a priming coat composed of equal parts of white and red lead mixed in boiled linseed oil that shows easy brushing, good flowing and spreading and good leveling properties shall be applied. Coats that have shown poor or fair spreading and leveling properties will not be acceptable.

ii) When the priming coat dries up all crack holes and such other defects shall be filled up with a mixture of 1 part white lead and 3 parts ordinary putty.

iii) The surface shall then be rubbed with pumice stone or sand paper and dusted clean.

17.13.4 SECOND AND THIRD COAT

i) Second coat shall consist of the paint as specified. In the absence of such specifications a mixture of white lead and linseed oil shall be applied.

ii) Third coat shall consist of the paint as specified. In the absence of such specification it shall consist of white lead tinted to approach the desired color and mixed with raw linseed oil as a carrier and a small proportion of turpentine as drier.

17.13.5 FOURTH OR FINISHING COAT

The finishing coat shall consist of paint as specified. In the absence of such specification, it shall consist of a large proportion of turpentine with a little varnish to serve as a binder and applied when the previous coat is still sticky and shall be evenly stippled over the surface with a stippling brush so as to dry flat with a velvet-like surface.

17.13.6 TREATMENT OF NEWLY CEMENT PLASTERED SURFACE

i) In case it has been specified or directed in writing by the Engineer-In-charge to paint a newly cement plastered surface without waiting for 12 months a solution of 5 Lbs. of zinc sulphate dissolved in a gallon of water, shall be applied to the surface and when It dries up a coat of pure raw linseed oil shall be given.

ii) Alternatively, the surface shall be treated with dilute sulphuric acid or hydrochloric (one part acid to 50 parts water) and then washed down with water.

iv) Unless otherwise specified or directed in writing by the Engineer-In-charge, after treating the surface, two coats of paint thinned with turpentine and having a little varnish as a binder, shall be applied.

v) The third coat of the specified paint shall be thinned with a mixture of three parts of boiled linseed oil to one part of turpentine.

vi) The fourth and finishing coat shall be given as specified in Clause 17.13.5.

17.14 PLASTIC EMULSION PAINT

The plastic emulsion Paint is not suitable for application on external, wood and iron surface and surfaces which are liable to heavy condensation. These Paints are to be used on internal surfaces except wooden and steel. Plastic Emulsion Paint of approved brand and manufacture and of the required shade shall be used.

17.14.1 PAINTING ON NEW SURFACE

The surface shall be thoroughly cleaned and dusted off. All rust, dirt, scales, smoke splashes, mortar droppings and grease shall be thoroughly removed before painting is started. The prepared surface shall have received the approval of the Engineer-in-Charge after inspection, before painting is commenced.

17.14.1.1 APPLICATION

The number of coats shall be as stipulated in the item. The Paint will be applied in the usual manner with brush, spray or roller. The Paint dries by evaporation of the water content and as soon as the water has evaporated the film gets hard and the next coat can be applied. The time of drying varies from one hour on absorbent surfaces to 2 to 3 hours on non-absorbent surfaces. Thinning of emulsion is to be done with water and not with turpentine. Thinning with water will be particularly required for the under coat which is applied on the absorbent surface. The quantity of water to be added shall be as per manufacturer’s instructions. The surface on finishing shall present a flat velvety smooth finish. If necessary more coats will be applied till the surface presents a uniform appearance.

17.14.1.2 PRECAUTIONS

(a) Old brushes if they are to be used with emulsion Paints, should be completely dried of turpentine or oil Paints by washing in warm soap water.

Brushes should be quickly washed in water immediately after use and kept immersed in water during break periods to prevent the Paint from hardening on the brush.

(b) In the preparation of wall for plastic emulsion painting, no oil base putties shall be used in filling cracks, holes etc.

(c) Splashes on floors etc. shall be cleaned out without delay as they will be difficult to remove after hardening.

(d) Washing of surfaces treated with emulsion Paints shall not be done within 3 to 4 weeks of application.

17.14.2 PAINTING ON OLD SURFACE

17.14.2.1 PREPARATION OF SURFACE

This shall be done, generally as specified in above except that the surface before application of Paint shall be flattened well to get the proper flat velvety finish after painting.

17.14.2.2 APPLICATION

The number of coats to be applied shall be as in description of item. The application shall be as specified above except that thinning with water shall not normally be required.

17.14.3 MEASUREMENTS

The length and breadth shall be measured correct to a cm. The area shall be calculated in sqm (correct to two places of decimal), except otherwise stated. Small articles not exceeding 10 sq. decimetre (0.1 sqm) of painted surfaces where not in conjunction with similar painted work shall be enumerated.

Note : Components of trusses, compound girders, stanchions, lattices and similar work shall, however, be given in sq. metres irrespective of the size or girth of members. Priming coat of painting shall be included in the work of fabrication.

In measuring painting, varnishing, oiling etc. of joinery and steel work etc. The factors as indicated in 17.16.3 shall be used to obtain the area payable. The factors shall be applied to the areas measured flat and not girthed.

17.15 PAINTING WITH SYNTHETIC ENAMEL PAINT

Synthetic Enamel Paint of approved brand and manufacture and of the required colour shall be used for the top coat and an undercoat of ordinary Paint of shade to match the top coat as recommended by the same manufacturer as far the top coat shall be used.

17.15.1 PAINTING ON NEW SURFACE

Preparation of surface shall be as specified in 17.4 as the case may be.

17.15.1.1 APPLICATION

The number of coats including the undercoat shall be as stipulated in the item.

(a) *Under Coat:* One coat of the specified ordinary Paint of shade suited to the shade of the top coat, shall be applied and allowed to dry overnight. It shall be rubbed next day with the finest grade of wet abrasive paper to ensure a smooth and even surface, free from brush marks and all loose particles dusted off.

(b) *Top Coat:* Top coats of synthetic enamel Paint of desired shade shall be applied after the undercoat is thoroughly dry. Additional finishing coats shall be applied if found necessary to ensure properly uniform glossy surface.

17.15.2 PAINTING ON OLD SURFACE

17.15.2.1 PREPARATION OF SURFACE:

Where the existing Paint is firm and sound it shall be cleaned of grease, smoke etc. and rubbed with sand paper to remove all loose particles dusted off. All patches and cracks shall then be treated with stopping and filler prepared with the specified Paint. The surface shall again be rubbed and made smooth and uniform.

If the old paint is blistered and flaked it will be necessary to completely remove the same as described in 17.4. Such removal shall be paid for separately and the painting shall be treated as on new surface.

17.15.2.2 PAINTING:

The number of coats as stipulated in the item shall be applied with synthetic enamel Paint. Each coat shall be allowed to dry and rubbed down smooth with very fine wet abrasive paper, to get an even glossy surface. If, however, the surface is not satisfactory additional coats as required shall be applied to get correct finish.

17.15.3 MEASUREMENTS

The length and breadth shall be measured correct to a cm. The area shall be calculated in sqm (correct to two places of decimal), except otherwise stated. Small articles not exceeding 10 sq. decimetre (0.1 sqm) of painted surfaces where not in conjunction with similar painted work shall be enumerated.

Note : Components of trusses, compound girders, stanchions, lattices and similar work shall, however, be given in sq. metres irrespective of the size or girth of members. Priming coat of painting shall be included in the work of fabrication.

In measuring painting, varnishing, oiling etc. of joinery and steel work etc. The factors as indicated in 17.16.3 shall be used to obtain the area payable. The factors shall be applied to the areas measured flat and not girthed.

17.16 MEASUREMENT AND PAYMENT

17.16.1 COMPOSITE RATE

The measurement and payment for the items of the work of Paints and Varnishing hereof shall be made corresponding to the applicable CSR items as provided in Contract Agreement and shall constitute full compensation, for procurement, transportation, performance in all respects and completion of work as specified including the site clearance as approved by the Engineer-in-Charge.

17.16.2 LABOUR RATE

The measurement and payment for the items of the work of Paints and Varnishing hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurement transportation, performance in all respects and completion of work as specified including site clearance, as approved by the Engineer-in-Charge except the cost of materials to be provided by Department at designated location as defined in the Contract Agreement.

17.16.3 SURFACE AREA

The area of one face doors, windows and partition etc. measured on flat surface shall be further multiplied by the following factors to give the total area for payment in case both faces are painted. In case only one face has been painted, the area paid will be half the area so obtained:-

a. Paneled framed, battened and braced or framed and battened or ledged and braced doors and windows. The area shall be multiplied by 2-1/4.
b. Doors and windows fully glazed. The area shall be multiplied by 1.
c. Partly glazed doors, windows and partitions. The area shall be multiplied by 2.
d. Iron bars or grills works. The area shall be multiplied by 1.
e. Doors and windows fixed with wire nettings;
f. If the wire netting is not painted. The area shall be multiplied by 1.
g. If the wire netting is paint. The area shall be multiplied by 1-1/4.
h. Partly wire netted doors and windows. The area shall be multiplied by 1-1/2.
i. Trellis work. The area shall be multiplied by 2.
j. Louvered or Venetian shutters and partitions. The area shall be multiplied by 3.
k. Balustrades. The area shall be multiplied by 1-1/2.

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18. LINING OF CANALS

18.1 SCOPE

This Section covers lining of earthen canal with a layer of any of the followings as specified on drawings and approved by the Engineer-in-Charge:

a) Asphalt/Bitumen spray
b) Clay Bricks or Clay Tiles
c) Concrete

The Contractor shall perform all associated the work as specified.

18.2 ASPHALT/BITUMEN MEMBRANE

18.2.1 Materials

a. Asphalt/bitumen grade 60/70 or as otherwise specified. The asphalt/bitumen is sprayed in place to form the impervious membrane.
b. Protective material like earth, gravel etc.

18.2.2 Formation Of Membrane

i. The thickness of Asphalt/bitumen membrane shall be as specified.

ii. The canal bed on which membrane is to be placed should be over excavated to allow the placement of membrane and protective material.
After rough excavation, the, surface is prepared for the application of asphalt by light dragging and rolling to obtain a relatively smooth surface in order to facilitate the laying of a uniformly thick and impermeable membrane. The rougher the sub-grade, the greater the quantity of asphalt required for satisfactory coverage.

iii. The special asphalt used for the membrane is prepared by the catalytic blowing of asphaltic materials. It has very low temperature susceptibility, a high degree of toughness, a resistance to tearing or breaking, and a long life. After the asphalt has been heated to approximately 400 ˚F, it is applied to the sub-grade under about 50 pounds pressure through spray nozzles, using either hand sprays or multiple spray bars mounted on the distributor. Holes or rough areas in the sub-grade can be adequately covered by the hand spray, though this method is somewhat slower. On the other hand, the distributor method is faster, and. therefore, more economical but can be applied satisfactorily only to reasonably smooth sub-grades.

iv. The hot-applied asphalt cools quickly and is soon ready for the application of the cover material. In fact, a few minutes after the application, the surface may be walked over by the construction personnel in covering operations. Since the purpose of the cover material is to hold the membrane in its place, and to protect it from the sunlight, water, wave wash, or livestock damage the kind and depth of cover material depend on factors like wave-action, water turbulence and velocity. Where water velocities are below one foot and a half per second, the soil removed from the canal in over-excavation may be used provided it is of reasonable stability. If soil from canal excavation is not suitable, material with greater cohesiveness (clay contents) and stability may be borrowed. In canals with very high water velocities, gravel blankets (usually of pit-run material) may be placed over the soil cover to depths between 3 and 6 Inches. Riprap is often used for areas below check structures or where turbulence is severe. Compaction of the cover material is not ordinarily required but may be advisable in some instances. The life of an asphalt-membrane lining largely depends on the maintenance of the cover which is subject to breaching and weeds growth. (Breaching may be defined as the erosion of the canal bank at the water surface resulting primarily from wave-action.)

v. The burled asphalt membrane lining with cover operates essentially as an unlined canal, plans for the location and extent of such treatment can be altered on new construction without affecting the design of the canal or structures. Accordingly final decisions on these matters may be deferred till sub-grade conditions are exposed by excavation.

vi. The membrane lining can be satisfactorily done both in cold and wet weather.

18.2.3 Measurement

Length and breadth shall be measured correct to a cm and area shall be calculated in square metres correct to two places of decimal. No deduction shall be made nor extra paid for voids not exceeding 0.20 sqm. Deduction for ends of dissimilar materials or other articles embedded shall not be made for areas not exceeding 0.10 sqm.

18.3 BRICK OR TILE LINING

The work to be done under brick or tile lining consist of constructing brick lining or tile lining according to the locations, dimensions and details shown on drawings or directed by Engineer-in-charge in accordance with these specifications and Engineer's instructions.

18.3.1 Materials

All bricks or tiles, sand, cement and other materials required in constructing the brick or tile lining shall be furnished by the Contractor and be approved by the Engineer-in-Charge before use. Bricks, tiles, and mortar required in constructing the lining, and all operations of the Contractor in constructing brick lining, shall be in complete conformity with the applicable provisions set forth in the Section – 11 'Brickwork'.

18.3.2 Formation, Dressing & Preparation Of Sub-Grade

i. The Contractor shall prepare the surfaces of the sub-grade in manner that will provide a smooth and firm foundation for the brick/tile lining. The bottom and side slopes, including the surfaces of compacted embankments, shall be finished accurately to the lines, grades and dimensions shown on the Drawings or established by the Engineer-in-Charge.

ii. All excavation of the sub-grade beyond the lines of the underside of the brick lining shall be filled with suitable material, moistened if required, and thoroughly compacted to the prescribed lines and grades in accordance with the requirements of the Section-3 "Earthwork" or the Contractor may fill the over-excavated portion of the sub-grade with a mortar bedding consisting of one part Portland cement and six to ten parts sand, as approved by the Engineer-in-Charge.

iii. The entire surface on which, brick-lining is to be placed shall be sprinkled with water till the optimum moisture content for compaction is attained as determined by the Engineer-in-charge or his authorized representative. It shall be compacted by rolling. Rolling shall be performed by using a smooth cylindrical roller. Minimum of two passes of the roller over the sub-grade shall be required.

   Unless otherwise specified or directed by the Engineer-In-charge, the width of a roller drum shall not exceed 4 feet. The weight of the roller drum when fully loaded shall not be less than 50 pounds per linear inch of drum width. A roller may, consist of two adjacent drum units, provided that a flexible coupling between drums is used, and that the space between drums shall not exceed 12 inches. Single drum rollers shall overlap each roll by one half the width of the roller, and two drum rollers shall overlap each roll by one half width of the roller plus one foot. No earth filling shall be permitted after the rolling of the sub-grade, and over-excavated or low portion shall be filled with mortar at the expense of the Contractor.

iv. After compaction, the entire area to be brick lined shall be thoroughly sprinkled with water till the finished sub-grade has been penetrated to a depth of 6 inches. The water shall not be applied at the rate which will cause the sub-grade to be muddy or soft. The finished sub-grade shall be duly approved by the Engineer-In-charge or his authorized representative before any brick-lining is laid.

18.3.3 Profile Wall

Unless otherwise specified or directed in writing by the Engineer-In-charge, profile walls shall be constructed 15 feet centre to centre at right angle to the centre line of the channel on the side slopes and at 30 feet centers on the bed. A profile wall shall also be constructed parallel to the centre line at each toe of the canal side slopes. The final excavation, trimming and compaction of the section may be performed before or after the completion of the walls.

The profile wall shall be laid by means of a theodolite. The excavation of trench in bed and on slopes for construction of profile including disposal of excavated material shall be made in accordance with applicable provisions of Section 3 – Earthwork.

A cement sand mortar as specified shall be laid as plaster over finally finished surface in accordance with applicable provisions of Clause 15.1.5 – Plastering. The wall shall be constructed in accordance with the Provisions of the Section 11 - Brickwork.

18.3.4 Placing Of Lining

Unless otherwise specified, the placing of lining shall follow the sequence as given below:-

i. A layer of 1:10 cement sand hand mixed mortar shall be plastered over the finally finished sub-grade, having an average thickness of ½ inch for making up inequalities in the section.

ii. Immediately over it a 1-½ inches thick layer of 1:6 cement sand machine mixed mortar shall be laid. (The mortar used shall have a slump of ½ inch to ¾ inch) To ensure that the correct ,thickness of 1-½ inches is laid over the whole surface, precast cubes 1:6 cement sand mortar having each side of 1-½ inches shall be placed on 1:10 plaster at 4 ft centre to centre along the centre line and at right angle to the channel and at 4 ft. intervals. The cubes shall be left embedded in the mortar with their tops flush with the surface.

iii. The 1:6 mortar layer shall be lightly rammed with wooden rammer and then trowelled to level out irregularities in the surface. The surface shall be rammed again with wooden rammer having ½ inch long spikes with round ends to make indentations.

iv. A 3/8 inch thick layer of 1:3 cement sand machine mixed mortar shall be placed over the 1:6 cement sand base. (The mortar used shall have a slump of 2 inch). To ensure an even thickness, the 1:3 mortar shall be laid in strips 4 feet wide with the help of thin laths 1-½" x 3/8" and about 18 feet long laid on the 1:6 cement sand base. The 1:3 mortar shall be spread with a trowel and leveled with a straight edge flush with the top of the lath. A day after the mortar is laid, it shall be lightly scraped with the wire brushes.

v. The next and final layer shall consist of the brick/tiles. The courses shall be marked on the profile walls and the string shall be stretched to keep them straight. Brick tiles to be laid on slopes shall be laid from bottom to the top of side slopes. The laying of the brick/tiles shall commence from the profile wall at the tangent point. The bricks/tiles shall be laid in the 1:3 cement sand machine mixed mortar. The thickness of the mortar bedding under the bricks/tiles shall be 1/8 of an inch and the vertical joints between the bricks/tiles shall be ¼ of an inch thick. All the joints shall be properly filled and to achieve this, the mason shall apply mortar to the sides of the bricks/tiles already laid, lay the next brick/tiles 1 inch to 2 inch away and then press it towards the first brick/tile squeezing out the mortar which would indicate that that joint has been filled. Before the bricks/tiles are laid they shall be soaked in water for at least 24 hours in soaking tanks. The mason shall have with him kerosene oil tin containing water, and the bricks/tiles from soaking tanks shall be placed in these tins. The mason shall use bricks/tiles only from these tins for his immediate requirements. Strict supervision shall be exercised to see that no un-burnt bricks/tiles are placed in the soaking tank and used.

vi. The joints of the work done on the previous day shall be tested with a broad chisel pointed 5/8 inch diameter iron bar. The hollow joints shall be marked with coal tar raked out and filled with the 1:3 cement sand mortar immediately. The brickwork shall be finally brushed and cleaned.

18.3.5 Curing

Curing of each layer of the following work is necessary.

a. Profile Wall
b. Sub-grade 1-½ inch thick cement sand 1:10 mix

c. Sub-grade 1-½ inch thick cement sand 1:6 mix
d. Sub-grade 3/8 inch thick cement sand 1:3 mix.

During summer, curing shall be start three hours after the completion of each layer and during winter the very next day. Curing can be done by covering the sprinklers, porous hoses or pucca drains constructed along the top of the bank.

The overflow of water shall be affected by a man going along the drain and pushing water by a wooden rod, dipped in the drain: The watering of work shall be carried out on the following lines:

i. **Profile Walls:**
A day after the walls are built, they shall be covered with jute cloth which is soaked by sprinkling water by hand, till curing can be started from the drain when ready.

ii. **Cement Sand Plaster 1: 10:**
A day after the mortar is laid, it shall be kept wet by sprinkling water by hand, till it is covered by the 1:6 cement sand base.

iii. **Cement Sand Base 1:6:**
A day after the 1:6 cement sand base is laid, the drain on its top shall be ready and the layer shall be kept thoroughly wet by overflow from this drain. Prior to the completion of the drain and putting it into operation the layer shall be kept wet by sprinkling water by hand.

iv. **Cement Sand Mortar 1:3:**
A day after the 1:3 cement sand mortar is laid. It shall be kept soaking wet by water being made to overflow from the drain.

v. **Brick Masonry:**
A day after the masonry is laid it shall be kept wet for 28 days by water being made to over flow from the drain.

18.3.6 Pneumatically Applied Mortar Lining

Pneumatically applied mortar shall consist of a mixture of Portland cement, sand, and water placed under pneumatic pressure. One part, by weight, of cement will be used with 4.5 parts, by weight, of surface dry sand.

The Contractor shall provide such means and equipment as are required to control accurately the relative amounts of cement, sand, and water entering the mortar. The equipment and its operation shall be subject to the approval of the Engineer-in-Charge.

The mortar shall be proportioned on the basis of integral sacks of cement, and the amount of sand shall be determined by direct weighing. The amount of water used shall be that required to produce mortar of suitable consistency, quality, and uniformity with the minimum rebound.

Fine aggregates shall conform to the requirements of ASTM C-33. Aggregate for air blown mortar may consist of not more than 30% pea gravel with a maximum nominal size less than 3/8 inches.

18.3.7 Placing Pneumatically-Applied Mortar Lining

All canal gates, pumps and appurtenances shall be properly covered and protected with viscuine prior to the placement of the concrete lining.

All absorptive surfaces against which pneumatically applied mortar is to be placed shall be moistened thoroughly. Free water will not be permitted on the surface during the application. Ground wires shall be installed in the canal prism to outline the finished surface of the lining as shown on the plans or as directed by the Engineer.

The mortar shall be applied from a nozzle held approximately four feet (4') from the surface, and in a stream as nearly perpendicular to the surface being covered as practicable.

The pressure in the placing machine shall be maintained at not less than forty-five pounds per square inch (45 psi) for hose lengths up to one hundred feet (100') and shall be increased five pounds per square inch (5 psi) for each additional fifty feet (50') of hose. Water pressure shall be maintained at least fifteen pounds per square inch (15 psi) greater than the pressure in the placing machine.

Sand pockets shall be removed and replaced with pneumatically applied mortar as herein specified. Rebound shall not be incorporated in the work in any manner.

Construction joints shall be sloped to a thin edge and the edge shall be thoroughly cleaned and wetted before the adjacent section of mortar is placed.

18.3.8 Measurement

Refer section 11

18.4 CONCRETE LINING

The work to be done under concrete lining, consists of constructing concrete lining according to the detail and as per locations shown on the drawings or designated by Engineer-in-charge in accordance with these specifications and the Engineer-in-charge's instruction.

18.4.1 General

i. Prior to the laying of concrete for canal lining: whether with Precast or cast in-situ Concrete, the Contractor shall ensure that the bottoms and sides of the excavated canal section are well compacted, trimmed and ready for the lining operation. In the event of failure to do so; any defects resulting in settlement, slips or bulges of concrete, the Contractor shall rectify the same at his own expense' by removing the concrete lining, compacting, trimming and relining the canal to the satisfaction of the Engineer-in-Charge.

ii. Profiles and concrete lining shall be constructed to the best standards of workmanship obtainable, and any objectionable irregularities, fins and offsets in the lining shall be removed by the Contractor.

iii. All bends in canal alignments shall be effected by means of smooth curves, the radius at the center-line of which shall not be less than twice the bed width of the canal.

iv. The concrete for canal lining shall be unreinforced 1:3:6 (3000 psi 6 inch x 12 inch cylinder strength).Where in-situ concrete lining is shown in the contract Drawings to be reinforced, a layer of steel fabric reinforcement shall be laid prior to the placing of the concrete.

18.4.2 Materials

i. Sand, cement, coarse aggregates and water conforming with provision of Section-5 Plain and Reinforced Concrete required in constructing concrete lining shall be furnished by the Contractor and be approved by the Engineer-in-Charge.

ii. Cement, Sand and aggregate used in constructing the lining shall be furnished by the Contractor in accordance with the provisions of and complete conformity with the stipulations and requirements specified in the Section 5 – Plain & Reinforced Concrete. Bricks and mortar required in constructing the profile walls and all operations of the Contractor in constructing those shall be in complete conformity with the applicable provisions set forth in the Section 11 – Brickwork.

iii. Admixtures: The Contractor may use an air entraining agent conforming to the requirements of ASTM Designation C-260 in all concrete as per direction of Engineer-in-Charge. The amount of air entraining agent, if used, shall be such as will affect the entrainment of four to six percent (4%-6%) of air, by volume of the concrete at the time of discharge from the mixer. The Contractor may use a pozzolan conforming to the requirements of ASTM Designation C-618 or a liquid admixture with pozzolan characteristics in accordance with ASTM Designation C-494.

18.4.3 Formation, Dressing & Preparation Of Sub-Grade

i. **Common Soils**.

Although the same specifications and precautions shall apply as described in case of brick lining, however, the sub grade shall be compacted to 95% of Laboratory maximum dry density determined by Standard Proctor test or the 70% relative density depending upon type of material. The compacted Sections should extend not less than 2 feet below the final grade measured perpendicular to the surface of canal prism.

ii. **Special Soils**

In case of special soils, following further clauses shall apply

a**) Predominantly Sandy Reaches**

When canal is in cutting in predominantly sandy reaches, compaction of subgrade shall be done as follows:

Consolidation of the bed shall be done by over-saturating the bed by flooding it with water before lining is laid; Consolidation of sides shall be done by over cutting the sub-grade by 6 inches and refilling it. With granular material stabilized with not less than 50% cement (measured by volume) and compacted by vibro-compaction.

b) Expansive Soils.

When dry bulk density of natural soil is less than 1.89 kg/cm3 (68 Ibs/in3) or the soil is of expansive nature, any of the practices detailed below shall be adopted (depending on swelling properties of the soil encountered).

If the expansive clay is in a thin layer or is in small pockets in an otherwise suitable sub grade, it shall be over excavated and replaced with a selected granular material properly compacted to a depth of 40 cm. If swelling of the clay encountered can be controlled by loading the surface with a non-expansive soil or gravel, the expansive clay bed shall be over excavated to depth of about 40 cm and filled to the grade of underside of the lining with good drainage material leading away the seepage water from the canal, to be released in to the canal again, through suitable pressure relief valves. The excavated surface of expansive clay shall be covered by polythene sheeting to prevent the entry of water into the clay.

c) Soils with High Gypsum Contents.

If Gypsum ($CaS0_4.2H_20$) is in high percentage in the soil and comes in contact with water, it dissolves causing cavities in the soil and damage to the structures by differential settlements.

Effective protective measures shall be taken to prevent gypsum coming in contact with water for making the concrete lining water proof, either by plastering the surface or placing a compacted layer of selected clay material under the lining or provide a flexible type membrane of Butyl or PVC etc,. Efficient drainage system may also be required to rapidly remove water that gets under the lining. The work shall be carried out as per the drawings and direction of the Engineer-in-Charge.

The Contractor shall rework the area which fails to meet specification requirement as above for common and special soils.

iii. **Tolerance limits of Sub-grade**

The previously compacted ground and embankments shall be trimmed within the following tolerances from given alignment.

a) + 20 mm on straight sections.
b) + 50 mm on tangents and partial curves.
c) + 100 mm on 90 degree curves.
d) + 20 mm from established grade.

e) After trimming, the sub grade shall be kept moist by intermittent fine spraying with water, prior to the lining operation. The period between trimming and lining shall not exceed 72 hours.

iv. **Sub-grade Plaster**

Unless otherwise specified 13 mm thick plaster cement sand mix (1:10) shall be carried out on well prepared sub-grade. The plastered surfaces shall be subjected to curing with water for 24 hours before concrete lining is done. Sub grade preparation and the cement plastering above it shall be performed for enough length in advance, as directed by the Engineer-in-Charge, to avoid delay of the lining operations. The surface of sub grade shall be true to level and according to the specified cross section (of the canal) to form a firm compacted bed for lining, However, if at any point, material of sub grade has been excavated beyond the neat lines required to receive lining, the excess excavation shall be filled with material to be specified/directed by the Engineer-in-Charge to make it compatible with sub grade material and thoroughly compacted. After compaction, the entire area on which concrete lining is to be laid shall be thoroughly sprinkled with water till the finished sub grade has been penetrated to a depth of nearly 150 mm Then finished sub-grade shall be duly approved by the Engineer-in-Charge.

18.4.4 The Concrete Mix

The concrete in principle shall be produced in accordance with applicable provisions of Section 5, Plain & Reinforced Concrete.

The concrete mix shall conform to the mix design specified in the Drawings. Concrete used in Canal Lining, as a general principle, shall be so mixed that it is firm enough to stay in place on the side slopes. The net water-cement ratio of the concrete (exclusive of water within or absorbed by the aggregates) shall range from 0.53 to 0.58 based on the climatic temperature. Temperature of concrete when it is placed shall not be more than 32 degree C and not less than 5 degree C. Tests of the concrete shall be made by the Engineer-in-Charge, for the purpose of checking workability, density, impermeability, durability and strength. The Contractor shall maintain arrangements for testing of concrete.

Thickness

Unless otherwise specified, the thickness of concrete shall conform to the approved design/drawings.

Thickness of Lining Suggested by USBR (United State Bureau of Reclamation)

Lining Type	Thickness (inch)	Discharge (cfs)
Unreinforced Concrete	2.00	0-200
	2.50	200-500
	3.00	500-1500
	3.50	1500-3500
	4.00	>3500
Asphaltic Concrete	2.00	0-200
	3.25	200-1500
	4.00	>1500
Reinforced Concrete	3.50	0-500
	4.00	500-2000
	4.50	>2000

18.4.5 Placing Concrete

a) General

Before Commencement of Operations of Concrete Lining of Canal, the Contractor shall submit a complete method statement for performance of the work.

b) Conventional Method

(i) Placing of concrete shall be started after all formwork, installation of parts to be embedded and preparation of surfaces upon which concrete is to be laid, have been completed. All absorptive surface against which concrete is to be laid shall be moistened thoroughly so that moisture shall not be withdrawn from freshly placed concrete, the surfaces, however shall be free from standing water and mud. The concrete shall unless otherwise approved by the Engineer-in-Charge be mixed in a mechanical mixer.

(ii) Concrete shall be placed and properly compacted to the satisfaction of the Engineer-in-Charge. The arrangements are to be such that the material may be conveniently handled and placed in the required position without re-handling or segregation in panels of 3m on either side with joints at specified places in between. A slump of 6 cm to 7 cm shall be allowed. Wherever possible .the concrete is to be deposited from bottom-opening skips; it shall not be delivered by chute or dropped from burrows or otherwise through a greater height than 1.2 m, except with the approval of the Engineer-in-Charge who may order the concrete to be dropped on to a bunker and turned over by hand before being placed.
The lining shall normally be placed first on the bed and then on sides. Where site conditions require laying of lining on sides first, it shall be supported on toe walls. The concrete shall be dumped and spread on the sides and bottom of the channel in panels of not more than 3 m on either side with joints at specified places in between. Before laying the concrete, precast or cast-in-situ, concrete bed sleepers shall be placed under the joints to serve as templates to reduce seepage through the joints and accurate dressing of the sub-grade. For placing of concrete on slopes, the use of a weighted vibrated steel faced slip-form screed in the advancing direction of the concrete pour, shall be supported directly on the sub-grade and operated longitudinally along it. This method of placing shall generally be adopted for moderately large canals. For larger canals and for better economy, longitudinally operated slip forms supported on rails placed on berms of the canal shall be adopted.

(iii) The surface on which concrete is to be deposited must be made and maintained free from standing water during concreting operations unless otherwise approved. Running water crossing or entering such areas must be brought under control to the satisfaction of the Engineer-in-Charge before concreting proceeds.

(iv) All construction joints are to be shuttered square to the work. Keyways are to be formed in all horizontal and vertical construction joints except where ordered to be omitted by the Engineer-in-Charge.

(v) All concreting shall be carried out in sections previously ordered or approved by the Engineer and shall proceed continuously in each section until completed and no interval shall be allowed to elapse while the work is in hand.

c) Placing Machine Made In-situ Lining.

For placing Machine Made In-situ lining, the Contractor shall use a construction train for laying the concrete canal lining which shall consist of mechanical trimmer: slip form paver and platforms for lining construction, for cutting and filling contraction joints and for applying curing compound. All lining machinery shall have been built by a reputable manufacturer and evidence of satisfactory operation of similar equipment under similar conditions shall be provided.
While trimmers and slip form pavers are used a qualified and experienced foreman provided by the manufacture: shall remain in attendance. The Engineer-in-Charge

will not permit construction of lining to commence unless he is satisfied that there is a sufficiency of back up plant (e.g. concrete dump trucks) for the lining to progress without significant interruption.

It shall also be ensured that all the operators and mechanics are trained and experienced in such equipment's. Sample lengths of canal lining shall be constructed in advance so that the Engineer-in-Charge may consider and approve the method of working which the Contractor proposes to employ and the quality of lining to be achieved.

d) Finishing

Unless otherwise specified or as directed by the Engineer-in-Charge, the surface of concrete shall be finished smooth and free from projections, honey combing and other objectionable defects. All unsightly 'ridges or lips shall be removed and undesirable local bulging shall be remedied by tooling and rubbing. Repairs to concrete surfaces and additions, where required, shall be made by cutting regular openings into the concrete to the required lines. The fresh concrete shall be trowelled to the surface of the opening.

Deviations from true line and grade shall not exceed one-tenth foot (0.1'). There shall be no abrupt changes in section, line or grade.

Transverse grooves, three-quarter inch (3/4") deep and approximate one-half inch (½") wide, shall be made in the concrete lining. The first groove shall be made ten feet (10') from the end of the lined section and at ten-foot intervals throughout the full length of the lined section

18.4.6 Precautions

(i) **No Partially Set Material to be used**

All concrete and mortar must be placed and compacted within 30 minutes of its being mixed unless otherwise approved; no partially set material shall be used in the work.

(ii) **Unsuitable Weather**

No concreting shall be allowed in the open during storms or rains. All concreting materials and plant are to be adequately protected against the effect of storms and rains.

All Concrete lining irrespective of whether pre cast or cast-in-situ, shall be laid in the dry. The Contractor shall provide sufficient pumping equipment to ensure that any dewatering that is required is effectively carried out.

18.4.7 Curing and Protection

(i) The concrete shall be covered with hessian cloth and kept watered and continuously damp for a minimum of seven days after placing or for such time as the Engineer-in-Charge may direct. Other methods of preventing the water of hydration in the concrete from evaporating may be used with the approval of the Engineer-in-Charge. After a period of 24 to 36 hours, the lining shall be cured for at least 28 days. On bed this shall be done by constructing 15 cm deep earthen bunds across the bed so that a small depth of water shall stand on the bed. The curing of side slopes shall be done by constructing masonry drains on the berms with weep holes or perforated pipes installed on the berms or by sprinklers. Curing compound SIKA or equivalent may be used if specified. The curing compound should be conforming to ASTM C-309.

(ii) Concrete shall be protected wherever practicable from the direct rays of the sun during the curing period.

(iii) Precast concrete slabs used for canal lining shall be cast to the dimensions as shown in the Drawings. They shall be laid square, in straight lines and in a workmanlike manner, and shall be pointed or grouted with 1:2 cement sand mortar. Laying of the slabs shall commence from the bed working up the slopes. Wavy, crooked or irregularly laid slabs will not be accepted and the Contractor shall at his own expense remove and rectify the same to the satisfaction of the Engineer-in-Charge. The Contractor shall exercise all care and diligence in the handling of the concrete slabs. Broken and irregularly shaped slabs shall be rejected and removed forthwith from the site by the Contractor.

18.4.8 Joints

(i) Contraction joints, where specified shall be formed as deliberate planes of discontinuity in the concrete structure as opposed to construction joints where continuity has to be maintained. A Construction joint shall consist of saw cut 7 mm in width and (1/6th the thickness of Concrete in depth. Alternatively to form such as to join the face of concrete slab or block first formed shall be painted with two coats of approved rubber bitumen paint before the adjoining slab or block is concreted.

(ii) Expansion joints as detailed in the Contract drawing shall be formed in the same way as construction joints. Generally, these shall be 13 mm wide; 102 mm to 152 mm deep. Either an approved compressible sheet or filler shall be supplied and placed in the joint to provide freedom for two adjacent concrete slabs / blocks to expand or the joint shall be filled with bitumen, sand & saw dust in the ratio of 1:2:2 and shall extend to full depth of lining. In certain specified situations a highly compressible joint filler of foam rubber or other approved material shall be used. The exposed edges of the joint shall be sealed with an approved synthetic rubber or similar resilient sealing compound.

18.4.9 Under- Drainage / Pressure Relief Valves.

In stretches of concrete lined canals where a buildup of hydrostatic pressure is expected behind the concrete lining, thereby endangering their stability, the Contractor shall supply and fix pressure relief valves on the bed of the canals together with the appropriate graded filter material as shown in the Drawings. The Contractor shall be responsible for obtaining particulars of locations of pressure relief valves from the Engineer-in-Charge prior to the laying of the concrete lining.The provision of relief values shall be associated with construction of the proper grading and laying of the filter material as specified to ensure proper and effective performance of the relief valves. Any relief valve rendered ineffective as a result of the Contractor's negligence and improper grading and laying of the filter material shall be removed and made good at the Contractor's own expense.

18.4.10 Concrete Panel Inspection And Repair

After three days of curing, the concrete panels will be inspected by the Engineer-in-Charge. All visible cracks will be marked with a water-based spray paint and be given a rating of 0, 1, 2 or 3 based on its severity.

- Rating 0 (0” to less than 1/8” in width): Crack will be monitored for thirty (30) days after the placement of the concrete. Crack will not be repaired unless it expands to a rating of 1.
- Rating 1 (1/8” to less than 5/16” in width): Crack will be primed and sealed with an adhesive joint sealant. Crack will be properly prepared and primed for water immersion as directed by the joint sealant’s manufacturer.
- Rating 2 (5/16” to less than 1/2” in width): Crack will be repaired with properly sized and installed sealant backer rod, primer and adhesive joint sealant. Crack will be properly prepared and primed for water immersion as directed by the joint sealant’s manufacturer.

- Rating 3 (1/2” and greater in width): Concrete panel will be removed and replaced or repaired as directed by the Engineer.

The crack shall be clean, dry, frost-free and free of oil and grease. Curing compound residue and other foreign matter must be thoroughly removed prior to the application of the joint sealant primer. The air temperature at the time of application will be between 40º and 100ºF or as recommended by the sealant and primer manufacturer. All cracks shall be repaired and allowed to cure for one week prior to total water immersion.

18.4.11 Measurement:

Refer Section 5

18.5 MEASUREMENT AND PAYMENT

18.5.1 Composite Rate

The measurement and payment for the items of the work of Lining of Canals hereof shall be made corresponding to the applicable CSR items as provided in Contract Agreement and shall constitute full compensation, for procurement, transportation, performance in all respects and completion of work as specified including the site clearance as approved by the Engineer-in-Charge.

18.5.2 Labor Rate

The measurement and payment for the items of the work of Lining of Canals hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurement transportation, performance in all respects and completion of work as specified including site clearance, as approved by the Engineer-in-Charge except the cost of materials to be provided by Department at designated location as defined in the Contract Agreement.

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19. PROTECTION AND DIVERSION WORKS

19.1 SCOPE

a) The protection and diversion works shall consist of works that may be required to divert the river stream or currents and/or to adopt such measures as may be necessary to strengthen and protect an existing work or an embankment. Such river training and diversion works shall though consist primarily of constructing embankments and dykes, excavating cunnetts and placement of protective pitchings, mattresses, rolls, nevertheless may include certain anticipated works to be executed performed or administered by the contractor to the extent of which is unforeseen or is not capable of portrayal in the drawings at the time of issue of the order for execution.

b) The scope shall, however, include furnishing all labour, materials, plant, equipment, instruments, accessories and services necessary to complete the work in accordance with herein stated specifications, requirements and stipulations or as directed by the Engineer-in-Charge.

19.2 GENERAL

a) Whenever construction of cunnetts, earthen excavations, construction of earthen embankments or raising earthen dykes are required to be constructed, specifications and requirements detailed in Section 3,Earthwork shall be adhered to, unless such specifications/requirements have been specially modified by the Engineer-in-Charge.

b) All materials such as pilchi, ban, bamboo's etc. shall be fresh & new and other materials such as bags (whether of jute/gunny or cloth) & ropes, GI wire and Taranga’s etc. shall be new. They shall be produced by the Contractor for approval of the Engineer-in-Charge before use. Where specified, the old bags shall also be used.

c) The stone for dumping and pitching shall consist of natural rock, quarried from approved locations. The stone for pitching shall be well graded within the limits as specified.

d) Rock spalls shall be not more than 25% larger than 4 inches & not more than 5% smaller than 2 inches.

e) Base course under pitching stone shall be not more than 25% larger than 3 inches & not more than 10% shall be smaller than 2 inches.

f) Cement/Aggregates and water for concrete and mortar shall conform to the applicable provisions of Section 5 - Plain & Reinforced Concrete.

g) The specific gravity of stone materials should not be less than 2.6. The water absorption shall not exceed 6%.

h) The loss under Los Angles rattler test (ASTM Designation C-131) shall not exceed ten percent (10%), by weight at 100 revolutions or 40% by weight at 400 revolutions.

19.3 DIVERSION WORKS

19.3.1 GENERAL

The diversion works are needed to change the course of existing channel for some specific purpose or protection of existing structure.

All the materials required such as brushwood, pilchi / sarkanda, wooden trestles, ropes, mats/ tarpaulins, gunny bags, stones and earth for construction of bunds for diversion shall be collected at site before undertaking closing operation for diversion of flow. Also sufficient labour and dozing equipment shall be arranged and made available for the work.

19.3.2 OPERATIONS INVOLVED

a) The site for final closing of a channel for diversion shall be one, where depths are not too great and bed is comparatively firm. Also, earth for construction of the bunds is available close at hand. The site finally selected shall be demarcated by dag belling the alignment of the closure bund on dry ground on either side of the channel.

b) The diversion for closing or redirection of a running channel shall be started by dozing the piled earth from both ends simultaneously at the approved point of closing when the flow is at its lowest stage and completed quickly.

c) In the active part of the channel (where water may be flowing) the bunds shall be constructed between specially formed pilchi rolls to prevent wastage of earth by the flowing water.

d) The pilchi roll shall be prepared from freshly cut pilchi/sarkanda and shall be generally 1 ft. (0.3 m) in dia and 11.5 ft. to 13 ft.(3.5 m to 4 m) long. Also they shall be well compacted and tightly tied with coarse munj ban or binding wire of steel at 12 inches (30 cm) intervals.

e) Whenever, directed by the Engineer-in-Charge (as in case when discharge in the channel is about 56.70 cumecs(2,000 cusecs) or more, stones in wire crates, instead of trestles, shall be placed/tipped at some specified distance/alignment on the upstream of proposed earthen bund such that their placing is advanced simultaneously from both the ends and the earthen bunds are continued behind them. The wire for crates shall conform with provisions for wire for gabions subsection 19.8.2.2.

f) Pilchi/sarkanda rolls shall be arranged against the stakes/stone placements to form a base. Mats and gunny bags sewn together shall be then placed over the pilchi/sarkanda rolls as directed by the Engineer-in-Charge, for their staunching against the flow through them.

g) The earth bunds shall be advanced simultaneously from each side till they meet and close the flow.

h) Where final head across the closing bund is likely to be more than about 1 m another pilchi roll base shall be putin to step down the head and facilitate the closure.

i) As pilchi/sarkanda rolls, mats and any bits of stakes in case of their breakage, get buried at site of closure and are a source of weakness: another earthen bund of specified dimensions, density/compaction, shall therefore, be placed below the closure bund, as specified or as directed by the Engineer-in-Charge.

j) The operations shall remain under continuous vigilance for safety of operations and their successful completion. Any remedial action which may become necessary shall be promptly taken.

19.4 PILCHI/SARKANDA MATTRESS

19.4.1 COMPOSITION

Unless otherwise specified or directed by the Engineer-in-Charge, pilchi/sarkanda mattresses shall consist of freshly cut pilchi/sarkanda rolls weaved tightly to form mattress of specified thickness, or as directed by the Engineer-in-Charge, usually 15 cm thick. The pilchi/sarkanda rolls laid as headers and stretchers shall be tied together with coarse munj ban at 15 cm centers.

19.4.2 LAYING

Pilchi/sarkanda mattress of specified sizes shall be rolled/carried/carted to channel edge, floated and placed in position after unrolling to protect channel bed against scour under diversion bunds. The mattresses may be loaded as directed by the Engineer-in-Charge or stones in munjt rangers, or gunny trangers, steel crates, cloth bags filled with sand, earth, bajri or brick bats to avert uplifting or flooring.

19.4.3 MEASUREMENT

Length and breadth shall be measured along the finished surface correct to a 10 cm and the area shall be worked out to nearest 0.1 sqm.

19.5 STONE PITCHING/RIPRAP AND REINFORCED CONCRETE SLOPE PROTECTION

19.5.1 DESCRIPTION

This work shall consist of furnishing and placing a protective covering of erosion resistant material as stone pitching/riprap or reinforced concrete slope protection on the locations shown on the plans for slopes or pier foundation protection. The work shall be done in accordance with the specifications and conformity with the lines, grades, thickness and typical cross-sections shown on the plans. The terms stone pitching and riprap are synonymous for these specifications.

The areas to receive slope protection of any kind shall be dressed smooth to the slopes or shapes called for on the plans and shall be free from stumps, organic matter, or waste materials. The base course under pitching stone/riprap shall be provided as shown on Drawings. Toe trench and/or base material is to be constructed; as specified and directed by the Engineer-in-Charge.

All materials, regardless of type or kind, shall be placed as per lines and levels called for on the Drawings.

19.5.2 STONE PITCHING/RIPRAP PROTECTION

19.5.2.1 MATERIAL REQUIREMENTS

Stones, base material, rock spalls for pitching/riprap shall conform with the provisions of Sub-Section 19.2(c), (d) & (e). Stones for pitching/riprap unless otherwise required shall be one of the following classes as shown on the Drawings or determined by the Engineer-in-Charge.

Class A: Stones ranging in weight from a minimum of 15 kg to a maximum of 25 kg with at least 50% by weight of the stones weighing more than 20 kg.

Class B: Stones ranging in weight from a minimum of 30 kg to a maximum of 70 kg with at least 50% by weight of the stones weighing more than 50 kg.

Class C: Stones ranging in weight from a minimum of 60 kg to a maximum of 100 kg with at least 50% by weight of the stones weighing more than 50 kg.

19.5.2.2 CONSTRUCTION REQUIREMENTS

a) Excavation

The bed for the stone pitching/riprap shall be excavated to the required depths and compacted, trimmed and shaped to the entire satisfaction of the Engineer-in-Charge or as shown on the plans.

b) Placing

i) Toe Trench

The stone shall be set in a toe trench as shown on the Drawings. The toe trench shall be filled with stone of the same class as the one specified for the pitching/riprap, unless otherwise specified. All toe trenches and excavations shall be approved by the Engineer-in-Charge with firm sub-grade or base prior to placement of stones. Stones shall be placed so as to provide minimum of voids. Larger stones shall be placed in the toe trench and on the outside surface of the slope.

ii) Slopes

Stones placed below water line shall be distributed so that the minimum thickness of the pitching is not less than the specified.

Stones above the water line shall be placed by hand. They shall be laid with close, broken joints and shall be firmly bedded into the slope and against the adjoining stones. The stones shall be laid perpendicular to the slope with ends in contact.

The pitching shall be thoroughly compacted as construction progresses and the finished surface shall present an even, tight surface. Interstices between stones shall be chinked with rock spalls firmly rammed into place.

Unless otherwise provided, stone pitching/riprap shall have the following minimum thickness, measured perpendicular to the slope:

Class A:	20 cm (8 inches)
Class B:	45 cm (18 inches)
Class C:	60 cm (24 inches)

The surface of riprap placed above the water line shall not vary from the theoretical surface by more than 8 cm (3 inches) at any point.

iii) Dry Stone Pitching/Riprap

The dry stone pitching/riprap unless otherwise directed shall be started from ground level and shall be placed in layers manually or other methods approved by the Engineer-in-Charge, all to secure a stable mass. Surface irregularities of the slope shall not vary more than 8 cm (3 inches) along the intended slope. All interstices, hollows and inequalities between stones shall be filled with sand, small pieces and wedged up tight with spawl driven in with slight hammering to the satisfaction of the Engineer-in-Charge.

iv) Grouted Stone Pitching/Riprap

Stone for this purpose shall, as far as practicable, be selected of the size and shape so as to secure fairly large, flat-surfaced stone which will lay up with a true and even surface and a minimum of voids. The stones shall be placed first and roughly arranged in close contact, the larger stones being placed near the base of the slope. The spaces between the larger stones shall be filled with stones of suitable size, leaving the surface smooth, reasonably tight, and conforming to the contour required. In general, the stone shall be laid with a degree of care that will ensure for plane surfaces a maximum variation from a true plane of not more than 3%. Warped and curved surfaces shall have the same general degree of accuracy as specified above for plane surface.

As each of the larger stones is placed, it shall be surrounded by fresh mortar and adjacent stones shall be shoved into contact. After the larger stones are in place, all of the spaces or openings between them shall be filled with grout consisting of one part of Portland Cement and three parts of the fine aggregates, with sufficient water to produce a plastic mix and the smaller stones then placed by shoving them into position forcing excess mortar to the surface, and ensuring that each stone is carefully and firmly bedded laterally. Mortar shall not be placed in temperature lower than five degree C. During hot, dry weather the work shall be protected from the sun and kept moist for a minimum of 3 days after placement. Stones shall be kept wet during placing of the mortar.

After the work has been completed as above described, all excess mortar forced up shall be spread uniformly to completely fill all surface voids. All surface joins shall then be roughly pointed up either with flush joints or with shallow, smooth raked joints.

Weep holes shall be provided through the riprap cover as shown on the plans or as directed by the Engineer-in-Charge.

19.5.3 REINFORCED CONCRETE SLOPE PROTECTION

19.5.3.1 MATERIALS

Materials for reinforced concrete slope protection shall conform with provisions of Sub-Section 19.2(f).

19.5.3.2 CONSTRUCTION REQUIREMENTS

The slopes with suitable material shall be prepared with appropriate compaction to form a sub-grade approved by the Engineer-in-Charge and formwork shall be completed accordingly.

After furnishing and fixing the steel reinforcement, reinforced concrete slope protection shall be constructed after light spray of water at the locations shown on the plans or where directed by the Engineer-in-Charge. Placing and finishing of concrete shall conform to the requirements specified in Section 5 – Plain & Reinforced Concrete.

19.5.4 MEASUREMENT

Work shall be measured in cubic metres unless otherwise specified. Any extra work over the specified dimensions shall be ignored. Dimensions shall be measured correct to the nearest 0.01 m i.e. 1 cm. Areas shall be calculated to the nearest 0.01 sq mtrs and the cubic contents shall be worked out to the nearest 0.01 cubic metres.

The area of pitching for drains shall be calculated by multiplying the perimeter (bed width plus side slopes) by the length of the pitching. The length, width and side slope shall be measured correct to a cm.

19.6 PILCHI/ BRUSHWOOD/ SARKANDA/ PITCHING

19.6.1 SCOPE

Unless otherwise specified or directed by the Engineer-in-Charge, Pilchi/Brushwood/ Sarkanda/ Pitching will cover preparing the slopes of river embankments and/or the downstream of falls in the Irrigation canals/drains and laying Sarkanda, Farash or Pilchi rolls in headers and stretchers to protect the bank(s) from side erosion and wave wash.

19.6.2 QUALITY

i. The pilchi. farash or sarkanda used for pitching shall be of the best quality,mature not over or under grown locally available and duly approved by the Engineer-in-Charge.

ii. It shall be used when it is still green.

19.6.3 DIMENSIONS

i) Unless otherwise specified or directed by the Engineer-in-Charge. The rolls as headers shall be nearly 5 ft. (1.5 m) long and 6 inches (15 cm) in diameter and those used as stretchers 30 ft. (9.5 m) long and 6 inches (15 cm) in diameter.

ii) The rolls shall be well compacted and tightly tied with coarse munjban or binding wire at 12 inches (30 cm) interval.

19.6.4 LAYING

i) The inner side of the embankment shall be cut out to accommodate the pitching or pitching shall be done on the surface of the existing bank strictly as specified or directed in writing by the Engineer-in-Charge.

ii) Unless otherwise specified or directed by the Engineer-in-Charge, the pitching shall be started form the ground level.

iii) The first or the lowest layer of rolls shall be laid as headers and as close to each other as possible in order to get one compact layer of pilchi.

iv) The second layer, unless otherwise specified shall be laid across the first layer, shall consist of stretcher rolls tied down by means of 1 meter long pegs driven at 1.5 m interval. The stretcher roll shall be so located that it lies just within the inner slope of the embankment.

v) After laying header and stretcher rolls a layer of good earth shall be placed and thoroughly compacted to make It level with the top of stretcher roll.

vi) The second and subsequent layers of header and stretcher rolls shall then be laid as previously and then process repeated till the pitching has been carried to the specified level.

vii) In case of new construction, the pitching shall be done along-with the embankment and horizontal layer in the main embankment shall correspond with the earthen layers placed between two consecutive layers of the rolls and compacted simultaneously.

viii) The position of the ends of the headers viz-a-viz that of stretcher roils shall be kept to maintain the specified slope. However, in case the slope had been scoured earlier the overall dimension of the embankment shall be slightly increased.

NOTE.

i) Use of farash shall be avoided, if pilchi is available.

ii) Sarkanda shall be used as a last resort. In case of sarkanda mattress or pitching the distance of pegs shall be reduced as directed by the Engineer-in-Charge or his authorized subordinate to check its tendency of floating.

19.6.5 MEASUREMENT

Length and breadth shall be measured along the finished surface correct to a 10 cm and the area shall be worked out to nearest 0.1 sqm.

19.7 GROYNES

19.7.1 SCOPE

Unless otherwise specified or directed by the Engineer-in-Charge groynes shall consist of brush wood filled between two or more rows of stakes (killas or bamboos) inter twinned by coir ban. The brush wood filling is loaded down as specified and/or as directed by the Engineer-in-Charge by ropes and weighted down with stone crates for bank protection.

19.7.2 LAYING

Killas or bamboo's of specified lengths and diameter are sharpened at one end and driven as specified or as directed by the Engineer-in-Charge.

In the river bed they are driven in rows of specified numbers and placed in line with the current. Green brush wood is filled between stakes and intertwined. When directed by the Engineer-in-Charge the brush wood is loaded/weighted down with stone etc.

The brush wood is replenished regularly as scour occurs and brush filling settles.

19.7.3 MEASUREMENT

Length and breadth shall be measured along the finished surface correct to a 10 cm and the area shall be worked out to nearest 0.1 sqm.

19.8 GABIONS

19.8.1 SCOPE

This work shall consist of wire-mesh gabions, furnished and placed in accordance with these specifications, and the specifications for the other work items involved, and at the locations and in conformity with the lines and grades shown on the Drawings. The work in general, covers gabions used for river and stream stabilization work, such as bank revetments, jetties, groins deflector, scour protection and retaining structures.

19.8.2 MATERIAL REQUIREMENTS

19.8.2.1 GENERAL

Gabions shall be enclosed by galvanized steel wire mesh, which shall be supplied folded flat to facilitate transport and handling.

Gabions shall be furnished in accordance with the various lengths, widths and heights required, by the Drawings, or as directed by the Engineer in-charge. If not otherwise required, all gabions shall be 40 inches (one meter) in width. The lengths shall be multiples of 2,3 or 4 times the width of the gabion and heights shall be three tenth (0.3), one half (0.5) or one (1) meteri.e14 inches, 20 inches or 40 inches.

19.8.2.2 WIRE

All wire shall be a good commercial quality of steel and size as per Drawings coated with a prime western speller or equal (AASHTO M 120) applied at a rate of not less than 0.8 ounces per square foot (0.25 kg/ Sq.M) of uncoated wire.

Uniformity of coating shall withstand ten (10) one-minute dips by the Preece Test in accordance with AASHTO T-66. “Uniformity of Coating by the Preece Test (Cooper Sulphate Dip) on Zinc Coated (Galvanized) Iron or Steel Articles”. Wire mesh shall withstand 220 hours of exposure before failure by rusting of any part when subjected to a salt spray test in accordance with ASTM B 117.

The tensile strength of the wire shall be in the range of four thousand (4,000) to six thousand (6000) kg / sq. cm. and shall have an elasticity to permit elongation of the mesh equivalent to a minimum of ten (10) % without reducing the gauge or tensile strength of the wire.

The minimum size of the wire used in fabrication of the gabion baskets shall be as follows:

Description	Diameter(mm)	US SteelWire Gauge
Body Wire	2.3	11
Selvedge or Perimeter Wire	2.8	9
Tying and Connecting Wire	1.95	13

19.8.2.3 FABRICATION

Gabions shall be in the form of rectangular baskets of the required dimensions and shall be manufactured from wire as specified above. Gabions shall be made of steel wire triple twisted forming a uniform hexagonal mesh pattern with openings eight (8) cm or by twelve (12) cm. The edges shall be formed into securely connected selvedges adequate to prevent raveling. Individual basket ties and connections shall be made by using a quantity of wire not less than 8 percent of the weight of each basket.

When the gabion length exceeds its width, it shall have securely tied diaphragms connected at all edges to form individual cells of equal length and width. Diaphragms shall be of the same material and manufacture as specified above for the gabions.

Four cross-connecting wires shall be provided in each cell having a height of one half the width or less, and eight (8) cross-connecting wires shall be provided in each cell having a height greater than one half the width.

All the characteristics and values given in the above specifications are subject to the tolerance of plus or minus five (5) percent.

19.8.2.4 ROCK FILL

Fill for gabions shall consist of hard, durable rock pieces that will not deteriorate when submerged in water or exposed to severe weather conditions. Rock pieces shall be generally uniformly graded in sizes ranging from ten (10) cm to twenty (20) cm. Filled gabions shall have a minimum density of one thousand three hundred sixty (1,360) kg per cubic meter. Void spaces shall be evenly distributed and shall not exceed a maximum of thirty (30) percent.

The rock shall meet the requirements of AASHTO M 63 except that the Sodium Sulphate Soundness Loss shall not exceed nine (9) % after five (5) cycles.

19.8.3 CONSTRUCTION REQUIREMENTS

Installation shall be performed in a skillful manner as approved by the Engineer in-charge. Beds for gabions shall be suitable level. Gabions forming elements of structures shall be securely connected along the complete length of top contract edges by means of the above specified tying and connecting wire.

Before the rock fill is placed the gabions shall be stretched in such manner as will permit proper shape, alignment and compaction of fill.

Rock fill for exposed faces of gabions walls shall be carefully selected for uniformity or size, and the pieces shall be hand placed to provide a neat appearance as approved by the Engineer in-charge. The vertical joints of gabion baskets shall be staggered as in running bond brickwork.

19.8.4 MEASUREMENT

Work shall be measured in cubic metres unless otherwise specified. Any extra work over the specified dimensions shall be ignored. Dimensions shall be measured correct to the nearest 0.01 m i.e. 1 cm. Areas shall be calculated to the nearest 0.01 sq mtrs and the cubic contents shall be worked out to the nearest 0.01 cubic metres.

19.9 MEASUREMENT AND PAYMENT

19.9.1 COMPOSITE RATE

The measurement and payment for the items of the work of Protection and Diversion Works hereof shall be made corresponding to the applicable CSR items as provided in Contract Agreement and shall constitute full compensation, for procurement, transportation, performance in all respects and completion of work as specified including the site clearance as approved by the Engineer-in-Charge.

19.9.2 LABOUR RATE

The measurement and payment for the items of the work of Protection and Diversion Works hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurement transportation, performance in all respects and completion of work as specified including site clearance, as approved by the Engineer-in-Charge except the cost of materials to be provided by Department at designated location as defined in the Contract Agreement.

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20. OUTLETS

20.1 SCOPE

The Scope covers all works required in connection with the construction, repairs, adjustments, dismantling, earthwork, etc. of an outlet as per approved Drawings and Specifications and may include such other works in connection therewith as may be specified or as directed by the Engineer-in-Charge.

The scope shall also include furnishing all labour, materials, plants, equipments, instruments, accessories and services necessary to complete the works such as excavation, concreting, brickwork etc. in a workman-like manner. The scope shall also include the outlet according to its sanctioned size as per approved Drawings and Alteration Form of the outlet.

20.2 CONSTRUCTION OF OUTLETS (OTHER THAN PIPE)

20.2.1 MATERIALS

i) Cement

Portland cement shall conform to ASTM C-150 Type-1 or B.S.S-12 and shall meet the requirements and stipulations, specified for Portland Cement in Section 5 – Plain & Reinforced Concrete.

ii) Sand

Sand shall conform to Specifications, requirements and stipulations specified for Sand in Section 5 – Plain & Reinforced Concrete.

iii) Aggregate

Course Aggregate shall conform to the specifications already given in Section 5 – Plain & Reinforced Concrete.

iv) Bricks

First class bricks sand moulded shall be used, which shall conform to the specifications for Brickwork under Section 11.

v) Water

Water shall conform to the Specifications for Water, Section 5 – Plain & Reinforced Concrete.

20.3 EXCAVATION

Excavation of the bank for the construction of an outlet shall be in accordance with Section 3 – Earthwork and made as per dimensions suitable to the size of the outlet structure with proper side slope and the depth given in the approved Drawing and earth thus obtained shall be thrown 2 cft. (6 meters) away from the edge of the cutting. Bottom of the excavated portion of bank shall be leveled and well compacted before laying of foundation concrete. If the length, width, depth, grade, levels and side slopes are not indicated on the Drawing, they shall be carried out to the profile agreed by the Engineer-in-Charge in writing. After the completion of work the excavated portions on both sides of the outlet shall be refilled, rammed and / or puddle as per specifications or as directed by the Engineer-in-Charge.

20.3.1 MEASUREMENT:

Refer Section 3

20.4 PLACING CONCRETE

The production and placing of concrete as specified shall be done according to approved mix and dimensions given on the drawing as per specifications in Section 5 – Plain & Reinforced Concrete. As the concrete is being placed, it should be compacted thoroughly and uniformly by means of hand tools or finishing machines to secure a dense structure and smooth surface. Immediately before placing concrete all surfaces upon or against which it is to be placed shall be free from standing water, mud, debris or loose material. The surfaces of absorptive materials against or upon which concrete is to be placed shall be moistened thoroughly so that moisture is not drawn from the freshly placed concrete.

Slabs to be laid on the water course culverts, liable to be damaged by dropping from a height, shall be lowered down to the ground by means of a rope or another approved appliance or as directed by the Engineer-in-Charge. If any slab is damaged or broken on account of the negligence of the Contractor he shall have to replace it at his own cost.

20.4.1 MEASUREMENT:

Refer Section 5

20.5 BRICKWORK

Brickwork for an outlet shall be executed according to the specifications given in Section 11 – Brickwork in addition to fixing cast-iron or brick block of APM Outlet or open flume outlet including dressing of bricks, which shall be treated as a separate item of work for payment purpose.

20.5.1 MEASUREMENT:

Refer Section 11

20.6 DISMANTLING AND ADJUSTING OF EXISTING OUTLETS

20.6.1 SCOPE

Dismantling of different types of existing outlets for including Kennedy Gauge outlet, Orifice, Adjustable Proportional Module, Open Flume, Tail Cluster Bifurcation, Tail Cluster Trifurcating, Tail Cluster Quadrification for the under-mentioned purposes as per approved Alteration Form or as directed by the Engineer-in-Charge in writing shall be done in accordance with Section 4 – Dismantling (Demolition) and would involve.

i) Dismantling Outlet old type such as KGO Orifice and replacing by APM or of types commensurate with the designed discharge size and change in site.

ii) Adjusting size, changing of site or type of the outlets of various types mentioned above.

iii) Improving the working conditions of the non-modular outlets by changing their type and if need be their site also.

iv) Dismantling side wall for taking out bricks block of APM and fixing Iron block in place of brick block and rebuilding dismantled walls.

v) Dismantling side walls of an open Flume outlet for adjusting its width(B), fixing roof block and rebuilding the side walls.

vi) Adjusting size(Y) of an APM outlet and rebuilding its side walls.

vii) Removing the old iron block of an APM outlet and re-fixing the iron block after adjusting its 'B' and 'Y' and rebuilding the side walls.

20.7 PIPE OUTLETS

20.7.1 SCOPE

The scope covers all works required in connection with the fixing of pipe outlets including earthwork excavation, concreting, fixing Cast Iron, Steel or RC Chume Pipes, brick work in face and walls, earthwork refilling and puddling etc. all items of work i.e. excavation, laying of pipes, concreting, brick work. The refilling, ramming and puddling of earthwork shall be carried out as per specifications given in the Section 3 **-** Earthwork of specifications and as directed by the Engineer-in-Charge.

20.8 CONSTRUCTING OR ADJUSTING OUTLETS IN RUNNING WATER

20.8.1 SCOPE

When work for a new or existing outlet is to be executed in running water, an earthen ring bund in a semi-circle form shall be constructed in the channel to provide a working space for the safe execution of work. Water side of this bund shall be protected by killa bushing so as to check side erosion by the running water and thus eliminate the possibility of any damage to the bund. After satisfactory completion of work this bund shall be removed to the satisfaction of the

Engineer-in-Charge. The modus operandi for dismantling and adjusting the existing outlet is given in Specification No. 20.6 above.

20.9 MISCELLANEOUS

20.9.1 SCOPE

In case of non-availability of water during construction of New Channels or in long closures, special arrangements for supply of water for construction and curing etc shall be made by the Contractor for which separate allowance shall be paid to the Contractor for each Outlet at the rate tendered by the Contractor corresponding to the applicable CSR item.

20.10 MEASUREMENT AND PAYMENT

20.10.1 COMPOSITE RATE

The measurement and payment for the items of the work of Outlets hereof shall be made corresponding to the applicable CSR items as provided in Contract Agreement and shall constitute full compensation, for procurement, transportation, performance in all respects and completion of work as specified including the site clearance as approved by the Engineer-in-Charge.

20.10.2 LABOUR RATE

The measurement and payment for the items of the work of Outlets hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurement transportation, performance in all respects and completion of work as specified including site clearance, as approved by the Engineer-in-Charge except the cost of materials to be provided by Department at designated location as defined in the Contract Agreement.

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21 ROAD AND ROAD STRUCTURES

21.1 CONSTRUCTION OF ROADS

21.1.1 EARTHWORK

21.1.1.1 General

The earthworks for Construction of Roads shall generally conform to the provisions of Section 3, Earthwork subject to the further provisions stated hereunder. AASHTO (American Associations State Highways Officials) Specifications shall apply for construction of roads unless otherwise specified.

21.1.2 CLEARING & GRUBBING

The clearing & grubbing required for construction of roads shall be carried out in accordance with applicable provisions of Clause 3.12.3 under Section 3 – Earthwork.

After the clearing and grubbing operation, all the depressions and cavities etc. shall be filled back with suitable material at. the Contractor's cost to the average level of the undisturbed original ground.

Rendering of the soil in the area, as unsuitable due to the Contractor's operation by way of littering and/or mixing of the cleared and grubbed material or any other reason, shall be to the Contractor's cost and shall be stripped and reinstated with acceptably suitable material without any payment.

Cleared and grubbed material shall not be left in or under embankments or other constructed facility. All removed materials shall be disposed of at locations outside the right-of-way and not visible from the roadway.

Disposal of removed materials at public and private sites away from the right of way shall be done at the Contractor’s sole expense, in accordance with all laws and regulations, after an agreement with the property owner or public agency has been fully executed. The Engineer shall be given fifteen (15) days prior notice and a written release from the property owner or public agency on whose property the materials are to be placed. Clearing and grubbing shall be waived off where the fill height is two (02) meters or more and at the discretion of the Engineer

21.1.3 MEASUREMENT

Length and breadth shall be measured correct to a cm, along the surface. Area shall be worked out in sqm correct to two places of decimal.

Measurement under this item shall be made in square meter of berms dressed or compacted in accordance with theoretical lines, or sections shown on the drawings, or as per existing edge of road.

In case partial fresh material is used to compensate for shortage of material in the top layer the quantity of such material shall be measured by survey levels of existing ground and designed lines, grades or sections shown on the drawing.

The quantity of material thus measured shall be paid under other items of works of formation

21.1.4 STRIPPING

21.1.4.1 General

This work shall consist of removing, transporting and depositing top soil in stock piles or spreading where indicated on the drawings or as directed by the Engineer-in-Charge.

21.1.4.2 Construction Requirement

The areas from which stripping of top soil is required shall be as indicated on the drawings or as directed by the Engineer-in-Charge. The Contractor shall remove top soil from these areas to depth as directed by the Engineer-in-Charge. Stripping of top soil in any case shall be not less than 4 inches (10 cm) in depth. The removed top soil shall be transported, deposited in stock piles at locations designated by the Engineer-in-Charge and/or spread where indicated on the drawings or as directed by the Engineer-in-Charge. Stripped material at stock pile shall not be used by the Contractor.

The top soil shall be placed separately from other excavated materials and be completely removed to the required depth from the area prior to the beginning of regular excavation or embankment work in that area. No payment will be made for top soil removed from places other than that directed by the Engineer-in-Charge.

21.1.5 COMPACTION OF NATURAL GROUND

21.1.5.1 General

The work shall consist of the compaction of the natural ground/original ground, the cleared and grubbed surface (i.e. the surface after cleaning and grubbing), stripped surface after stripping and the excavated surface after excavation, prior to commencement of the embankment construction in accordance with these specifications as shown on the Drawings or as directed by the Engineer-in-Charge. The compaction shall be carried out through a written order by the Engineer-in-Charge.

21.1.5.2 Construction Requirements

The natural ground/cleared and grubbed surface/ stripped surface/ excavated surface shall be broken up, ploughed, scarified; all sods and vegetation matter removed and compacted to a depth of 200 mm and to the specified density as given below

For Height of Embankment below sub grade level	%age of maximum dry density as determine by AASHTO T-180
0 to 300 mm (0 to 30 cm)	95
300 to 750 mm (30 to 75 cm)	93
Over 750 mm (75 cm)	90
Below the foundation of structure	95

21.1.5.3 Measurement

Length and breadth shall be measured correct to a cm, along the surface. Area shall be worked out in sqm correct to two places of decimal.

21.1.6 ROADWAY & BORROW EXCAVATION FOR EMBANKMENT

21.1.6.1 Roadway Excavation

Roadway excavation shall comprise all excavation that is not classified as structural excavation carried out within the limits of roadway including permanent drainage ditches and side slope cuts. The classification of the excavation shall conform to the provisions of Clause 3.2 under Section 3 of Earthwork.

21.1.7 BORROW EXCAVATION

21.1.7.1 General

Borrow excavation shall be taken for construction of embankments and backfills where necessary and shall comply with the provisions of Clause 3.11.3, Section 3 – Earthwork.

21.1.8 CONSTRUCTION REQUIREMENT

All material removed from excavation shall be used in the formation of embankment, sub-grade, shoulders and at such other places as directed, unless it is declared unsuitable and ordered to waste by the Engineer-in-Charge. No excavated material shall be wasted without written permission from the Engineer-in-Charge, and when such material is to be wasted it shall be so placed that it will present a neat appearance and not be an injury to abutting property. The material shall be declared unsuitable if the soaked CBR (96 hours) is less than five (5) percent or it falls under A-6 or A-7 of AASHTO soil classification.

During construction of the roadway, the road shall be maintained in such a condition that it will be well drained at all times. All slopes, except in solid rock or other material shall be trimmed precisely as per cross-sections and care must be exercised that no material shall be loosened beyond the required slopes. In blasting rock slopes, a reasonably uniform face shall be left, regardless of whether or not the excavation is carried beyond the specified side slope. All breakage and sides shall be removed by the Contractor and disposed of as directed by the Engineer-in-Charge.

Rock, shale and other unsuitable road bed material encountered in cuts shall be excavated to require width and depth indicated on the plans or as otherwise directed. Any over- breakage below the depth shown on the plans will not be paid for. Backfill of the over-cut shall be of approved earth material and shall have the same density requirements as specified on the plans and shall be at the expense of Contractor.

Borrow-pits shall be located so that the nearest edge of the pit is at, least thirty (30) meters from the roadway toe of slope unless otherwise directed by the Engineer-in-Charge. Permission to use any borrow material including its suitability, shall be obtained in writing from the Engineer-in-Charge at-least fifteen days in advance of the proposed date of taking borrow materials.
In no case shall borrow material be obtained from downstream of any hydraulic structure. However the borrow-pit may be established at five hundred (500) meters upstream of the hydraulic structure. The side slopes of the pits or channels shall be constructed as shown on the plans or directed by the Engineer-in-Charge. In no case the side slopes of borrow pit be steeper than a slope; 1:5 (V:H).
Upon abandonment of borrow pit or quarry area the Contractor shall at his own expense, clean and trim the borrow-pit or quarry area, the right of way, and adjoining properties which were occupied during execution of work, all to the satisfaction of the Engineer-in-Charge.
Where between two successive cross-sections of the road, the proportions of rock boulders, in sizes larger than a one quarter (1/4) of a cubic meter, to earth is more than 50%, the excavation will be considered wholly as rock.

Rock material above ground level such as stones, boulders, piles of stone, and dry stones walling whose individual sizes are greater than one quarter of a cubic meter shall be removed and disposed of if directed by the Engineer-in-Charge. When the Contractor is directed to excavate unsuitable material below the surface of original ground in fill areas other than required for cleaning and grubbing, the depth to which these unsuitable materials are to be removed will be determined by the Engineer-in-Charge. The Contractor shall schedule his work in such a way that authorized cross-sections can be taken before and after the material has been removed.
The excavation in rock shall be carried out strictly in conformity with provisions of Sub-Section 3.8 of Section 3 – Earthwork.

21.1.9 MEASUREMENT

The filling shall be measured and quantity of earth work computed from cross sections of filling or the embankment. No deduction shall be made for voids. For further details refer Section-3.

21.1.10 EMBANKMENT CONSTRUCTION

21.1.10.1 General

The work shall consist of formation of embankment, including preparation of area for placing and compaction of embankment material in layers and in holes, pits and other depressions within the road-way area in accordance with the specifications and in conformity with the lines, grades, thickness and typical cross-section shown on the plans or established by the Engineer-in-Charge. The work shall also include the compaction, trimming and shaping of the side slopes as shown on the plans and removal of any excess fill as directed by the Engineer prior to placement of top soil on slopes of the embankment where required

21.1.10.2 Material Requirements

Material for embankment shall consist of suitable material excavated from road way excavation or structural excavation or borrow. Borrow material will be used only when material obtained from roadway or structural excavation is not suitable or is deficient for embankment formation and shall include all lead and lift.

Wet excavated material which will be suitable when dry and if approved by the Engineer-in-Charge shall first be allowed to dry before being placed in the embankment

The material under this item shall conform to the following specification.

a) Contractor shall use AASHTO Class A-1, A-2, A-3, A-4, A-5, soil as specified in AASHTO M-145 or other material approved by the Engineer-in-Charge.

b) C.B.R. of the material shall not be less than five (5) percent, determined in accordance with AASHTO T-193. CBR value shall be obtained at a density corresponding to the degree of compaction required for the corresponding layer.

c) Swell value of the material for embankment formation shall not exceed 0.3 percent. In case sandy material be used for embankment formation, it shall be properly confined with a material approved by the Engineer-in-Charge and shall not be used on slopes of embankment.

d) In areas subject to flood and prolonged inundation of the embankment, such as at bridge sites, the material used in embankment unless rock, shall be AASHTO Class A-1 or A-2, soils. Other soils may be used only with the written consent of Engineer-in-Charge.

e) For the purpose of embankment and sub-grade construction, the following shall be considered as unsuitable materials:

- Material from soil AASHTO classification group A-6 and A-7.
- Material from swamps, marshes and bogs.
- Peat, logs, stumps and perishable materials.
- Organic soils.
- Material having a C.B.R value less than 7% determined according to AASHTO T-193, for the embankment depth of 30 cm below sub-grade.

- f) The moisture content of the soil at the time of compaction shall be optimum to achieve the compaction up to the specified density. The maximum dry density and optimum moisture content shall be determined from moisture density test (AASHTO T-180 Method 0) performed on different type of soil to be used in the construction of the work. Optimum moisture content and the moisture range required for the soil to achieve the desired compaction shall be approved by the Engineer-in-Charge.
- The soil shall be compacted at optimum moisture content with +1 % to -2 % tolerances, commensurate with the soil type, unless otherwise directed by the Engineer. When compaction is determined by "Relative Density Test" the tolerance for moisture content shall be finalized during the compaction trial and approved by the Engineer-in-Charge.

21.1.10.3 Construction Requirements

a) Formation of Embankment with Common Material

If suitable material is not available in the Project area, the Contractor may opt, without any additional cost to the Employer, to blend granular material with locally available A6/A7 soils to achieve a uniform blend that meets the material requirements stated above. Such widely divergent materials may be mixed, sampled and tested outside the embankment limits and the mixture may be used as a proposed source of borrow material as outlined in Section 21.1.8. However, the Contractor will submit his method statement to the Engineer and get it approved before proceeding with the work. Approval of this method statement by the Engineer shall not relieve the Contractor of his responsibility to use the suitable material in the Works. Material for embankment, obtained and approved as provided above, shall be placed in horizontal layers of uniform thickness and in conformity with the lines, grades, sections and dimensions shown on the Drawings or as required by the Engineer. The layers of loose material other than rock shall be not more than 20 cm. thick, unless otherwise allowed by the Engineer after a trial section is prepared and approved for each material source and/or borrow area.

Depth in centimetres below sub-grade level	Percent of Maximum Dry Density as Determined by
0 to 30	95
30 to 75	93
Over 75	90

In place density determinations of the compacted layers shall be made in accordance with AASHTO T-191 or other approved methods. For all soils, with the exception of rock fill materials, containing more than 10% oversize particles retained on 19 mm(¾ inch) sieve, the in place density thus obtained shall be adjusted to account for such oversize particles as or directed by the Engineer-in-Charge. Subsequent layers shall not be placed and compacted unless the previous layer has been properly compacted and accepted by the Engineer-in-Charge.

Material for embankment at points inaccessible to normal compacting equipment shall be placed in horizontal layers of loose material not more than 15centimetres thick and compacted to the densities specified above by the use of mechanical tempers or other appropriate equipment.

The compaction of the embankment shall be carried out at the designated moisture content consistent with the available compacting equipment. Embankment material that does not contain sufficient moisture shall be given additional moisture by means of approved sprinklers and mixing to obtain the required compaction. Material containing more than the optimum moisture may not, without written approval of the Engineer-in-Charge, be incorporated in the embankment until it has sufficiently dried out. The drying of wet material may be expedited by the scarifier disking or other approved methods.

When materials of widely divergent characteristics, such as clay and chalk or sand, drawn from different sources, are to be used in the embankment they shall be deposited in alternate layers of the same material over the full width of the embankment to depths approved by the Engineer-in-Charge. Rock, clay or other material shall be broken up, and no accumulation of lumps or boulders in the embankment will be permitted. No surplus material shall be permitted to be left at the toe of embankment or at the top of cut sections. Side slopes shall be neatly trimmed to the lines and slopes shown on the drawings or as directed by the Engineer, and the finished work shall be left in a neat and acceptable condition. The slopes of the design road cross-section shall be trimmed and compacted to the densities as specified above for different zones.

Relative Density Test

For cohesion-less free-draining soils for which impact compaction will not produce a well-defined moisture density relationship curve and the maximum density, the Test for the Relative density of Cohesion-less soils ASTM D-4253/4254 shall be used to determine the relative density.

Relative density is defined as the state of compactness of a soil with respect to the loosest and densest state at which it can be placed by the laboratory procedures described in the ASTM D-4253/4254. The field Density and actual Moisture Content of the compacted embankment shall be determined by field tests according to AASHTO T 191.

b) Formation of Embankment on Steep Slopes

Where an embankment is to be constructed against an existing slope of 1 vertical to 5 horizontal or steeper, hill sides, existing shoulders or where new fill is to be placed and compacted against existing pavement or where embankment is to be built along one half the width at a time, the existing slope shall be benched. The horizontal dimension of benches shall be greater than half the width of the compacting equipment in use except where this would result in a vertical dimension at the back of the bench of more than 60cms in which case the horizontal dimension may be reduced. The compaction of benches shall be as per section 21.1.8 of the General Specifications.

No measurement shall be made of the volume of material cut from the existing slope, recompacted at the same place or reused elsewhere for benching purpose. Filling against the slope will be calculated on the volume of fill placed against the original slope. Existing slope in the context of this clause includes a partially constructed embankment but does not include the side of trench excavation.

c) Formation of Embankment on Existing Roads

Before fill is placed and compacted on an existing roadway, the existing embankment and/or pavement may be levelled by cutting, rolling or scarifying by approved mechanical means to a level to be determined by the Engineer-in-Charge. The earth, old asphalt or other material arising as a result of this operation will be declared either suitable or unsuitable for use in the embankment by the Engineer-in-Charge. The payment for incorporation of such item shall be decided by the Engineer-in-Charge.

d) Formation of Embankment in Water Logged Areas

Where embankments are constructed across marshlands, tidal flats, or wet ground which is soft (such as .SPT < 5) and compressible and will not support the weight and forces of hauling and compacting equipment, the lower part of the embankment may be constructed by dumping successive loads in a uniformly distributed layer (bridging lift) of a thickness necessary to support equipment hauling but not more than 50 cm, and the placing and compacting of subsequent layers. Such supporting layers shall not be subjected to compaction requirements specified in clause 21.1.8.3. The remainder of the embankment shall be constructed in layers as specified. The material of working platform shall be as per clause 21.1.8.2.

It should also be checked that selected grading is such that intrusion into the working platform material of sub-grade or natural ground surface material is not allowed.

For this condition to be met it will be required that the ratio as below shall be checked and followed:

$$\frac{D15-(Granular\ Fill\ Material)}{D85-(Natural\ Ground\ Material)}<5$$

D15 & D85 mean the particle diameters corresponding to 15% and 85% respectively, passing (by weight) in a grain size analysis.

The thickness of the working table as prescribed above shall be approximately 0.5 meter unless directed otherwise by the Engineer-in-Charge, and the width shall be that of the embankment. The placement and compaction of the working table shall be carried out by use of light equipment, as directed by the Engineer-in-Charge.
No density requirements are specified for the working platform, however, subsequent layers above it shall be compacted to the densities specified in 21.1.8.3.

When the roadway profile is so low that the construction of the lower part of the embankment using a "bridging lift" will not permit the placement and compaction of fifty (50 cm) centimeters of acceptable embankment material, Contractor shall prepare a proposal to raise profile of the embankment and submit it to the Engineer-in-Charge for his approval.

Boulders and rock fragments larger than twenty (20 cm) centimetres in maximum dimension shall not be placed in the embankment any closer than twenty (20) centimeters from top of the embankment.

Embankment settlement period for critical section, where height is greater than 5.0 meter, is approximately three (3) months. Embankment therefore, shall remain in place for the required settlement period before placing the 30 cm thick subgrade layer, excavating for abutments, wing walls or retaining wall foundations or installing foundation piles at each location.

The embankment settlement test specified herein shall be in addition to the test section in sub section 108.3.9.

The sub-grade/embankment above the working platform shall be compacted as specified in sub-section 108.2 for the applicable zones of compaction.

e) Formation of Embankment with Rock Material

Embankment formed of material consisting predominantly of rock fragment of such size that the material cannot be placed in layers of the thickness prescribed without crushing, pulverizing or further breaking down the pieces, such material may be placed in layers not exceeding in thickness than the approximate average size of the rocks except that no layer shall exceed 80 cm. (eighty centimetres) of loose measurement and compacted by a vibratory roller with the minimum mass as shown in the following table.

Mass per metre width of Vibrating roll (Kg/M)	Depth of fill layer (mm)	Number of passes of the Roller on each layer
2300-2900	400	5
2900-3600	500	5
2600-4300	600	5
4300-500	700	5

>5000	800	5

The material shall be carefully placed in layers, so that all larger stones will be well distributed and voids completely filled with smaller stones, clean small spells, shale, earth, sand, gravel, to form a solid mass. After placing rock material surface shall be covered with a layer of fine material having thickness less than twenty (20) centimeters. Such fine material shall be reserved from roadway excavation by the Contractor. Should such material be available but not reserved, Contractor will supply and place borrow material for forming smooth grade without extra payment.

Each layer shall be bladed or levelled with motor grader. bulldozer or similar equipment capable of shifting and forming the layer into a neat and orderly condition. No rock larger than eight (8) centimeters in any dimension shall be placed in the top fifteen (15) centimeters of embankment unless otherwise allowed by the Engineer-in-Charge.

Material for each layer should be consolidated with heavy weight vibratory roller until settlement as checked between two consecutive passes of roller is less than one (1) percent of the layer thickness. In evaluation of settlement, survey points should be established and rolling continued until difference of levels as checked after two consecutive passes is less than one (1) percent of the total layer thickness. More over initial rolling of overlaid fine material shall be done without watering to ensure their intrusion in voids of rock layer beneath. Watering shall be done when voids are properly filled.

Embankments, which are formed of material that contain rock but also contain sufficient compactable material other than rock or other hard material to make rolling feasible, shall be placed and compacted in the manner prescribed above and to the point when settlement is within above mentioned requirement. Compaction test will be made whenever the Engineer-in-Charge determines they are feasible and necessary. Each layer must be approved by the Engineer before the next layer is placed.

When rock to be incorporated in fill is composed largely of weak or friable material, the rock shall be reduced to a maximum size not exceeding fifty (50) percent of the thickness of the layer being placed.

f) General Requirements

To avoid interference with the construction of bridge abutments and wing walls, the Contractor shall at points determined by the Engineer-in-Charge, suspend work on embankment and/or in cuts forming the approaches to any such structure until such time as the construction of the later is sufficiently advanced to permit the completion of the approaches without the risk of interference or damage to the bridge works. The cost of such suspension of work shall be included in the contract unit prices for embankment. In carrying embankments up to bridges, culverts or pipe drainage, care shall be taken by the Contractor to have the embankments brought equally on both sides of any such structure. The contractor shall make special arrangements to ensure proper compaction in restricted spaces and around structures without any extra compensation for this work.

When as a result of settlement, an embankment requires the addition of material up to 30 cm in thickness to bring it up to the required grade level, the top of the embankment shall be thoroughly scarified before the additional material is placed, without extra payment to the Contractor for the scarification.

The Contractor shall be responsible for the stability of all embankments and shall replace any portions that in the opinion of the Engineer-in-Charge have been damaged or displaced due to carelessness or neglect on the part of the Contractor. Embankment materials which may be lost or displaced as a result of natural causes such as storms, cloudburst or as result of unavoidable movement or settlement of the ground or foundation upon which the embankment is constructed shall be replaced by the Contractor with acceptable material from excavation or borrow. No additional compensation will be allowed for the replacement except that the quantity of material required will be paid for at the contract price for the type of material used.

During construction, the roadway shall be kept in shape and drained out at all times. When unsuitable material has been placed in the embankment by the Contractor, he shall remove it without extra payment.
Embankment filling shall be brought up and compacted over the full width of the embankment of the carriageways in one operation in layers parallel with the sub-grade level. At no time shall any part of the embankment width under one carriageway be left more than one-layer lower than any other part of the embankment width.

Shoulder construction shall be brought up simultaneously with the pavement construction. In order to prevent water penetration into the pavement layers during construction, shoulder and median construction shall be brought up simultaneously with the pavement construction whenever the transverse slope of the sub-grade slopes downwards towards the pavement or sub-grade.

Embankment side slopes shall be neatly trimmed to the dense lines and slopes shown on the drawings or as directed by the Engineer-in-Charge and the finished work shall be left in a neat and acceptable condition.

The fill behind abutments and wing walls of all bridges, pipe slab and box culverts shall be deposited in well-compacted, horizontal layers not exceeding twenty (20) cm in thickness to the density 100 percent of max. dry density as per AASHTO T180(D).

g) Formation of Embankment with A-3 Material

The construction of embankments with A-3 material shall be accomplished as shown on the plans, specified in Particular Specifications and Special Provisions and as directed by the Engineer-in-Charge. Construction of embankment with A-3 material shall be carried out in a series of operations as follows:

Edge berms shall first be constructed along both sides of the staked embankment, except where the embankment is to be constructed against hillsides or existing embankment, using Class A-1, A-2 or A-2-4 soils from roadway excavation or borrow or any other source which resist erosion by wind and water and are approved by the Engineer. However, if Engineer so approved A-4 material having PI value 4-8 from borrow excavation can be used for confinement. Edge berms shall be constructed with an external side slope as shown on the plans or specified in the Particular Specifications and Special Provisions, but not steeper than one (1) vertical to three (3) horizontal. Edge berms shall be constructed not more than forty (40) centimetres in height and not less than 2.0 meters wide at the top. The materials shall be placed and spread in layers as specified in these Specifications , material shall be excavated, hauled, deposited and spread within the edge berms to the full height of the edge berms using any means other than hydraulic sluicing.

h) Formation of Embankment on Existing Structures

When an embankment surface is to be constructed over an area previously occupied by a building basement, cellar, irrigation canal, well, any previous excavation, or other such construction that will not permit the use of normal compaction equipment, the embankment construction shall conform to the backfilling requirements specified in Structural Backfilling in these Specifications, until the normal compaction equipment can be used. The material shall be compacted to the density specified for the adjacent embankments.

i) Trial Section

Before starting the filling of the embankment, the Contractor shall construct trial sections of minimum 200 meters and maximum of 500 meters or as directed by the Engineer with each soil type/source proposed to be used as fill material. The soils used in the trials shall be the same as those intended to be used for the formation of embankment and the compacting equipment shall be the same that the Contractor will use for the main work.

The construction of embankment with any type of soil/material source shall be subject to written approval of the Engineer after the trial section made for that particular type of soil/material source.

The objective of these trials shall be to determine the optimum moisture content and the relationship between the number of passes of compacting equipment and density obtained for the soil types under trial and for the verification of the soil type itself. No separate payment will be made for this work, The Engineer-in-Charge may order additional compaction test sections when deems necessary

21.1.11 SUB-GRADE PREPARATION

21.1.11.1 General

The sub-grade preparation shall include that part of the work on which the sub-base is placed or in the absence of sub-base acts as the base of the pavement structure. It shall extend to the full width of the road bed including the shoulders and lay-byes as indicated on the drawings or as specified herein.

21.1.11.2 Construction Requirements

a) Prior Works

Before commencing the work all structures such as culverts, drains, ditches (including fully compacted backfill over them) outlets for drainage, head walls/wing walls of culverts and any other minor structure which will be below thirty (30) centimetres of existing sub-grade level or all the structure which will be below (30cm) of newly placed sub-grade level, shall be in such operative conditions as to ensure prompt and effective drainage and to avoid damage to sub-grade by surface water.

No work of sub-grade preparation will be started before the prior work herein described has been approved by the Engineer-in-Charge.

b) Compaction Requirement

All materials down to a depth of 30 cm below the sub-grade level in earth cut or embankment shall be compacted to at least 95 percent of the maximum dry density as determined according to AASHTO T-180 Method 'B' or 'D' whichever is applicable or corresponding relative density as per ASTM D-4254-83.

c) Sub-grade Preparation in Earth Cut

In case bottom of subgrade level is within thirty (30) cm of the natural ground, the top ~ fifteen (15) cm material shall be removed and stockpiled at a nearby location. The exposed surface shall then be scarified, broken up, adjusted to optimum moisture content and compacted to minimum density of ninety five (95) percent of the maximum dry density as determined by AASHTO T-180 Method D. Second layer of sub-grade shall then be prepared by incorporating the above mentioned stockpiled material to ensure that the depth of sub-grade layer is thirty (30) cm.

In case, the bottom of sub-grade is below the natural ground by more than thirty (30) cm, the material above the top of sub-grade shall be removed and subsequent layer of thirty (30) cm shall be prepared in two layers as per the method describe above.

In case, unsuitable material is encountered at the sub-grade level within the depth of Thirty (30) cm, the same shall be removed and replaced by the approved material. The Contractor shall be paid for removal of unsuitable material for replacement by approved material. Subgrade of thirty (30) cm shall in any case be prepared and compacted in two layers of fifteen (15) cm each.

d) Sub-grade Preparation in Rock Cut.

Excavation in solid rock shall extend to at least fifteen (15) centimetres below the sub-grade level. Rock shall be undercut neatly to required elevation and sections shown on the plans or as directed by the Engineer-in-Charge. Transverse and longitudinal profile checked by template shall be accurate to the specification, Cuts below sub-grade level shall be backfilled with selected sub-base material and compacted to at minimum ninety eight (98) percent of the maximum dry density as determined by AASHTO T-189, method 'D' at Contractor's own cost.

No rock shall be higher than two (2) centimetres above the undercut section elevation. The undercut material shall be placed in embankment or disposed off at the direction of Engineer-in-Charge.

e) Sub-grade in Embankment

When the sub-grade is formed in embankment, its width shall be the full width of top of embankment and material placed in the upper part of embankment down to a depth of thirty (30) centimetres below sub-grade level shall meet compaction requirement of Section (a). Soils having a minimum value of C.B.R of seven (7) percent and swell value of not more than 0.3 percent shall be used. The C.B.R less than 7% may be used in case, the design allows for it. Unsuitable material if encountered within the formation layer as per laboratory specified test, shall be removed, disposed of and replaced by suitable one as per direction of the Engineer-in-Charge for which no payment will be admissible to the Contractor. Rollers of approved size and type, accepted by the Engineer-in-Charge, shall be used for compaction. Water shall be added to obtain optimum moisture content, if necessary.

f) Sub-grade Level in Existing Roads

Where indicated on the drawings or directed by the Engineer-in-Charge that the existing road surface is to be used as the sub-grade, the correct elevation on which the base or sub-base is to be laid shall be obtained, where necessary, either by means of levelling course or by scarification. The levelling course shall be constructed to the requirements of the Engineer-in-Charge and paid for under the appropriate pay item involved. Scarification shall include disposal of any surplus material in the adjacent embankment or elsewhere as may be ordered by the Engineer-in-Charge. When the width of the new road is greater than that of the existing roads, surface shall be prepared as herein provided and the part that falls outside the existing road surface shall be prepared according to Sections (c), (d) and (e) above or Section (g) below as the case may be.

g) Sub-grade Extension

When the width of the existing pavement, either to be scarified or not, is insufficient to contain the sub-base or base to be placed upon it, the Engineer-in-Charge may order to strengthen and place the sub-base or base on one or both sides of the existing pavement. This work shall consist of the removal and disposal of any unsuitable material and its replacements with suitable material to such width and depth as required by the Engineer-in-Charge.

The excavated material shall, if declared suitable for use elsewhere in the embankment by the Engineer-in-Charge be so used. If declared unsuitable it shall be disposed off.

h) Protection of Completed Sub-grade

Any part of the sub-grade that has been completed shall be protected and well drained. Any damage resulting from carelessness of the Contractor shall be repaired as directed by the Engineer-in-Charge without additional payment.

The Contractor shall be responsible for all the consequences of traffic being admitted to the sub-grade. He shall repair any ruts or ridges occasioned by his own traffic or that of others by reshaping and compacting with rollers of the size and type necessary for such repairs. He shall limit the amount of sub-grade preparation to an area easily maintained with the equipment available. Sub-grade preparation and sub-base or base placing shall be arranged to follow each other closely. The sub-grade, when prepared too soon in relation to the placing of the sub-base, is liable to deteriorate, and in such case the Contractor shall, without additional payment, repair, reroll, or re-compact the sub-grade as may be necessary to restore it to the state specified herein.

(i) Templates and Straightedges, Tolerance Limits

The Contractor shall provide for the use of the Engineer-in-Charge, satisfactory templates and straight edges in sufficient numbers to check the accuracy of the work, as provided in these specifications and no subsequent work shall be permitted until the sub-grade levels and shape have been checked and approved by the Engineer-in-Charge. Tolerance limits shall be as follows:

Thickness + 20 mm, level + 0 & - 40 mm; 3 M straightedge 30 mm cross fall + 0.5 mm. Longitudinal grade in 30M + 0.1%.

(j) **Finishing Tolerances and Requirements**

Quality Assurance measuring or testing shall involve verification that the sub-grade is constructed, timely finished and trimmed in a neat, workmanlike manner to the lines, grades and typical cross sections shown on the Plans or staked by the Engineer-in-Charge within the required tolerances.

21.1.11.3 Granular Sub-Base Course

General

The work under these specifications shall consist of furnishing, spreading in one or more layers and compacting granular sub-base according to the specifications and drawings and/or as directed by the Engineer-in-Charge.

21.1.11.4 Material Requirements

Granular sub-base material shall consist of natural or processed aggregates such as gravel, sand or stone fragment and shall be clean and free from dirt, organic matter and other deleterious substances, and shall be of such nature that it can be compacted readily under watering and rolling to form a firm, stable sub-base.

The material shall comply to the following grading and quality requirements.

The sub-base material shall have a gradation curve within the limits for grading A, Band C given below. However grading A may be allowed by the Engineer-in-Charge in special circumstances.

Grading Requirements for Sub-base Material			
Sieve designation Standard / Alternate	Mass Percent Passing Grading		
(mm.) / inches	A	B	C
60.0(2 ½ inches)	100	-	-
50.0(2 inches)	90-100	100	-

25.0(1 inch)	50-80	55-85	100
9.5(3/8 inch)	-	40-70	50-85
4.75 (No. 4)	35-70	30-60	35-65
2.0 (No. 10)	-	20-50	25-50
0.425 (No. 40)	-	10-30	15-30
0.075 (No. 200)	5-15	5-15	5-15

(a) The Coefficient of Uniformity D60/D10 shall be not less than 3, where D60 and D10 are the particle diameters corresponding to 60% and 10%, respectively, passing (by weight) in a grain size analysis curve.

b) The Material shall have a CBR value of at least 50%, determined according to AASHTO T-193, The CBR value shall be obtained at a density corresponding to Ninety eight (98) percent of the maximum dry density determined according to AASHTO T-180 Method-D.

c) The coarse aggregate material retained on sieve No.4 shall have a percentage of wear by the Los Angeles Abrasion (AASHTO T-96) of not more than fifty (50) percent.

d) In order to avoid intrusion of silty and clayey material from the sub-grade in the sub-base, the ratio D15 (Sub-base)/D85 (Sub-grade) should be less than 5.
Where D85 & D15 are the particle diameters corresponding to eighty-five (85)% and fifteen(15)%, respectively, passing (by weight) in a grain size analysis, curve.

e) The fraction passing the 0.075mm (No. 200) sieve shall not be greater that two third of the fraction passing the 0.425mm (No. 40) sieve. The fraction passing the 0.425mm sieve shall have a liquid limit of not greater than 25 and a plasticity index of 6 or less.

f) If oversize is encountered, screening of material at source shall be done invariably and no handpicking shall be allowed. However handpicking may be allowed by the Engineer-in-Charge if oversize quantity is less then 5% of the total mass.

g) Sand equivalent for all classes shall be 25min.

21.1.11.5 Schedule of Material Sampling and Testing

Sampling & testing of the materials shall be done as per the following schedule:

- Gradation (AASHTO T-27); 3 samples from the source or one per thousand cubic meters.
- Plasticity index (AASHTO T-89 & T-90); 3 samples from the source plus as desired on the basis of visual inspection.
- CBR (AASHTO T-193); 3 samples from the source plus according to variation in gradation.
- Abrasion (AASHTO T-96); 3 samples from the source or one per 500 cum.
- Max density (AASHTO T-180); one per 1,000 Cu. m.

21.1.11.6 Construction Requirements

a) Spreading

Granular sub-base material shall be deposited on the roadbed or shoulders in a quantity which will provide the required compacted thickness without resorting to spotting, picking up or otherwise shifting the sub-base material.

Granular sub-base material shall be spread on approved sub-grade layer as a uniform mixture. Segregation shall be avoided during spreading and the final compacted layer shall be free from concentration of coarse or fine materials.

The aggregates shall be spread and compacted in one or more layers of thickness not exceeding 15 cm, and not less than 7.5 cm. All layers shall be spread and compacted in a similar manner.

Granular sub-base material shall be spread in uniform layers conforming to their transverse and longitudinal requirements. Hauling or placement of material will not be allowed during such weather or such road conditions which may cause cutting or rutting of sub-grade or contamination of sub base material.

b) Compaction Trial

Prior to commencement of granular sub-base operation, Contractor shall construct a trial length, not to exceed, five hundred (500) meters and not less than two hundred (200) meters with the same approved sub-base material as will be used during construction to determine the adequacy of the Contractor's equipment, loose depth measurement necessary to result in the specified compacted layer depths, the field moisture content, and the relationship between the number of compaction passes and the resulting density of the material.
In case the required results are not attained then the Contractor with the approval of the Engineer-in-Charge shall change the equipment and/or the procedure to achieve the required results.

c) Compaction

The moisture content of sub-base material shall be adjusted prior to compaction by watering with approved sprinklers mounted on trucks or by drying out, as required, in order to obtain the specified compaction.

The sub-base material shall be compacted by means of approved vibrating rollers or steel wheel rollers (rubber tyred rollers may be used as a supplement), progressing gradually from the outside towards the centre, except on super-elevated curves, where the rolling shall begin at the low side and progress to the high side. Each succeeding pass shall overlap the previous pass by at least one third of the roller width. While the rolling progresses, the entire surface of each layer shall be properly shaped and dressed with a motor grader, to attain smooth surface free from ruts or ridges and having proper section and crown. Rolling shall continue until entire thickness of each layer is thoroughly and uniformity compacted to specified density.

Any area inaccessible to rolling equipment shall be compacted by means of mechanical tampers, where the thickness in loose layer shall not be more than 10 cm.

If the layer of sub-base material or part thereof does not conform to the required finish, the Contractor shall, at his own expense, rework, water, and re-compact the material before next layer of the pavement structure is constructed.

Immediately prior to the placing of first layer of sub-base course the sub-grade (both under the travel way and the shoulders) shall conform to the required level and shape. Prior to placing the succeeding layer of the material, the top surface of previous layer shall be sufficiently moist to ensure bond between the two layers. The edges or edge slopes shall be bladed or otherwise dressed to conform to the lines and dimensions on the plans.

No material for construction of the sub-base shall be placed until the sub-grade has been approved by the Engineer-in-Charge.

d) Compaction Requirements

The relative compaction of each layer of the compacted sub-base shall not be less than ninety eight (98) percent of the maximum dry density determined according to AASHTO T-180 Method-D. The field density shall be determined according to AASHTO T-191 or other approved method. For all materials, the field density thus obtained shall be adjusted to account for oversize particles (retained on 19mm sieve) as directed by the Engineer-in-Charge. Also adjustment of any material retained on 4.75 mm sieve, AASHTO Method T-224 shall be used.

It shall be ensured that same size of sample is placed in oven for moisture determination in case of laboratory density (proctor) and field density. Moisture content for calculation of field density and proctor shall be observed on material passing 4.75 mm sieve. At least 4 density tests shall be carried out for each layer of 400 meters length.

e) Tolerances

The sub-base shall be compacted to the desired level and cross slopes as shown on the drawings. The allowable tolerance shall be +10mm or -20mm for the total thickness of the sub-base and + 0 mm or -25 mm for final level of the sub-base.

21.1.11.7 Measurement

The length and breadth shall be measured to the nearest centimetre. The depth of consolidated layer shall be computed to nearest half centimetre by taking average of depths at the centre and at 30 cm from the left and right edges at a cross section taken at 100 metre intervals or less as decided by the Engineer-in-Charge by making small pits. The consolidated cubical contents shall be calculated in cubic metres correct to two places of decimal.

The quantity of subbase to be paid for shall be measured by the theoretical volume in place as shown on the drawings or as directed and approved for construction by the Engineer, placed and accepted in the completed granular subbase course. No allowance will be given for materials placed outside the theoretical limits as shown on the cross-sections.

21.1.12 AGGREGATE BASE-COURSE

21.1.12.1 General

This item shall consist of furnishing, spreading and compacting one (1) or more layers of aggregate base on a prepared sub-grade, sub-base, or existing road surface, in accordance with the specifications and the drawings and or as directed by the Engineer-in-Charge.

21.1.12.2 Material Requirements

a) Aggregates

Material for aggregate base course shall consist of crushed hard durable gravel, rock or stone fragments. It shall be clean and free from organic matters, lumps of clay and other deleterious sub-stances. The material shall be of such a nature that it can be compacted readily under watering and rolling to form a firm, stable base for both flexible and rigid pavements.

The aggregate base shall comply to the following grading and quality requirements.

i) The gradation curve of the material shall be smooth and within the envelope limits' for Grading (A or B) given below:

Sieve designation Standard/ Alternate mm / (inches)	Mass Percent Passing Grading	
	A	B
50.0 (2 inches)	10	100
25.0 (1 inch)	7	75-95
9.5 (3/8 inch)	30-65	40-75
4.75 (No. 4)	25-55	30-60
2.0 (No. 10)	15-40	20-50
0.425 (No. 40)	8-20	12-25
0.075 (No. 200)	2-8	5-10

The material shall be well graded such that the coefficient of Uniformity D60/D10 shall be greater than four(4).

ii) Crushed Aggregate (material retained on sieve No.4) shall consist of material of which at least ninety (90) percent by weight shall be crushed particles, having a minimum of two (2) fractured faces.

iii) The Coarse aggregate shall have a wear by the Los Angeles Abrasion test (AASHTO T-96) of not more than forty (40); if overlaid by T.S.T and forty five (45) if overlaid by Asphaltic concrete.

iv) The material shall have a loss of less than twelve (12) percent when subjected to five cycles of the Sodium Sulphate Soundness test according to AASHTO T-104.

v) The sand equivalent determined according to AASHTO T-176 shall not be less than 45 and the material shall have Liquid Limit of not more than twenty five (25) and plasticity Index of not more than (6) as determined by AASHTO T-89 and T-90.

vi) The material passing the 19 mm sieve shall have a CBR value of a minimum eighty (80) percent, tested according to the AASHTO T-193. The CBR value shall be obtained at the maximum dry density determined according to AASHTO T-180, Method D.

vii) Laminated material shall not be allowed.

21.1.12.3 Filler Material

If filler, in addition to that naturally present in the aggregate base material is necessary for meeting the grading requirement or for satisfactory bonding of the material, it shall be uniformly blended with the base course material at the crushing plant or in a pug mill unless otherwise approved. The material for such purpose shall be obtained from sources approved by the Engineer-in-Charge. The material shall be free from organic matter, dirt, shale, clay and clay lumps or other deleterious matter and shall conform to the following requirements.

AASHTO Sieve	Percent Passing
3/8 inch	100
4	85-100
100	10-30
Plasticity Index (AASHTO – T-90)	6 Maximum
Sand Equivalent (AASHTO T-176)	30 Maximum

21.1.12.4 Schedule of Material Sampling & Testing

Sampling and testing of the material shall be done as per the following schedule:

- Gradation (AASHTO T.27); 3 per source plus 1 for each 1000 cum.
- Plasticity index (AASHTO T-89 & T-90); 3 per source plus as desired on the basis of visual inspection.
- CBR (AASHTO T-193); 3 per source plus as required on variation of aggregates.
- Abrasion (AASHTO T-96); 3 per source plus 1 for each 5000 cum.
- Sodium sulphate (AASHTO T-104); 3 per source plus 1 for each 5000 cum.
- Fractured faces; 3 per source plus as per visual inspection.
- Moisture density (AASHTO T-180); 1 for each 1000 cum.

21.1.12.5 Construction Requirements

a) Preparation of Surface for Aggregate Base Course

In case crushed aggregate base is to be laid over prepared sub base course, the sub base course shall not have loose material or moisture in excess to optimum moisture content.

b) Spreading

Aggregate base material shall be deposited on the roadbed in a quantity which will provide the required compacted thickness without resorting to spotting, picking up or otherwise shifting the base material. Aggregate base material shall be spread on approved sub-base layer as a uniform mixture. Segregation shall be avoided during spreading and the final compacted layer shall be free from concentration of coarse or fine materials.

The aggregates shall be spread and compacted in one or more layers of thickness not exceeding 15 cm, and not less than 7.5 cm. All layers shall be spread and compacted in a similar manner.

Aggregate base material shall be spread in layers conforming to the transverse and longitudinal requirements. Hauling or placement of material will not be allowed during such weather or such road conditions which may cause cutting or rutting of sub-grade or contamination of base material.

Moisture content determination shall conform in all respects to requirements specified in 21.1.10.4(d).

c) Trial Section

Prior to commencement of aggregate base course operations, a trial section of two hundred (200) meters minimum, but not to exceed five hundred (500) meters shall be prepared by the Contractor using same material and equipment as will be used at site to determine the adequacy of equipment, loose depth measurement necessary to result in the specified compacted layer depths, field moisture content, and relationship between the number of compaction passes and the resulting density of material.

d) Compaction

The moisture content of base material shall be adjusted prior to compaction by watering with approved sprinklers mounted on trucks or by drying out, as required, in order to obtain the specified compaction. The base material shall be compacted by means of approved vibrating rollers or steel wheel rollers (rubber tyre rollers may be used as a supplement) progressing gradually from the outside towards the centre, except on super-elevated curves, where the rolling shall begin at the low side and progress to the high side. Each succeeding pass shall overlap the previous pass by at least one third of the roller width. While the rolling progresses, the entire surface of each layer shall be properly shaped and dressed with a motor grader, to attain surface free from ruts or ridges and having proper section and crown. Rolling shall continue until entire thickness of each layer is thoroughly and uniformity compacted to specified density. Any area inaccessible to rolling equipment shall be compacted by means of mechanical tampers, where the thickness in loose layer shall not be more than 10 cm.

If the layer of base material, or part thereof does not conform to the required finish, the Contractor shall, at his own expense, rework, water, and re-compact the material before next layer of the pavement structure is constructed. Immediately prior to the placing of first layer of base course the sub-base top (both under the travel way and the shoulders) shall conform to the required level and shape. Prior to placing the succeeding layers of the material the top surface of the previous layer shall be sufficiently moist to ensure bond between the two layers. The edges or edge slopes shall be bladed or otherwise dressed to conform to the lines and dimensions on the plans.

No material for construction of the base course shall be placed until the sub-base has been approved by the Engineer-in-Charge.

e) Compaction Requirements

The relative compaction of each layer of the compacted base shall not be less than 100 percent to the maximum dry density determined according to AASHTO T-191 or other approved method. For all materials, the field density thus obtained shall be adjusted to account for oversize particles (retained or 19 mm sieve) as directed by the Engineer-in-Charge. Also for adjustment of any material retained on 4.75 mm sieve, AASHTO Method T-224 shall be used. Moisture content for calculation of field density shall be observed on material passing 4.75 mm sieve. At least density tests shall be carried out on each layer of 400 meters.

f) Maintaining Base Course

Completed base course shall be maintained in an acceptable condition at all times until prime coat is applied. When base course is to carry traffic for an indefinite length of time before receiving surfacing, the Contractor shall maintain the surface until final acceptance by wetting, balding, rolling and addition of lines as may be required to keep the base tightly bound and leave a slight excess of material over the entire surface which must be removed and the surface finish restored before application of prime coat.

g) Tolerances

The completed base course shall be tested for required thickness and smoothness before acceptance. Any area having waves, irregularities in excess of one (1) cm in three (3) M or two (2) cm in fifteen (15) M shall be corrected by scarifying the surface, adding approved material, reshaping, re-compacting and finishing as specified. Skin patching of an area without scarifying the surface to permit proper bonding of added material shall not be permitted. The allowable tolerances shall be +5mm or -10mm for the total thickness of the base course and + 5mm or 10mm in the final level of the base course.

21.1.12.6 Brick Ballast Sub-base or Base-Course

a) Where specified the brick ballast of size 1 ½" to 2" (3.75mm – 50mm) made out of first class bricks complying with the requirements of Section 11 – Brickwork shall be used as sub-base & base material for construction of roads.

b) The brick ballast shall be placed in layer of 6" for thickness as specified. The preparation of sub-grade shall meet the provisions of Section 21.1.9 or as specified. Brick bats shall be raked off the stack with rakes to clear of mud and dust if any. The brick ballast shall be spread evenly over the prepared surface to the required depth with a finishing material to avoid segregation. Brick ballast shall be carefully laid and packed, bigger size being placed at the bottom to 3" depth unless specified otherwise, after the area shall be grouted with fine sand.

c) The brick ballast shall be consolidated by dry rolling with 3 ton or light weight power roller and or as directed by the Engineer-in-Charge.

21.1.12.7 Measurement

The length and breadth shall be measured to the nearest centimetre. The depth of consolidated layer shall be computed to nearest half centimetre by taking average of depths at the centre and at 30 cm from the left and right edges at a cross section taken at 100 metre intervals or less as decided by the Engineer-in-Charge by making small pits. The consolidated cubical contents shall be calculated in cubic metres correct to two places of decimal.

The quantity of Brick Ballast Sub-base or Base-Course to be paid for shall be measured by the theoretical volume in place as shown on the drawings or as directed and approved for construction by the Engineer, placed and accepted in the completed Brick Ballast Sub-base or Base-Course. No allowance will be given for materials placed outside the theoretical limits as shown on the cross-sections.

21.1.13 WATER BOUND MACADAM BASE-COURSE

21.1.13.1 General

This work shall consist of furnishing and placing one or more courses of clean crushed stone base mechanically interlocked by rolling, and voids thereof filled with screening with the assistance of water, laid on a prepared sub-grade, sub base, or existing pavement in conformity with the lines, grades and. cross-sections shown on the drawings.

21.1.13.2 Material Requirements

a) **Coarse Aggregates**

Coarse aggregates either crushed or broken stone shall conform to the quality requirements as specified hereunder except that no CBR testing is required. The gradation curve of the coarse aggregates shall be within the envelop limits as follows:

US Standard Sieve Sizes	Percent Passing by weight		
	Class-A	Class-B	Class-C
102mm (4")	100	_	_
89 mm (3-1/2")	90-100	_	_
76 mm (3")	_	100	_
63.5 mm (2-1/2")	25-60	90-100	100
50 mm (2")	_	25-75	90-100

37.5 mm (1-1/2")	0-15	0-15	35-70
25 mm (1")	_	_	0-15
19 mm (3/4")	0-5	0-5	_
12.5 mm (1/2")	_	_	0-5

Los Angeles Abrasion Value shall not exceed 45% and Flakiness Index shall not exceed 15%; co-efficient of uniformity shall be greater than four (4); 90% of the particles shall have at least 2 faces crushed; soundness test shall not produce loss more than 12% and CBR value of material passing 19 sieve shall not be less than 80%.

b) **Fine Aggregates**

Fine aggregates (filler material or screenings or murum) shall consist of natural sand or crushed stone screenings free from clay lumps, dirt and other objectionable material. The fine aggregate shall be of the following gradation:

US Standard Sieve Sizes	Percent Passing by weight
9.5mm (3/8 inch)	100
4.35mm (No. 4)	85-100
0.15mm (No. 100)	10-30

The material passing No. 40 sieve shall have Liquid Limit of not more than 25 & Plasticity Index of not more than 6.When more than one layer is required to complete the Macadam course to the thickness shown on the drawings, each layer shall be constructed as prescribed before.

21.1.13.3 Physical Requirements

The additional physical requirements of coarse aggregates for water bound macadam will satisfy the following limits:-

a. Los Angeles Abrasion Value Max 45%
b. Flakiness Index Max 15%
c. The loss when subject to five cycles of the Sodium Sulphate Soundness test. (AASHTO T-104) shall be less than twelve (12).

21.1.13.4 Binding Material

Binding material to prevent ravelling of water bound macadam shall consist of fine grained material passing 100 percent through sieve # 40 and possessing Plasticity Index (P.I) value of four to nine (4-9) when the Water Bound Macadam (WBM) is to be used as a surfacing course, and up to 6 when WBM is being adopted as sub-base/base course with bituminous surfacing. If lime stone formations are available nearby, lime stones dust or as directed by the Engineer, may be used fully employed for this purpose.

21.1.13.5 Construction Requirements

a) Equipment

Any combination of machines or equipment that will produce the results meeting these specifications may be used with the approval of the Engineer-in-Charge. These include mechanical spreaders, water sprinklers and rollers/compactors.

b) Structure Preparation

Preparation of surface for water bound macadam shall be carried out in the same manner as for aggregate base course Sub-Section 21.1.11.5(a).

Where the existing road surface is black topped, 50 mm x 50 mm furrows shall be cut in the existing surface at one (1) meter intervals at forty five (45) degree to the centre line of the carriage-way before proceeding with the laying of coarse aggregates.

Before starting with WBM Construction, necessary arrangements shall be made for the lateral confinement of aggregates. One method is to construct side shoulders in advance to a thickness corresponding to the compacted layer of the WBM course. After shoulders are ready, there inside edges may be trimmed vertical and the included area cleaned of all spilled material thereby setting the stage for spread of coarse aggregates. The practice of constructing WBM in a trench section excavated in the finished formation must be avoided.

c) Spreading and Compaction

Crushed stone shall be deposited and spread on the prepared surface to the proper depth so that the compacted layer will not exceed two and a half (2.5) times the thickness of maximum aggregate size. Each layer shall be inspected thoroughly before rolling to detect high or low spots. Crushed stones shall be added or shifted to provide a true surface. The course aggregate layer, after being laid to proper thickness, shall be lightly rolled sufficient only to establish the required grade and level of the stones.

Spreading of the coarse aggregates shall be followed by rolling with a smooth wheel roller weighing at least 10 tons. Rolling shall begin at the lower edge of the shoulders to lock the stones firmly at the edge then progress gradually towards the centre line. Rolling shall continue until the aggregate is well keyed and does not creep ahead of the roller.

In no case, shall coarse aggregates be stored in heaps directly on the area where these are to be laid nor shall the hauling over a partly completed base be permitted, however dumpers shall be allowed at the construction area where the material will be spread quickly after dumping.

Following the initial rolling, dry screenings shall be applied uniformly over the surface. Dry rolling shall be continued while screenings are being applied. The surface shall be swept with mechanical or hand brooms to aid spreading of the screenings.

When the interstices in the coarse aggregate are filled with screening, the surface shall be sprinkled with water until it is saturated. The rolling, sprinkling and application of additional screenings shall continue until a grout is formed that fills all the voids and forms a wave of grout in front of the roller. When more than one layer is required to complete the Macadam base course to the thickness shown on the drawings, each layer shall be constructed as before prescribed.

d) Construction Control Testing

Tests for compliance with the requirements of materials will be as deemed necessary and to the satisfaction of the Engineer-in-Charge.

e) Maintenance

The completed base course shall be maintained in an acceptable condition until the necessary subsequent treatment is applied.

21.1.13.6 Measurement

The length and breadth shall be measured to the nearest centimetre. The depth of consolidated layer shall be computed to nearest half centimetre by taking average of depths at the centre and at 30 cm from the left and right edges at a cross section taken at 100 metre intervals or less as decided by the Engineer-in-Charge by making small pits. The consolidated cubical contents shall be calculated in cubic metres correct to two places of decimal.

21.1.14 CRUSHED STONE SOLING

21.1.14.1 Stones

The stones shall be clean, hard stones, free from decay and weathering. They shall be in block and hammer dressed on all sides. The sizes of the stones unless otherwise specified shall be approximately 22.5 cm. in depth and not less than 15 cm. in any other direction.

21.1.14.2 Preparation of Surface

The stones shall be placed on sub-grade prepared as specified under Sub-section 21.1.9. The sides and bottom of sub-grade shall be brought to the required slope and gradient and shall be compacted to a firm and even surface.

21.1.14.3 Laying of Stone

The depth of stone laid shall be of 22.5 cm. depth unless specified otherwise. Profiles shall be put up by means of pegs and strings or by placing stones, at intervals of not more than 15 meters. The stones shall then be laid closely in position in between the profile and firmly embedded with joints staggered and with exposed faces true to line, gradient and in uniform slope throughout.

Cross bands of approximately 22.5 cm. width through bond stones equal to the full depth shall be provided at an interval of approximately 3 metres centre to centre both longitudinally and transversely.

The interstices between adjacent stones shall be packed with stones, spawls & chips of proper size, well driven in with crow bars to ensure tight packing and complete filling of all interstices. Such filling shall be carried simultaneously with the placing in position of the large stones and shall in no case be permitted to fall behind. Final wedging shall be done with the largest sized chip practicable, each chip being well driven home with a hammer so that no chip is possible of being picked up or removed by hand.

21.1.14.4 Measurement

The length and breadth shall be measured to the nearest centimetre. The depth of consolidated layer shall be computed to nearest half centimetre by taking average of depths at the centre and at 30 cm from the left and right edges at a cross section taken at 100 metre intervals or less as decided by the Engineer-in-Charge by making small pits. The consolidated cubical contents shall be calculated in cubic metres correct to two places of decimal.

21.1.15 BRICK SOLING

21.1.15.1 General

The brick soling of road shall consist of laying a course of burnt brick over prepared sub-grade and filling the interstices with sand.

21.1.15.2 Materials

a) Bricks

The bricks shall conform to the provisions of Section 11 – brickwork as specified. They shall be well burnt, rather slightly over-burnt without being vitrified. They shall be of uniform colour, regular in shape and size, with sharp and square corners and parallel faces. They must be homogenous in texture and emit a clear ringing sound when struck. They shall be free from flaws and cracks. They shall not absorb more than 1/6th of their weight of water after being soaked for one hour and shall show no signs of efflorescence on drying. Compressive strength shall not be less than 2000 pounds per square inch or 140.62 Kgs./ Sq. cm.

b) Sand

Sand shall be used for filling joints between the bricks. It shall conform to Specification 11.7.2(ii) – Cement Mortar – Brickworks.

c) Water

Water for mortar shall conform to specification 11.7.2(ii) Cement Mortar – Brickwork.

21.1.15.3 Construction Requirements

a) **Preparation of Sub-grade**

The sub-grade shall be constructed in accordance with clause 21.1.9 of this Section.

The sub-grade shall have a camber of 1:60 except at curves where requisite super-elevation shall be given.

b) **The Construction Procedure**

The centre line of the proposed road shall be marked on the sub-grade and necessary level pegs shall be fixed every 25 feet along the sides of the road. Bricks shall be laid on edge 4.5 inches thick. A 3 inches wide and 9 inches deep brick on end edging shall be laid on both sides of the brick on edge soling. A string course of 9 inch brick on edge shall be laid on both sides of the trench as well as in the centre parallel to the centre line of the roads. The bricks shall be laid diagonally towards the centre line of the road between the string courses and to correct levels. Bricks shall be laid by the masons with close fine joints and shall be set properly with wooden mallets. All joints shall be evenly spaced and laid diagonally to the centre line of the road. The direction of the diagonals shall be changed every 25 feet and each section shall be broken by a cross string course 9 inches wide bricks on edge. After the bricks have been laid and approved by the Engineer-in-charge, the joints shall be carefully filled with clean sand.

21.1.15.4 Measurement

The length and breadth shall be measured to the nearest centimetre. The depth of consolidated layer shall be computed to nearest half centimetre by taking average of depths at the centre and at 30 cm from the left and right edges at a cross section taken at 100 metre intervals or less as decided by the Engineer-in-Charge by making small pits. The consolidated cubical contents shall be calculated in cubic metres correct to two places of decimal.

21.1.16 CRACK – RELIEF LAYER

21.1.16.1 General

The work shall consist of constructing a layer of graded crushed aggregate or asphaltic open-graded plant mix on a prepared soil-cement base course in accordance with these specifications and in conformity with the lines, grades, thicknesses and typical cross sections shown on the Drawings.

21.1.16.2 Material Requirements

a) Aggregates

Material for graded crushed aggregates shall in all respects conform with the requirements specified under 21.1.11 with the following exceptions and supplementary requirements:

i. The portion of the aggregate retained on the 9.5 mm. (3/8 inch) sieve shall not contain more than 10 percent by weight of flat and/or elongated particles (ratio of maximum to minimum dimension = 2.5:1).
ii. Crushed aggregates shall consist of particles with not less than Ninety (90) percent of the portion retained on the 4.75 mm. (No.4) sieve having at least two fractured faces.

Aggregates for the asphaltic open-graded plant mix shall conform to the requirements of 21.1.12 with the following exceptions:

Fine aggregates and mineral filler will be required. Sand equivalent and plasticity requirements are not applicable.

b) Asphaltic Material

Asphaltic binder shall be asphalt cement, 60-70 penetration grade, meeting the requirements of AASHTO M-20.

c) Asphaltic Open-Graded Mixture

The composition of the asphaltic open-graded crack-relief layer shall meet the following criteria:

AGGREGATE GRADING REQUIREMENTS		
Sieve Designation		Percent Passing
mm	inch	by Weight
50	2	100
37.5	1-1/2	75-90
19	¾	50-70
4.75	No. 4	8-20
0.15	No.100	0-5
Asphalt Cement content of total Mix		2-3% by weight
Mixing Time		30 seconds (maximum)
Mix Design		Within Master Range Gradation

The exact percentage of asphalt cement content shall be such that at least Ninety five (95) percent coating of aggregates will be achieved when tested in accordance with AASHTO T–195.

21.1.16.3 Construction Requirements

Prior to construction of the crack-relief layer (CRL) the completed base course shall be duly accepted by the Engineer-in-Charge.

21.1.16.4 Graded Crushed Aggregate

Construction of this layer shall conform in all respects to the requirements specified under Item 21.1.11.

A Asphaltic Open-Graded CRL

Construction of this layer shall conform in all respects to the requirements specified under Item 21.1.23 except as provided below:

a) Compaction shall be accomplished by ten (10) Ton steel Wheeled tandem rollers. A maximum of three complete coverage, or as otherwise directed by the Engineer-in-Charge shall be sufficient. No density test will be required, however the compaction shall be achieved in the same manner as displayed in the total test and to satisfaction of the Engineer-in-Charge.

b) The consistency and temperature of the mix shall be such controlled that it does not squeeze out or move under the pressure of compacting roller. For this purpose, trial reaches shall be prepared by the contractor to fix the above parameters.

   In order to ensure the stability of CRL before the placement of any subsequent layer or opening of a layer to traffic, a priming time of 4 days in hot weather will be allowed. This time may be reduced to two days where the lower temperature allows.

c) All traffic shall be kept off this layer until a subsequent layer has been placed on it. Any damage caused by traffic moving directly on the crack-relief layer shall be the responsibility of the Contractor and all necessary repair work thereto shall be at the Contractor's expense.

21.1.17 GEOTEXTILES

21.1.17.1 General

The work covered by this section shall consist in furnishing all material, labour, equipment and placing of Geo-textiles on prepared surfaces complete in accordance with the specifications for the work items involved, in thickness and to the dimensions shown on the typical cross-section of applicable drawings or as directed by the Engineer-in-Charge.

21.1.17.2 Geotextile Functions

Where indicated on the drawings or directed by the Engineer-in-Charge, Geotextile will be placed to perform one or more of the following functions.

- On road foundation for the purpose of separation between road fill material and soft underlying soils in order to eliminate the need for removal of poor subsoil material and quick and effective drainage of soil-fill interface.
- For subgrade stabilization and increasing soil shear strength by providing bonding mechanism of the Geotextile-soil system.
- As a filter for all drainage systems where a danger of clogging by fine particle of adjacent soil is possible. The Geotextile will retain the particles from passing whilst allowing the seepage water to pass through.
- As a filter element for all bodies of water where the soil can be eroded by current, wave action or changing water levels.
- For permanent protection of synthetic sealing systems (Geo-membrane) against mechanical damage during installation and after completion of construction.

21.1.17.3 Material Requirements

1. **Composition and Environmental Behaviour**

   The raw material of Geotextile shall be Ultra Violet stabilized polypropylene. The fibres shall consist of continuous filaments of approximately 40 micron diameter and mechanically bonded by needling. The Geotextile material shall be resistant to acid and alkaline media in the pH range 2 to 13, resistant to lime, cement and concrete, resistant to all naturally occurring bacteria and fungi. A prolonged outside exposure of several months shall have no effect on the properties of Geotextile.

2. **Mechanical and Hydraulic Properties**

   - To ensure free drainage, the geotextile shall have high water permeability.
   - Geotextile shall offer high retention capability for almost all types of soils.
   - The geotextile shall have optimum stress-strain behaviour even with low unit weight for high resistance against installation damage.

21.1.16.4 Construction Requirements

a. Preparation

The surface shall be fairly levelled before placement of Geotextile. It is to be ensured that there are no protruding stones which may damage the geotextile fabric.

b. Geotextile Placement

The Geotextile shall be rolled out directly on top of the prepared surface in a manner as recommended by the manufacturer. It shall be over lapped at the edges as shown on the drawings or as recommended by the manufacturer.

c. Placement of Fill

The first layer of fill material shall be applied by overhead placement. Traffic on the geotextile itself shall be avoided. Necessary precautions shall be observed to ensure that geotextile shall not be damaged during placement.

d. Spreading

Spreading of fill material shall be done with suitable equipment and procedure ensuring that geotextile must not be damaged by high axle load stresses of spreading equipment travelling on sharp fill over the geotextile.

e. Compacting

The compacting method (Static/ Dynamic) shall be suited to sub-grade/ fill material.

f. Jointing of Geotextile Panels

A tension joint shall be achieved by overlapping, welding or sewing as shown on drawings or approved by the Engineer-in-Charge.

g. Overlapping

Overlapping width shall not be less 30 cm on even surface and 50 cm on uneven surface. In order to avoid displacing the geotextile during backfill over end panel joints, the connecting panel must be placed underneath the end of the previously rolled out geotextile.

h. Welding

Welding width shall not be less than 10 cm. A wide pattern gas torch shall be used at a low temperature and about 20 cm from the geotextile. The welded geotextile section shall be continuously pressed down by walking on it during placement.

i. Sewing

The stitching method shall be single thread, double thread or butterfly type suitable to geotextile thread type and strength. The thread shall be sufficiently tightened and stitch density shall be three to six stitches per inch.

21.1.17.4 Geotextile Function for Repaving

This section deals geotextiles placed between old pavement and new asphalt overlay, along with suitable tack coat of bitumen. Where indicated on drawings or directed by the Engineer-in-Charge, geotextile will be placed to perform one or more of the following functions:

- To ensure proper adhesion between old pavement and new asphalt overlay & thus reducing the overall flexural tensile stresses and increasing life of road surface.
- As a cut off layer for the prevention of propagation of cracks in the pavement.
- As water barrier, even under high pressure to stop reflective cracking in the pavements.

1. Construction Requirements
    - Removal of dirt, dust and vegetation from wearing surface and cracks.
    - Filling potholes and larger cracks (>5mm) with hot mix or an adequate filler.
    - Removal of sharp or craggy edges on surface.
    - On badly damaged roads, a level course of approximately 1.5 cm shall be laid to avoid the labour intensive and time consuming operation of crack filling.

2. Applying the tack coat

    Depending on the condition of the old surface, a calculated amount of tack coat approximately 1.1 kg/m^2 active binder is to be sprayed evenly on the prepared surface before laying geotextile, making sure that:-
    - The bitumen is applied beyond the width of the geotextile by about 5 cm on either side.
    - The spraying temperature for pure bitumen is kept between 150^{o}C and 170^{o}C to achieve a coating as even as possible.
    - When using bitumen emulsion, the coating amount is adjusted to contain the required average amount of bitumen.
    - The coating is only applied to areas where the paving felt is to be laid.
    - No additional pre-spray agent is applied on top of the paving felt.
    - Where only sections for the road are covered with the paving felts, their surfaces must be gritted.

3. Laying Geotextile

    Geotextile shall be laid by hand or machine taking into account that:
    - When using pure bitumen as tack coat, Geotextile may be laid immediately after coating.
    - When using bitumen emulsion, Geotextile shall not be laid until the emulsion has cured.
    - Wrinkles shall be avoided.

- Edges lengthways and across will be overlapped by 5-10 cm, an additional pure bitumen binder of 0.9 kg/m^2 shall be applied on the overlapping seams.
- Transverse overlapping is to be carried out with reference to the direction in which the asphalt finisher will proceed i.e. under the previous one so that the felt does not shift out of place when the asphalt concrete is applied.
- When one half of the road is made (leaving the other open to traffic), at least 25 cm of the lengthways felt edge shall remain uncovered to allow overlapping when laying the other half of the road.
- During short time stoppages of construction work, the road under construction shall be opened only to slow traffic without detriment to Geotextile.
- Rain water on the Geotextile surface shall be allowed to evaporate before applying a top layer.

4. Applying the Asphalt Concrete Surface

The asphalt concrete surfacing shall be applied immediately after laying Geotextile preferably by crawler type finisher, taking the following points into consideration.

- The material mix shall have a temperature between 145^{o}C and 165^{o}C.
- To avoid types of the finisher or truck sticking to the felt (which can happen in hot climates or where too much tack coat has been applied), some of the mix can be spread manually in the pathway of the vehicles.

21.1.17.5 Geotextile testing

Geotextile testing shall be in accordance with the following standard test method.

Properties	Standard
Weight	ASTM D-3776
Thickness	ISO 9863
CBR Puncture Resistance Test	BS 6906/4
Strip Tensile test	ASTM D-4595
Grab Tensile Test	ASTM D-1682
Tear strength test	ASTM D-1682
Penetration resistance test (drop test)	NT Build 243
Vertical permeability	BS 6906/3
Pore size	E DIN 60500/6

Based on the required functions and the type of stresses, the contractor shall propose the type of geotextile. The contractor shall furnish technical literature and manufacturer's certificates of guarantee for the type of geotextile material for approval of Engineer –in-charge prior to delivering the material to the site. The certificate shall note compliance to the specifications and shall state the result of the test performed on the material, as required by the specifications.

21.1.17.6 Measurement

The length & breadth of the area of Geotextile of specified thickness has been provided shall be measured correct to a centimeter and the area shall be calculated in square metres correct to two decimal places.

21.1.18 INTERLOCKING CONCRETE PAVING BLOCKS

21.1.18.1 General

The work shall consist of precast concrete paving blocks intended for the construction of low speed roads, parking areas, lay byes, industrial and other paved surfaces subjected to all categories of static and vehicular loading and pedestrian traffic. Paving blocks covered by these

Specifications are designed to form a structural element and the surfacing of pavements having the block to block joints filled, so as to develop frictional interlock and placed in conformity with the lines, grades, thicknesses and typical cross-section shown on the drawings or as directed by the Engineer-in-Charge.

21.1.18.2 Material Requirements

For execution of this item provisions made in BS 6717 shall be applicable. Detailed requirement of materials and construction shall be as under:

1. Binders and Binder Constituents

Paving blocks shall be made using one or more of the following binders or binder constituents complying with the requirements of the relevant standards:

Section	Description	Section	Standard
21.2	Ordinary Portland Cement	21.3	BS 12
21.4	Portland Blast-furnace	21.5	BS 146:
21.6	Portland Pulverized Fuel ash	21.7	BS 6588
21.8	Pulverized fuel ash	21.9	BS 3892:
21.10	Ground granulated blast-	21.11	BS 6699

Where pulverized fuel ash is used, the proportions and properties of the combination with Portland cement shall comply with as BS 6588. Where ground granulated blast furnace slag is used, the proportions and properties of the combination with Portland Cement shall comply with BS 146: Part 2.

Aggregates

Paving blocks shall be made using one or more of the following aggregates complying with the relevant standards:

Section	Description		Standard
21.2	**Natural Aggregates** (Crushed or Uncrushed)	21.4	**BS : 882 : 1983** (except grading requirement in clause 5)
21.5	Air Cooled blast-furnace slag	21.6	**BS 1047 : 1083** (except grading requirement in 4.8)
21.7	**Pulverized Fuel Ash** Ground granulated blast-furnace slag	21.8	BS 3892 : Part-1 or Part-2 BS 6699

a) Acid Soluble Material (Fine Aggregate)

When tested as described in BS 812 : Part 119, the fine aggregate (material passing a 4.75 mm sieve complying with BS 410) shall contain no more than 25% by mass of acid soluble material either in the fraction retained on or in the fraction passing, a 600µm sieve.

b) Water

The water shall be of drinking quality or in accordance with the provisions in Sub-Section 5.3.1.6 under Plain & Reinforced Concrete.

c) Admixtures and Pigments

Proprietary accelerating, retarding and water reducing agents shall comply with Sub-Section 5.3.1.7 under Plain & Reinforced Concrete. Pigments shall comply with BS 1014.

Calcium chloride shall comply with BS 3587.

d) Finishes

The finish should be agreed between the manufacturer and the Engineer-in-Charge. Concrete described as “natural colour” shall contain no pigment.

In composite paving blocks the surface layer shall be formed as an integral part of the block and shall be not less than 5 mm thick.

e) Binder Content

The cement content of the compacted concrete shall be not less than 380 kg/m^3. For equivalent durability, paving blocks made with binder constituents other than ordinary Portland cement shall have higher binder content than paving blocks made in a similar way using only Portland Cement. The Engineer-in-Charge will decide the additional binder content. The compressive strength test will be the only guide to the amount of additional binder needed.

21.1.18.3 Sizes and Tolerances

1. Sizes

Paving blocks shall have a work size thickness of not less than 60 mm Type-R blocks shall be rectangular with a work side of 200 mm and a work side width of 100 mm Type-S blocks shall be of any shape fitting within a 295 mm square coordinating space and shall have a work size width not less than 80mm.

The preferred thicknesses are 60 mm, 65 mm, 80 mm & 100 mm.

A chamfer around the wearing surface not exceeding 7mm in width or depth shall be permitted. All arises shall be of uniform shape.

2. Tolerances

The maximum dimensional deviations from the stated work sizes for paving blocks shall be as follows:

Length	$\pm$ 2mm
Width	$\pm$ 2mm
Thickness	$\pm$ 3mm

Where a paving block includes profiled sides, the profile shall not deviate from the manufacturer's specification by more than 2mm.

21.1.18.4 Compressive Strength

The average compressive strength of paving blocks shall be not less than 49 N/mm^2 (7000 psi) and the crushing strength of any individual block shall be not less than 40 N/mm^2 (6000 psi).

21.1.18.5 Sampling

The following sampling procedure shall be used for the compressive strength test.

a) Before laying paving blocks, divide each designated section, comprising not more than 5000 blocks, in a consignment into eight approximately equal groups. Clearly mark all samples at the time of sampling in such a way that the designated section or part thereof and the consignment represented by the sample are clearly defined. Take two|(2) blocks from each group.

b) Dispatch the sample to the test laboratory, taking precautions to avoid damage to the paving blocks in transit. Each sample shall be accompanied by a certificate from the person responsible for taking the sample, stating that sampling way carried out in accordance with this Part of BS 6717.

c) Protect the paving blocks from damage and contamination until they have been tested. Carry out any tests as soon as possible after the sample has been taken.

21.1.18.6 Marking

The following particulates relating to paving blocks made in accordance with this standard shall be indicated clearly on the delivery note invoice, manufacturer's or supplier's certificate or brochure supplied with the consignment of blocks:

a) The name, trade mark or other means of identification of the manufacturer.

b) The number and date of this British Standard, i.e. BS 6717: Part 1 : 1986*; or latest revision.

21.1.18.7 Construction Requirements

1. Laying the Paving Blocks

   The total area to be covered with paving block shall be prepared by:

   a) Compaction of sub-grade
   b) Laying of sub-base in a thickness specified
   c) Laying of crushed aggregate base or lean concrete in thickness as per typical section.

2. Tolerance

   Tolerance of these layers shall be as per applicable requirement of each item of this specifications.

3. The total area will thereby be divided with nylon strings into sectors of not more than 1.5 square meters. This shall be done to control the alignment of paving blocks and to avoid multiplication of deviation in sizes of paving blocks.

   Payment for each of the above item shall be made under the relative item of work.

21.1.18.8 Measurement

The length & breadth of the area of interlocking Paver Blocks of specified thickness has been provided shall be measured correct to a centimeter and the area shall be calculated in square metres correct to two decimal places.

21.1.19 ASPHALTIC MATERIALS

21.1.17.1 Asphalt Cement

Asphalt Cement shall be an oil asphalt, or a mixture of refined liquid asphalt and refined solid asphalt, prepared from crude asphaltic petroleum. It shall be free from admixture with any residues obtained by the artificial distillation of coal, coal tar, or paraffin and shall be homogeneous and free from water. No emulsification shall occur when a 30 gram sample is boiled for 2 hours with 250 cubic centimetres of distilled water in a 500 cubic centimetres Erlenmeyer flask equipped with a reflex condenser.

Asphalt Cement shall be classified by penetration and when tested in accordance with the standard methods of tests of the AASHTO, the grades of asphalts shall conform to .the requirements set forth in Table 21(a) and 21(b). The grade of asphalt to be used shall be in accordance with these specifications or the Special Provisions or as directed by the Engineer-in-Charge.

21.1.17.2 Environmental Factors

In area where highly frost susceptible soils and severe low temperature conditions are encountered, it may be necessary to remove and replace soils susceptible to frost heave or take other precautions prior to pavement construction. In extremely hot climates, asphalt mixes should be designed to resist rutting and maintain stiffness at high temperatures.

Because asphalt mixtures are influenced by temperature, it is recommended that different asphalt grades be used where different temperature conditions prevail. Table below gives recommended asphalt grades for various temperature conditions.

SELECTING ASPHALT GRADE

Temperature Condition	Asphalt Grade $\pm$
Cold, mean annual air temperature $\leq$ 7°C(45°F)	AC-10, AR-4000, 80 / 100 pen.
Warm, mean annual air temperature between 7°C (45°F) & 24°C (75°F)	AC-20, AR-8000, 60 / 70 pen.

Hot, mean annual air temperature $\geq$ and 24ºC (75ºF)	AC-40, AR-8000, 40 / 50 pen.

Both medium setting (MS) and slow setting (SS) emulsified asphalts are used in emulsified asphalt base mixes. They can be either of two types; cationic (ASTM D-2397 or AASHTO M-208) or anionic (ASTM D-977 or AASHTO M-140). Selecting one of the two shall depends on the type of aggregate used for better affinity.

The grade of emulsified asphalt is selected primarily on the basis of its ability to satisfactorily coat the aggregate. This is determined by coating and stability test (ASTM D-244, AASHTO T-59). Other factors important in the selection are the water availability at the job site, anticipated weather at the time of construction, the mixing process to be used, and the curing rate.

21.1.17.3 Cut-Back Asphalt

Liquid asphalts (cut-back) shall consist of materials conforming to the following classifications. When tested in accordance with the standard methods of tests of the AASHTO, the grades of liquid asphalt shall conform to the requirements specified in the Tables 21(c) and 21(d). Medium curing products designated by letters MC, shall consist of asphalt cement fluxed or blended with a kerosene solvent. Rapid curing products designated by the letters RC, shall consist of asphalt cement with a penetration of approximately 80 to 100, fluxed or blended with a naphtha solvent.

21.1.17.4 Emulsified Asphalt

Asphaltic emulsions shall be composed of a bituminous base uniformly emulsified with water and an emulsifying or stabilizing agent. They shall be classified according to use as Rapid Setting (RS) or Slow Setting (SS), and shall conform to the requirements specified in Table 21(e).

The bituminous base used in manufacturing RS-1 type emulsion shall be asphalt cement, Grade 120-150 or Grade 200-300, as designated by the Engineer-in-Charge.

The bituminous base used in manufacturing SS-1 type emulsion shall be paving asphalt, Grade 60-70 or Grade 120-150, as designated by the Engineer-in-Charge.

TABLE 21(a)
APPLICATION TEMPERATURE RANGE 'C'

Description	Spray	Mix
Asphalt Cement (All grades)	160 (max)	As required to achieve viscosity of 75-150 secs. Saybolt-Furol or as required to achieve a Kinematic Viscosity of 150-300 centistokes.
Cut-back or Emulsified Asphalts		
MC-70, RC-70	27-65	27-65
MC-250	38-93	38-93
RC-250	38-79	27-65
MC-800	85-127	71-99
RC-800	71-107	57-85
SS-1, SS-1H	24-55	-
RS-1	24-55	-
RS-2	44-70	-

TABLE 21 (b)
REQUIREMENTS FOR ASPHALT CEMENT (AASHTO M-20)

Description	Penetration Grade							
	40-50		60-70		80-100		120-150	
	Min	Max	Min	Max	Min	Max	Min	Max
Penetration at 77ºF (25ºC) 100g 5sec.	40	50	60	70	85	100	120	150
Flash point, Cleveland Open Cup, 0ºF (0ºC)	150 (232)	- -	450 (232)	- -	450 (232)	- -	425 (218)	- -
Ductility at 77ºF (25ºC) 5 cm per min. cm.	99	-	99	-	99	-	99	-
Solubility in trichloroethylene percent	99	-	99	-	99	-	99	-
Thin-film oven test, 1/8 inch (3.2mm), 325ºF, (163ºC), 5 Hrs. Loss on heating, percent	-	0.8	-	0.8	-	1.0	-	1.3
Penetration of residue, percent of original	58	-	54	-	50	-	46	-
Ductility of residue at 77ºF (25ºC), 5 cm. per min. cm.	-	-	50	-	75	-	100	-

TABLE 21 (c)
REQUIREMENTS FOR MEDIUM-CURING TYPE ASPHALT (AASHTO M-82)

Description	MC-70		MC-250		MC-800	
	Min	Max	Min	Max	Min	Max
Water percent	-	0.2	-	0.2	-	0.2
Flash point (tag. open cup) C	38	-	66	-	66	-
Kinematic Viscosity at 60ºC (140ºF) (See Note 1) Centistokes	70	140	250	500	800	1600
Distillation test: Distillate, percentage by volume of total distillate to 360ºC 680ºF)						
to 225ºC (437ºF)	0	20	0	10	-	-
Description	MC-70		MC-250		MC-800	
	Min	Max	Min	Max	Min	Max
to 260ºC (500ºF)	20	60	15	55	0	35
to 315ºC (600ºF)	65	90	60	87	45	80
Residue from distillation to 360ºC (680ºF) volume percentage of Sample by difference	55	-	67	-	75	-
Tests on residue from distillation: Penetration, 100 g., 5 sec., at	120	250	120	250	120	250

25ºC (77ºF)						
Ductility, 5 cm/min.cm.(see note 2)	100	-	100	-	100	-
Solubility in Trichloroethylene percent	99	-	99	0	99	-

Note-1: As an alternative, Saybolt Furol Viscosities may be specified as follows:
Grade MC-70 Furol viscosity at 50°C (122°F) – 60 to 120 sec.
Grade MC-250 Furol viscosity at 60°C (140°F) – 125 to 250 sec.
Grade MC-800 Furol viscosity at 82.2°C (180°F) – 100 to 200 sec.

Note-2: If penetration of residue is more than 200 and its ductility at 25°C (77°F) is less than 100 cm, the material will be acceptable if its ductility at 15.5°C (60°F) is more than 100 cm.

TABLE 21 (d)
REQUIREMENTS FOR RAPID-CURING TYPE ASPHALT (AASHTO M-81)

	RC-70		RC-250		RC-800	
	Min	Max	Min	Max	Min	Max
Water percent Flash point (tag. open cup) ºC	- -	0.2 -	- 27	0.2 -	- 27	0.2 -
Kinematic Viscosity at 60ºC (140ºF)(See Note 1) centistokes	70	140	250	500	800	1600
Distillation test: Distillate, percentage by volume of total distillate to 360ºC (680ºF)						
to 190ºC (374ºF)	10	-	-	-	-	-
to 225ºC (437ºF)	50	-	35	-	15	-
to 260ºC (500ºF)	70	-	60	-	45	-
to 315ºC (600ºF)	85	-	80	-	75	-
Residue from distillation to 360ºC(680ºF) volume percentage of Sample by difference	55	-	65	-	75	-
Tests on residue from distillation: Penetration, 100 g. 5 sec. at25ºC (77ºF)	80	120	80	120	80	120
Ductility, 5 cm/min. cm. of 25ºC (77ºC) cm.	100	100	-	100	-	-
Solubility in Trichloroethylene percent	99	-	99	-	99	-

Note-1: As an alternative, Saybolt Furol Viscosities may be specified as follows:
Grade MC-70 Furol viscosity at 50°C (122°F) – 60 to 120 sec.
Grade MC-250 Furol viscosity at 60°C (140°F) – 125 to 250 sec.
Grade MC-800 Furol viscosity at 82.2ºC (180°F) – 100 to 200 sec

TABLE 21 (e)
REQUIREMENTS FOR EMULSIFIED ASPHALT (AASHTO M-140)

TYPE.........................	Rapid – Setting				Slow - Setting			
GRADE......................	RS – 1		RS – 2		SS – 1		SS -1h	
	Min	Mix	Min	Mix	Min	Max	Min	Max
TEST OF EMULSIONS								
Viscosity, saybolt furol at 77°F (50°C), sec.	10	100	-	-	20	100	20	100
Viscosity, saybolt furol at 122°F (50°C), sec.	-	-	75	400	-		-	-
Settlement 5 days, percent(a)	-	5	-	5	-	5	-	5
Storage stability test, one day(b)	-	1	-	1	-	1	-	1
De-mulsibility C 35 ml 0.02 NCaCL2 percent	60	-	60	-	-	-	-	-
Cement mixing test, percent	-	-	-	-	-	2.0	-	2.0
Sieve test, percent	-	0.1	-	0.1	-	0.1	-	0.1
Residue by distillation, percent	55	-	63	-	57	-	57	-
Test on residue from distillation test penetration 77°F (25°C) 100g. 5 sec.	100	200	100	200	100	200	40	90
Ductility, 77°F (25°C), 5 cm/mim.cm.	40	-	40	-	40	-	40	-
Solubility in Trichloroethylene percent	97.5	-	97.5	-	97.5	-	97.5	-
Suggested Uses Surface treatment & penetration macadam tack coat	Surface treatment & penetration macadam.		Plant or road mixture with graded and fine aggregates a substantial quantity of which passes a No.8 (2.3 mm) sieve & a portion of which may pass No. 200 (0.75 mm) sieve: slurry seal treatment.					

NOTES:
a) The test requirement for settlement may be waived when the emulsified asphalt is used in less than 5 days' time; or the Engineer-in-Charge may require that the settlement test be run from the time the sample is received until it is used, if the elapsed time is less than 5 days.
b) The 24-hours (1 day) storage stability test may be used instead of the 5-day settlement test.
c) The de-mulsibility test shall be made within 30-days from date of shipment.

21.1.18 BITUMINOUS SURFACE TREATMENT

21.1.18.1 General

This work shall consist of furnishing and application of three courses of asphaltic material of the specified type and grade with one, two or three covers of aggregates in accordance with these specifications to the width shown on the Drawings or as directed by the Engineer-in-Charge.

21.1.18.2 Material Requirements

a) Aggregate

Aggregate shall consist of clean, dry, hard, tough, angular, sound crushed stone, or crushed gravel of uniform quality, free from dust, clay, and other deleterious materials and from excess of flat or laminated pieces. All aggregate materials shall have a percentage of wear by the Los Angeles Abrasion test (AASHTO T-96) of not more than 40 percent. When subjected to 5 cycles of sodium sulphate soundness testing as determined by AASHTO T-104, it shall have a weight loss not greater than 10 percent. The moisture content in the aggregate applied directly to the surface of the bituminous material shall not exceed 3 percent by weight plus one half ½ the water absorption of the aggregate at the time of delivery to the project.

The portion of aggregate retained on the 9.5mm (3/8 inch) sieve shall not contain more than 15 percent of particles by weight so flat or elongated, or both, that the ratio between the maximum and the minimum dimensions exceeds 2.5:1.Flakiness index tested under BS-812(1990) Part 105 shall be 25(max) for nominal size18mm and 12mm and 30(max) for nominal 9 mm. size The percentage composition by weight of aggregate shall conform to the following gradations:

US Standard Sieve	Percentage Passing by Weight			
	Size No.1(18mm)	Size No.2(12mm)	Size No.3(9mm)	Size No.4(6mm)
1" (25.00 mm)	100	--	--	–
¾" (19.00 mm)	90 – 100	100	--	–
½" (12.50 mm)	20 – 55	90 – 100	100	–
3/8" (09.50 mm)	0 – 15	40-70	85-100	100
No. 4 (04.75 mm)	0 – 5	0 – 15	10-30	85 – 100
No. 8 (02.38 mm)	--	0 – 5	0 – 10	10 – 40
No. 16 (01.18 mm)	--	0	0-5	0 – 10
No. 200 (0.075 mm)	--	--	---	–

b) Asphaltic Material

The asphaltic material shall conform to the requirements of AASHTO M-20, M-81, M-82 and M-140. The type shall be the following or as instructed by the Engineer-in-Charge.

Triple surface treatment: AC 85-100, RC-70, RS-1 or RS-2.

21.1.18.3 Construction Requirements

Surface treatment shall be applied when the weather is warm and dry, and the road surface is clean and dry. Spraying shall not be done unless the road temperature has been above 20 degree centigrade for at least one hour prior to the commencement of spraying operations, and the temperature shall not be less than 20 degree centigrade during spraying. Prior to applying the asphaltic material, dirt and other objectionable materials shall be removed from the surface. If so directed by the Engineer-in-Charge, the surface shall be cleaned by power brooming until all loose and foreign materials are removed.

a) **Equipment**

The liquid asphaltic material shall be sprayed by means of a pressure distributor of not less than 240 gallon capacity, mounted on pneumatic tyres of such width and number that the load produced on the road surface will not exceed 560 lb. per inch width of tyre. It shall be of recognized manufacture.

The tank shall have a heating device able to heat a complete charge of asphaltic liquid upto 180 degree Centigrade. The heating device shall be such that overheating will not occur. The flames must not touch directly on the casting of the tank containing the asphaltic liquid. The Contractor will be responsible for any fire or accident resulting from heating of bituminous materials. The liquid shall be circulated or stirred during the heating. The tank shall be so insulated that the drop in temperature when the tank is full and not being heated, will not allow temperature drop by more than 2^{o}C/hour. A thermometer shall be fixed to the tank to enable continuous control of the temperature of the liquid. The thermometer shall be placed in such a way that the highest temperature in the tank is measured. The tank shall be furnished with a device that indicates the quantity. The pipes for filling the tank shall be furnished with an easily interchangeable filter.

The distributor shall be such that the spray width of the asphaltic liquid can be varied in steps of maximum (4 inch) to a total width of 13 ft (4 m). The spraying bar shall have nozzles from which the liquid is sprayed in fan shaped pattern on the road surface with uniform distribution over the total spraying width.

The distributor shall have a pump driven by a separate motor for dosing the liquid or the speed of the pump shall be synchronized with the speed of the distributor. The pump shall be furnished with an indicator showing the performance in liters per minute. At the suction side, the pump shall have an easily exchangeable filter.

The distributor shall be furnished with a tachometer indicating the speed in meter per minute. The tachometer shall be visible from the driver’s seat. The function of the distributor shall be so exact that the deviation from the prescribed quantity to be spread on 10 square feet does not exceed 10%. The distributor shall also be equipped with a device for hand spraying of the bituminous liquid.

b) **Application of Asphaltic Materials**

Asphalt cement, liquid asphalt and emulsified asphalt shall be applied by means of pressure distributor at the temperature specified for the type and grade of asphalt being used. The rates of application shall be within the range given in Table 21(f), however, the exact rate shall be determined by the Engineer-in-Charge.

The spreading of bituminous materials shall be at least 10 cm wider than the width covered by the aggregate from the spreading device. The distributor shall be moving forward at proper application speed at the time the spray bar is opened. Any skipped areas or deficiencies shall be corrected in an approved manner. Junctions of spreads shall be carefully made to assure a smooth riding surface. The length of spread of bituminous material shall not be more than that which trucks loaded with cover coat material can immediately cover. Under no circumstances shall operations speed in such manner that bituminous material will be allowed to chill, setup, dry , or otherwise impair retention of the cover coat.

The distributor when not spreading shall be so designed that the spray bar or mechanism will not drip bituminous material on the surface of the travelled way. Distribution of bituminous shall be so regulated and sufficient bituminous material left in the distributor at the end of each application, so that there will be a uniform distribution of bituminous material. In no case shall the distributor be allowed to expel air with bituminous material thereby causing uneven coverage. The angle of the spray nozzles and the height of spray bar shall be so adjusted and frequently checked that uniform distribution is ensured. The distribution shall cease immediately upon any clogging or interference of any nozzle and corrective measures shall be taken before distribution is resumed.

c) **Spreading of Aggregate**

Immediately after applying the asphaltic material, dry aggregate shall be uniformly and evenly distributed over the treated surface from an approved mechanical aggregate spreader. The truck carrying the aggregate shall move back-ward as it spreads the same so as to prevent the tyres of the truck and the mechanical aggregate spreader from driving directly on the newly sprayed asphalt. No portion of the binder shall remain uncovered for a period in excess of 20-minutes after spraying. Immediately after spreading of the aggregate, the treated surface shall be rolled with a self -propelled pneumatic-tyred roller having a minimum contact pressure of 40 psi (2.8 kg/sq.cm). A steel-wheeled roller weighing between 6 to 8 tons should be used as a second roller. Rolling shall continue until a smooth, thoroughly compacted surface is obtained. Procedures of starting, stopping or turning of equipment which results in displacement of cover material or damage to seal courses is prohibited.

Any place where binder shows on the surface shall be covered with additional aggregate and further rolled and broom-dragged until even surface results, and does not adhere to wheels of vehicles. Over lapping the application of cover material shall be avoided and all spillage shall be removed from surface.

The quantity of aggregate to be used shall be within the ranges specified in Table 21(f) however, the exact rate shall be determined by the Engineer-in-Charge.

TABLE 21 (f)

Bituminous Surface Treatment		Aggregate		Bituminous Material	
Type	Application	Size No.	Quantity KG/Sq.M	Quantity Litre/Sq.M	Type
SINGLE	Single	2	12.5	1.19	(a)
				1.63	(b)
DOUBLE	First	1	24	1.90	(a)
				2.14	(b)
	Second	3	12.5	1.19	(a)
				1.63	(b)
TRIPLE	First	1	24	1.90	(a)
				2.14	(b)
	Second	2	12.5	1.19	(a)
				1.63	(b)
	Third	3	6.5	0.68	(c)
SEAL COAT / PAD COAT WITH AGGREGATE		4	4	0.5	(c)

NOTE: Bituminous material types are (a) asphalt cement, (b) cut-back (c) asphalt cement or cut-back.

21.1.18.4 Maintenance of Traffic

Detouring of highway traffic for this work will not be provided for or permitted, except when authorized by, the Engineer-in-Charge. All construction operations shall be coordinated to result in the least practicable delay of traffic. One way traffic shall be maintained and traffic speeds restricted to fifteen (15) Km per hour. The contractor shall provide flagmen, warning signs barricades, and sufficient number of pilot cars to control traffic through the bituminous sealing operations when so directed by the Engineer-in-Charge. Pilot cars shall be used to lead the traffic through the areas of all distribution and sealing operations. Pilot cars shall be light "Pick-up"; trucks or other approved vehicles and shall be equipped with signs reading "PILOT CAR - DO NOT PASS" on both English and Urdu. Two (2) signs shall be mounted on the vehicles so as to be clearly visible from both directions.

One(1) flagman shall be stationed immediately ahead of the application of the bituminous material and one(1) flagman immediately behind the section being rolled. Suitable speed limit signs shall be displayed, and the signs shall be moved forward with the flagman as the work progresses.

No separate payment shall be made for conformance to this paragraph all items being considered subsidiary to all of the items in the CSR items.

21.1.18.5 Working Period

All work shall be so .conducted that the work of applying asphalt and aggregate and of all rolling shall be completed during the time from sunrise to sunset and under favourable weather conditions determined by the Engineer-in-Charge.

21.1.18.6 Maintenance of completed work

When directed by the Engineer-in-Charge, the Contractor will be required to add bituminous material or aggregate or both to portion of the project. Furnishing additional bituminous material and furnishing, spreading, dragging and rolling of additional aggregate will 'not be paid for separately but will be considered as subsidiary work pertaining to the relevant item of "Bituminous Surface Treatment".

21.1.18.7 Opening to Traffic and after-care

There shall be no delay in opening a completed surface dressing to traffic at a controlled speed. Prior to opening to traffic any spillage of aggregates shall be removed and any binder drips or windblown contamination shall be dusted with crusher waste. After 2-3 days under traffic, excess stone will be removed by brushing.

21.1.18.8 Pad Coat

To ensure chipping retention when surface dressing a very hard surface, a pad cat consisting of application of an initial binder spray followed by 6mm. chipping will be applied. After stabilizing of pad coat under traffic, the appropriate surface dressing will be applied.

21.1.19.1 Measurement

The length and width of the finished work shall be measured correct to a cm along the finished surface of the road. The area shall be calculated in square metre, correct to two places of decimal.

The thickness of surface treatment shall be the ruling criterion for payment.

21.1.19 BITUMINOUS PRIME COAT

21.1.19.1 General

This work shall consist of furnishing all plant, labour, equipment, material and performing all operations in applying a liquid asphalt prime coat on a previously prepared and untreated earth sub grade, water-bound base course, top of road way shoulders, (and as otherwise shown on the plans) in accordance with the specifications and in conformity with the lines shown on- the drawings.

21.1.19.2 Material Requirements

Asphaltic material shall be either cutback or emulsified asphalt, whichever is specified.

21.1.19.3 Construction Requirements

Prime coat shall be applied when the surface to be treated is dry; except that when emulsified asphalt is used, the surface may be reasonably moist. The application is prohibited when the weather is foggy or rainy, or when the atmospheric temperature is below 15ºC unless otherwise directed by the Engineer-in-Charge. Prior to the application of the prime coat, all loose materials shall be removed from the surface and the same shall be cleaned by means of approved mechanical sweepers or blowers and/or hand brooms, until it is as free from dust as is deemed practicable. No traffic shall be permitted on the surface after it has been prepared to receive the bituminous material. Prior to the application of prime coat on bridge decks and concrete pavements, the surfaces shall be cleaned of all loose material as described. All expansion joints shall be cleaned and filled with bituminous material as directed by the Engineer-in-Charge. Area to be primed will be classified as under:

i) The top of earth surface or water bound base courses from a point twenty (20) centimetres outside the edge of the pavement line to 20 cms outside the line on the opposite side of the roadway.
ii) The top of the shoulders from the inter-section of embankment slope and top of sub-grade to the edge of the pavement line.
iii) The bridge wearing surface from curb to curb and end to end of bridge wearing surface.
iv) Other surfaces as shown on the plans or instructed by the Engineer-in-Charge.

Primed surface shall be kept undisturbed for at least 24 hours so that the bituminous material travels beneath and leaves the top surface in non-tacky condition. No asphaltic operations shall start on a tacky condition.

21.1.19.4 Equipment

The tank shall have a heating device able to heat a complete charge of asphaltic liquid upto 180 degree Centigrade. The heating device shall be such that overheating will not occur. The flames must not touch directly on the casting of the tank containing the asphaltic liquid. The Contractor will be responsible for any fire or accident resulting from heating of bituminous materials. The liquid shall be circulated or stirred during the heating. The tank shall be so insulated that the drop in temperature when the tank is full and not being heated, will not allow temperature drop by more than 2ºC/hour. A thermometer shall be fixed to the tank to enable continuous control of the temperature of the liquid. The thermometer shall be placed in such a way that the highest temperature in the tank is measured. The tank shall be furnished with a device that indicates the quantity. The pipes for filling the tank shall be furnished with an easily interchangeable filter.

The liquid asphaltic material shall be sprayed by means of a pressure distributor of not less than 1000 litre capacity, mounted on pneumatic tyres of such width and number that the load produced on the road surface will not exceed hundred (100) kg. per cm width of tyre. It shall be of recognized manufacturer. The distributor shall be able to vary the spray width of the asphaltic liquid in steps of maximum 10 cm, to a total width to four (4) meters. The spraying bar shall have nozzles from which the liquid is sprayed fan shaped on the road surface equally distributed over the total spraying width.

The distributor shall be equipped with a device for hand spraying of the bituminous liquid.

All equipment shall be subject to the approval of the Engineer-in-Charge. The distributor shall have a pump for spraying the liquid driven by a separate motor or the speed of the pump shall be synchronized with the speed of distributor. The pump shall be furnished with an indicator showing the performance in litres/min. At the suction side the pump shall have a filter easily exchangeable. The thermometer shall be fixed which indicates the temperature of the liquid immediately before it leaves the spraying bar.

The distributor shall be furnished with the Tachometer indicating the speed in meter/min. The Tachometer shall be visible from the driver seat.

Application of Asphaltic Material

Immediately before applying prime coat, the full area of surface to be treated shall be free from ruts, corrugations, loose materials and other irregularities.

Prime coat shall be applied on a dry surface, however the surface may be reasonably moist when emulsified asphalt is used. The application shall not be done when the weather is foggy or rainy, or when the atmospheric temperature is below fifteen (15) degree centigrade unless otherwise directed by the Engineer-in-Charge. Prior to the application of the prime coat the surface shall be cleaned by means of approved mechanical sweepers or blowers and/or hand brooms, until it is free from dust and loose material as far as practicable. No traffic shall be permitted on the surface after it has been prepared to receive the bituminous material. The bridge decks and concrete pavements surfaces shall also be cleaned of all loose materials. All expansion joints shall be cleaned and filled with bituminous material as directed by the Engineer-in-Charge. Areas to be primed shall be:

i) The top of earth surface or water bound base courses from a point twenty (20) centimetres outside the edge of the pavement either side of the roadway.

ii) The top of shoulders from the intersection of embankment slope and top of sub-grade to the edge of the pavement line.

iii) The bridge wearing surface from curb to curb and end to end of bridge wearing surface.

iv) Other surfaces as shown on the plans or instructed- by the Engineer-in-Charge.

The rate of application of asphaltic material (cut back/emulsified) shall be according to the following rates or as approved by the Engineer-in-Charge.

Sr. No.	Type of Surface	Liters/ Sq. M.	
		Minimum	Maximum
1.	Earth surface, shoulders Water Bound base courses	0.65	1.75
2.	Bridge, Wearing Surfaces, Concrete Pavement	0.15	0.4

The prime coat shall be left undisturbed for a period of at least 24 hours and shall not be opened to traffic until it has penetrated and cured sufficiently so that, it will not be picked up by the wheel of passing vehicles. The contractor shall maintain the prime coat until the next course is applied. Care shall be taken that the application of bituminous material is not in excess of the specified amounts any excess shall be blotted with sand or shall be similarly treated. All area inaccessible to the distributor shall be sprayed manually using the device for hand spraying from the distributor. The surface of structures and trees adjacent to the area being treated shall be protected in such a manner as to prevent their being spattered or marred.

Where no convenient detour is available for traffic, operations shall be confined to one half the roadway width at a time. The contractor shall provide proper traffic control so that vehicles may proceed without damage to the primed area. Work shall not be started on the portion previously covered until it has dried and is ready for traffic.

21.1.19.5 Measurement

Bituminous Prime coat, for both items shall be measured as finished work over the area specified to be covered, in square metres at the bitumen content specified in the item.

Weight of Bitumen per Sq.m shall be the bases for Payment.

21.1.20 SURFACE DRESSING ON OLD SURFACE WITH HOT BITUMEN (ONECOAT)

21.1.20.1 General

This treatment consists of cleaning old painted surface and applying a coat of hot bitumen on the prepared base, blinding with stone chippings and consolidation with road roller.

21.1.20.2 Materials

The aggregates & asphalt materials unless otherwise specified shall conform to the provisions of Clause 21.1.19.2.

21.1.20.3 Preparation

Repairs: Pot holes or patches and ruts in the surface course which is to be surface treated, shall be repaired by removal of all loose and defective material by cutting in rectangular patches and replacement with suitable material.
For the purpose of repairs the area of pot holes shall be taken upto 0.75 sqm and depth up to 5 cm. All pot holes, patches and ruts up to 2 cm deep shall be repaired and brought to level with premix and properly consolidated while those of depths greater than 2.5 cm shall be repaired with similar specifications as adopted originally.

Prior to the application of the surface dressing all dust, dirt, caked mud, animal dung, loose and foreign material etc. shall be removed 30 cm on either side, beyond the full width to be treated, by means of mechanical sweepers and blowers or with wire brushes, small picks, brooms etc. The material so removed shall be disposed off as directed by the Engineer-in-Charge.
For a water bound macadam surface, the interstices between the road metal shall be exposed up to a depth of about 10mm by means of wire brushes. The surface shall then be brushed with soft brooms to remove all loose aggregate. Finally the traces of fine dust which get accumulated while brushing shall be thoroughly removed from the surface by blowing with gunny bags.
The prepared surface shall be closed to traffic and maintained fully clean till the binder is applied.

21.1.20.4 Construction Requirements

The construction for dressing shall be carried out complying with the provision of clause 21.1.19.3.

21.1.20.5 Measurement

Hot Bitumen Coat for both items shall be measured as finished work over the area specified to be covered, in square metres at the bitumen content specified in the item.

21.1.21 BITUMINOUS TACK COAT

21.1.21.1 General

The work covered by this section shall consist of furnishing all plant, labour and equipment for application of asphaltic material on a previously prepared asphaltic layer in addition to performing all operation in connection with the application of a bituminous tack coat, complete as shown on the typical cross-sections of applicable drawings.

21.1.21.2 Material Requirements

Asphaltic material shall be either emulsified asphalt, or cut back asphalt as specified.

21.1.21.3 Construction Requirements

a) **Equipment**

Equipment shall conform in all respect to the provision under Item 21.1.20.4 and shall be subject to the approval of the Engineer-in-Charge.

b) **Application of Asphaltic Material**

Immediately before applying the tack coat, all loose material, dirt or other objectionable material, shall be removed from the surface to be treated as directed by the Engineer-in-Charge. The tack coat shall be applied only when the surface is dry, however for emulsified asphalt, application may be made on a reasonable moist surface. Application of tack coat shall be avoided in case of foggy or rainy weather or at temperatures below 15ºC. Tack coat will not be applied until the surface has been inspected and approved by the Engineer-in-Charge.

Asphaltic material shall be applied at the specified temperature for the particular material being used. Rates of application of cut back or emulsified asphalt shall be within 0.2-0.7 litres per square meter. The exact rate shall be specified by the Engineer-in-Charge.

Care shall be taken that the application of asphaltic material is not in excess of the specified amount; any excess asphalt shall be blotted by sand or similar treatment. All areas inaccessible to the distributor shall be treated manually using the device for hand spraying from the distributor. The surfaces of structures and trees adjacent to the areas being treated shall be protected in such a manner as to prevent their being spattered or marred.

Where no convenient detour is available for traffic, operations shall be confined to one-half the roadway width at a time. The Contractor shall provide proper traffic control so that vehicles may proceed without damage covered by previous application until the surface previously covered has dried and is ready for paving.

Traffic shall be kept off the tack coat at all times. The tack coat shall be sprayed only so far in advance of the surface course as will permit it to dry to a "tacky" condition. The Contractor shall maintain the tack coat until the next course has been placed. Any area that has become fouled, by traffic or otherwise, shall be cleaned by Contractor at his own cost before the next course is applied.

21.1.21.4 Measurement

Bituminous Prime coat, for both items shall be measured as finished work over the area specified to be covered, in square metres at the bitumen content specified in the item.

Weight of Bitumen per Sq.m shall be the bases for Payment.

21.1.22 ASPHALTIC CONCRETE ROAD MIX

21.1.22.1 General

This work shall consist of furnishing of aggregates and asphalt binder plant, labour, equipment and performing all operations in connection with the construction of asphaltic concrete road mix on a previously constructed and accepted sub-grade, sub-base or base course, and in accordance with this section of the Specification, the drawings and the directions of the Engineer-in-Charge.

21.1.22.2 Material Requirements

Unless otherwise specified or directed, the materials for asphalt concrete mix shall comply with the followings specifications:

a) Mineral Aggregates

Mineral aggregates for bituminous concrete shall consist of coarse aggregate, all conforming with the following requirements:

Course aggregate which is the material retained on No.4 sieve shall consist of crushed rock, crushed gravel or a mixture of crushed rock and crushed gravel. The aggregate shall not contain more than 8% by weight of flat and elongated particles. Ratio of maximum to minimum dimensions of particles shall not exceed 5:1. At least (90) percent by weight shall have two or more fractured faces.

Fine aggregate which is material passing No.4 sieve, shall consist of 100% crushed material from rock or boulder. No natural sand will be allowed in the mix.

When the combined grading of the coarse and fine aggregates is deficient in material passing No. 200 sieve, additional filler material shall be added. The filler material shall consist of finely divided rock dust, hydrated lime, hydraulic cement or other suitable mineral matter. At the time of use, it shall be sufficiently dry to flow freely and free from conglomerations. Filler Material shall conform to following gradations.

US Standard Sieve	Percent Passing by Weight
No. 30	100
No. 50	95-100
No. 200	70-100

The coarse and fine aggregates shall meet the following applicable requirements:

i) The percentage of wear by the Los Angeles Abrasion test (AASHTO T-96) shall not be more than forty percent (40%).

ii) The loss when subject to five cycles of the Sodium Sulphate Soundness test (AASHTO -T-104) shall be less than twelve (12)

iii) The Sand Equivalent (AASHTO T-176) determined after all processing except for addition of asphalt cement shall not be less than forty five (45).

iv) Fine aggregates shall have a liquid limit not more than twenty five (25) and a plasticity index of not more than four(4) as determined by AASHTO T-89 & T-90

v) The portion of aggregate retained on the 9.5 mm (3/8 inch) sieve shall not contain more than 15 percent by weight of flat and/or elongated particles (ratio of maximum dimensions = 2.5:1)

b) Asphaltic Material

Asphalt binder to be mixed with the aggregate to produce asphalt concrete shall be asphalt cement having penetration grade 40-50, or 60-70 or 80-100 as approved by the Engineer-in-Charge, Generally it will meet the requirements of AASHTO M-20.

c) Sampling and Testing Schedule of Materials

i) Coarse Aggregates:

- Abrasion (AASHTO T-96); 3 per source plus 1 for 5000 cum.
- Sodium sulphate soundness (AASHTO T-104); 3 per source plus 1 for 5000 cum.
- Stripping (AASHTO T-182); 3 per source.
- Fractured faces, flake & elongated particles; 3 per source plus as per visual observations.
- Specific gravity (AASHTO T-85); 2 per source for each size.

ii) Fine Aggregates:

- Sand equivalent (AASHTO T- 176); or plasticity index (AASHTO T-89 and T-90); 3 per source.
- Specific gravity (AASHTO T-84); 2 per source.

iii) Asphalt:

- Specific gravity (ASSHTO T-228); 2 per shipment.
- Penetration (AASHTO T-49); 3 per week.

21.1.22.3 Asphalt Concrete Mixture

a) **Composition**

Unless otherwise specified, the composition of the asphaltic concrete paving mixtures for concrete mix shall conform to class shown in the following table:

Sieve Designation		Percent Passing by Weight
mm	inch	
25	1	100
19	3/4	90-100

9.5	3/8	56-80
4.75	No. 4	35-65
2.38	No. 8	23-49
0.30	No. 50	5-19
0.075	No. 200	2-8

Asphalt Content Weight Percent of total mix.	3.5 (minimum)
The asphalt concrete binder course mixture shall meet the following Marshal Test Criteria:	
Compaction, no. of blows each end of specimen	75
Stability (Minimum)	1000 kg.
Flow 0.25 mm (0.01 inch)	8-14
Percent air voids in mix.	4-8
Percent voids in mineral aggregate	According to article 5.3, MS-2, (Asphalt Institute USA) edition 1993
Loss of stability	25% (Max.)
Filler/Bitumen ratio	1-1.5 (applicable to hot climate (<40^{o}C)

b) **Job-Mix Formula**

A Job-Mix Formula (JMF) for the asphaltic concrete to be used for the project shall be established jointly by the Engineer-in-Charge and the Contractor. Job-Mix Formula shall combine the mineral aggregates and asphalts in such proportion conforming to specification requirements.

The JMF shall be established according to the procedure prescribed by the Engineer-in-Charge.

Each JMF shall indicate a single percentage of aggregate passing each required sieve size and a single percentage of bitumen to be added to the aggregate.

After the JMF is established samples of materials taken from the asphalt plant during operations shall conform the following ranges of tolerance.

Combined Aggregates

Sieve	Permissible variation Weight of total mix. Percent by weight
Retained No.4 and larger sieves No.8 No. 30 No. 200 Asphalt	$\pm$6.0 % $\pm$4.0 % $\pm$3.0 % $\pm$2.0 % $\pm$0.3 %

Asphalt Content

Weight percent of total mix. $\pm$ 0.3 %

In addition to meeting the above requirements, the JMF shall also satisfy other requirements as prescribed by the Engineer-in-Charge.

Should a change of sources of materials be made, a new Job Mix Formula shall be established before the new material is used. When unsatisfactory results or other unacceptable conditions make it necessary, a new Job Mix Formula will be required.

c) **Asphalt Additive**

Cellulose Fibers shall be used as an asphalt additive with the aim of eliminating bleeding tendencies at the rate of 0.2 to 0.25 percent by weight of the total mix. Additives shall be fed by a separate feeding system or manually into pug-mill for each batch. The weight of the additive shall be determined in accordance with the percentage specified in the job mix formula.

21.1.22.4 Construction Requirements

21.1.22.4.1 Equipment

a) **Bituminous Mixing Plant**

Plants used for the preparation of bituminous mixtures shall be either "Batching Plants" conforming to AASHTO M-156 or continuous mixing as approved by the Engineer-in-Charge and shall be of adequate capacity, coordinated and operated to produce a mixture within the limits of these specifications. Mixing plant shall meet the following general requirements.

i) Sufficient Capacity:

Mixing plants shall be of sufficient capacity and coordinated to handle adequately the proposed bituminous construction. Plants shall have minimum 3 cold bins and 3-5 decks of hot sieves.

ii) Plant Scale:

Scales shall be accurate to 0-5 percent of the maximum load that may be required. Poises shall be designed to be locked in any position to prevent unauthorized change of position. In lieu of plant and truck scales the Contractor may provide an approved automatic printer system which will print the weights of the material delivered or any other weighing device found satisfactory by the Engineer-in-Charge, provided the system is used in conjunction with an approved automatic batching and mixing control system. Such weights shall be evidenced by a weigh ticket for each load, or any other weigh system satisfactory to the Engineer-in-Charge.

iii) Scales shall be inspected and calibrated as often as the Engineer-in-Charge may deem necessary to assure their continued accuracy, the Contractor will have on hand not less than 10 fifty-pound weights for testing the scales,

iv) Equipment for preparation of Bituminous Material:

Tanks for the storage of bituminous material shall be equipped to heat and hold the material at the required temperatures. The heating shall be accomplished by steam coils, electricity, or other approved means so that no flame shall be in contact with the tank. The circulating system for the bituminous material shall be designed to assure proper and continuous circulation during the operating period. Provision shall be made for measuring and sampling storage tanks.

v) Feeder for Drier:

The plant shall be provided with accurate mechanical means for uniformly feeding the aggregate into the drier so that uniform production and uniform temperature will be obtained.

vi) Drier:

The plant shall include a drier or drier which continuously agitate the aggregate during the drying process. For cold type bituminous mix, equipment for mechanical cooling of the dried aggregate the temperature prescribed for cold mixtures shall be mixer to operate at full capacity.

vii) Screens:

Plant screens, capable of screening all aggregates to the specified sizes and proportions and having normal capacities in excess of the full capacity of the mixer, shall be provided.

viii) Bins:

The plant shall include storage bins of sufficient capacity to supply the mixer when it is operating at full capacity. Bins shall be arranged to assure separate and, adequate storage of appropriate fractions of the mineral aggregates. Separate dry storage shall be provided for filler or hydrated lime when used and provided with overflow pipes of a size and at such location as to prevent backing up of material into other compartments of bins. Each compartment shall be provided with its individual outlet gates which shall cut off quickly and completely. Bins shall be equipped with adequate tell-tale devices to indicate the position of the aggregates in the bins at the lower quarter points.

ix) Bituminous Control Unit:
Satisfactory means, either by weighing or metering, shall be provided to obtain the proper amount of bituminous material in the mix within the tolerance specified. Means shall be provided for checking the quantity or rate of flow of bituminous material into the mixer.

x) Thermometric Equipment:
An armoured thermometer of adequate range in temperature reading shall be fixed in the bituminous feed line at a suitable location near the charging valve at the mixer unit. The plant shall be equipped with either an approved dial-scale, mercury actuated thermometer, an electric pyrometer or other approved thermometric instruments so placed at the discharge chute of the drier as to register automatically or indicate the temperature of heated aggregate.

xi) The Engineer-in-charge may require replacement of any thermometer by an approved temperature recording apparatus for better regulation of the temperature of aggregates.

xii) Dust Collector:
The plant shall be well equipped with a dust collector constructed to waste or return uniformly to the hot elevator all or any part of the materiel collected as directed.

xiii) Truck Scales:
The bituminous mixture shall be weighed on approved scales furnished by the Contractor or on public scales at the Contractors expense. Such scales shall be inspected and calibrated as often as the Engineer-in-Charge deems necessary to assure their accuracy. The accuracy shall be in accordance with paragraph(ii).

xiv) Safety Requirements Adequate and safe stairways to the mixer platform and sampling points shall be provided and guarded ladders to other plant units shall be placed at all points where accessibility to plant operations is required. Accessibility to the top of truck bodies shall be provided by a platform or other suitable device to enable the Engineer-in-Charge to obtain sampling and mixture-temperature data. Hoist or pulley or pulley system shall be provided to raise scale calibration equipment, sampling equipment and other similar equipment from the ground to the mixer platform and to return. All gears, pulleys chains, sprockets, and other dangerous moving parts shall be thoroughly guarded and protected. Ample and unobstructed space shall be provided on the mixing platform. A clear and unobstructed passage shall be maintained at all times in and around the truck loading area. This area shall be kept free from drippings from the mixing platform.

b) **Hauling Equipment**
Dump trucks used for hauling bituminous mixtures shall have tight, clean smooth metal beds which have been thinly coated with an approved material (vegetable oil or soap solution). The mixture will be delivered on the road at a temperature not less than hundred and thirty (130) degree C. Drivers of Dump trucks will ensure that while moving backwards the vehicles, paver in not pushed back producing a hump.

c) **Asphalt Pavers**
Asphalt pavers shall be self-contained, power propelled units provided with an automatically controlled activated screed or strike off assembly, heated if necessary, capable of spreading and finishing courses of asphalt plant mix material in lane widths applicable to the specified typical section and thickness shown on the plans.
The paver shall be equipped with a receiving hopper having sufficient capacity for a uniform spreading operation. The paver shall be equipped with automatic feed controls, properly adjusted to maintain a uniform depth of material ahead of the screed. The screed or strike off assembly shall be capable of producing a finished surface of the required evenness and texture without tearing, shoving or gouging the mixture.
The pavers shall be equipped with automatic screed controls with sensors for either or both sides of pavers, capable of sensing grade from an outside reference line, sensing the transverse slope

of the screed and providing the automatic signals which operate the screed to maintain the desired grade and transverse slope. The sensor shall be so designed that, it will operate from a reference line or a ski-line arrangement.

The traverse slope controller shall be capable of maintaining the screed at the desired slope within plus or minus 0.1 percent variation. Manual operation will be permitted in the construction of irregularly shaped and minor areas.

Whenever the breakdown or malfunction of the automatic controls occurs, the equipment may be operated manually or by other methods in order to allow the contractor to use the asphalt already produced at the plant or in transit, provided this, method of operation will produce results otherwise meeting the specifications.

Reference line will be required for both outer edges of the travelled way for each main line roadway for vertical control. Horizontal control utilizing the reference line will be permitted. The grade and slope for intermediate lanes shall be controlled automatically from reference line or by mean of ski and a slope controlled device or a dual ski arrangement. When the finish of the grade prepared for paving is superior to established tolerance and when it is considered that further improvement of the line grade cross-section and smoothness can best be achieved without the use of reference line a ski-line arrangement may be substituted subject to the approval of Engineer-in-Charge. The use of reference line shall be reinstalled immediately whenever the contractor fails to maintain a superior pavement. The contractor shall furnish and install all pins, bracket, tension devices, wire and accessories for satisfactory operation of the automatic control of the equipment.

d) **Rollers**

Rollers shall be steel wheel, pneumatic tyre or vibratory or a combination thereof. The roller(s) shall be in good condition, capable of reversing without backlash and shall be operated at speeds slow enough to avoid displacement of the bituminous mixture. The number and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition. The use of equipment which results in excessive crushing of the aggregates will not be permitted.

21.1.22.4.2 Preparation of Aggregates

Before being led to the dryer, coarse and fine aggregates and filler if used for the asphaltic base courses shall be placed in separate stock piles or cold bins.

Each aggregate ingredient shall be heated and dried at temperature not to exceed hundred and sixty three (163) degrees centigrade, they shall be removed from the binds and returned to their respective stock.

Immediately after heating, the aggregates shall be screened to required size and stored in separate bins for batching and mixing with bituminous materials.

21.1.22.4.3 Asphalt Mix

Asphalt cement shall be heated within temperature range of hundred and thirty five (135) degrees to hundred and sixty three degrees (163) centigrade at the time of mixing.

Dried aggregates weighted and drawn to pugmill shall be combined with proportionate amount of asphalt cement according to the job mix formulas. Temperature of asphalt, except for temporary fluctuation, shall not be lower than 15 degrees centigrade below the temperature of the aggregates at the time the materials enter into the pugmill.

In no case shall the temperature of asphalt mix exceed hundred and sixty three (163) degree centigrade when discharged from the pugmill.

21.1.22.4.4 Testing of Asphalt Mix

At least three test shall be performed on daily production to check;

- Extraction (Percentage of bitumen)

- Gradation
- Bulk specific gravity
- Air Voids
- Void filled with bitumen

21.1.22.4.5 Preparation of Base of Existing Pavement Surface

Before spreading materials, the surface of base or existing pavement on which the mix is to be placed shall be conditioned by application of a prime or tack coat as specified.

After a prime coat is applied, it shall be left undisturbed not less than twenty four (24) hours. The contractor shall maintain the primed surface until the mix material has been placed. This maintenance shall include the spreading of sand or other approved material, if necessary to prevent adherence of the prime coat to the tyres of vehicles using the primed surface, and patching any breaks in the primed surface with additional bituminous material or any area of primed surface with additional bituminous material. Any area of primed surface that has become damaged shall be repaired before the mix is placed. It should be ensured that primed surface is not in tacky condition when premix is laid.

A tack coat shall be applied on existing surface. After the tack coat is applied, it shall be allowed to dry until it is in the proper condition of tackiness to receive the mix. The tack coat shall be applied only as far in advance of the placing of mix, as is necessary to obtain the proper condition of tackiness. Any breaks in the tack coat shall be repaired. When the surface of the existing pavement or old base is irregular, it shall be brought to uniform grade and cross-section by levelling course as directed. A thin coating of bituminous material shall be placed on contact surface of curbing, gutters, manholes, and other structures, prior to the bituminous mixture being placed against them.

21.1.22.4.6 Spreading and Finishing

The mixture shall be laid upon an approved surface, spread and struck off to the section and elevation established. Asphalt pavers shall be used to distribute the mixture either over the entire width or over such partial width as may be practicable.

Care shall be taken to ensure that material is properly compacted up to joint positions. If this is not done or results in undesired surface of a layer, the Engineer-in-Charge may instruct unacceptable material to be cut back before laying the adjacent material. Joints in superimposed layers of asphaltic material must be offset longitudinally by at least 2 m and transversely by at least 30 cms. Longitudinal joints in wearing course shall, after cutting back, be of good alignment and preferably coincident with the position of carriageway markings. Except where laying in echelon, joints in wearing course shall be cut back to a vertical face and tack coated. Kerb faces, ironwork and the like in contact with wearing course shall be tack coated prior to laying wearing course.

The outer edges of wearing course shall be cut back to a good alignment, parallel with the road alignment. This will require a small additional width of wearing course to be laid.

The Contractor should allow, within his bid rates, for this additional width and for all cutting back wearing course, which will not be measured for payment. Tack coating of vertical faces will not be measured for payment.

On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impracticable, the mixture shall be dumped spread and screeded to give the required compacted thickness ensuring even distribution of course and fine material.

When production of the mixture can be maintained and when practical; pavers shall be used in parallel formation along the length of the road to place the wearing course in adjacent lanes and shoulders.

All mixtures shall be spread at a temperature of not less than hundred and thirty (130) degree C and all initial rolling or tamping shall be performed when the temperature of the mixture is such that the sum of the air temperature plus the temperature of the mixture is between 165 degree C and 190 degree C. The mixture shall not be placed on any wet surface or when weather conditions will otherwise prevent its proper handling or finishing.

21.1.22.4.7 Compaction

After spreading and strike off and as soon as the mix condition permits the rolling to be performed without excessive shoving or tearing, the mixture shall be thoroughly and uniformly compacted. Rolling shall not be prolonged when cracks appear on the surface. Initial or breakdown rolling shall be done by means of either a tandem steel roller of three wheeled steel roller. Rolling shall begin as soon as the mixture will bear the roller without undue displacement. The number and weight of rollers shall be sufficient to obtain the required compacting while the mixture is still in workable condition. The sequence of rolling and the selection of roller types shall provide the specified pavement density. Initial rolling with a tandem steel roller or a three wheeled steel roller shall follow the paver as closely possible.

Unless otherwise directed, rolling shall begin at the lower side and proceed longitudinally, parallel to the road centreline, each trip overlapping one-half of the roller width, gradually progressing to the crown of the road. When paving in echelon or abutting a previously placed lane the longitudinal joint should be rolled first followed by the regular rolling procedure. On super elevated curves the rolling shall begin at the lower side and progress to the high side overlapping the longitudinal trips parallel to the centreline. Intermediate rolling with a pneumatic tyred roller shall be done behind the initial rolling. Final rolling shall eliminate marks from previous rolling. In no case shall the temperature be less than hundred and twenty (120) degree Centigrade. For initial break down rolling while all other compacting operations shall be completed before the temperature drops down to hundred and ten (110) degree C.

Rollers shall move at a slow but uniform speed with the drive roll or wheels nearest the paver. Rolling shall be continued until all roller marks are eliminated and a minimum density of Ninety seven (97) percent of a laboratory compacted specimen made from asphaltic material which is obtained for daily density measuring test. Any displacement resulting while reversing the direction of a roller, or from other causes, shall be corrected at once by the use of rakes and addition of fresh mixture when required. Care shall be exercised in rolling not to displace the line and grade of the edges of the bituminous mixture. To prevent adhesion of the mixture to the rollers, wheels of rollers shall be kept properly moistened with water or water mixed with very small quantities of detergent or other approved material. Excess liquid will not be permitted. Along forms, curbs, headers, walls and other places not accessible to the roller, the mixture shall be thoroughly compacted with hot hand tempers, smoothing irons or with mechanical tampers. On depressed areas, tempers be used or cleated compression strips may be use under the roller to transmit compression to the depressed area. Any mixture that becomes loose and broken mixed with dirt, or is in any way defective in finish or density shall be removed and replaced with the surrounding area. Mix in any area showing excess of deficiency or bituminous material shall be removed and replaced. Sequence of laying and compaction of premix shall be so managed that a long time does not elapse between successive dump trucks which may cool down the un-compacted premix, between paver & compacted asphalt below 120^{o}C.

21.1.22.4.8 Frequency of Testing for Cores

Core shall be taken for each seven hundred fifty (750) square meters of base or fraction thereof in special cases. If the core so taken shall fail against the specified density, then two (2) additional cores shall be taken in the longitudinal alignment of the road at an interval of three (3) meters on either sides with respect to the failing core and shall be tested against field density. If these core pass, then the individual compaction of the core shall not be less than Ninety three (93) percent and average of these three cores, in no case be less than Ninety five (95) percent. If average of the cores further fails against compaction, then, retake the cores at a distance of fifteen (15) meters on either side and compaction shall be checked in the same fashion. In case of failure of the average of these five cores, the failed area shall be removed and subsequently be replaced by specified mix in an approved manner under the expense of Contractor.

21.1.22.4.9 Pavement Thickness and Tolerances

After completion of final rolling, the finished surface shall be tested for smoothness with three (3) meters straight edge by the Engineer-in-Charge at selected locations. The variation of surface from testing edge of straight edge between any two (2) contacts with the surface shall at no point exceed six (6) millimetres when placed either parallel or perpendicular to centreline of roadway.
Any irregularities that exceed the specified tolerances or that retain water on the surface shall be corrected by removing the defective area and replacing with new base course without additional cost to the Employer. For determination of the average thickness, six (6) cores per Kilometre shall be taken or as directed by the Engineer-in-Charge.

When layer thickness of asphaltic base source is deficient by more five (5) mm from that specified in the drawings, the deficiency shall be removed with satisfactory base course material and or made up by additional asphalt concrete wearing coarse thickness without extra cost to the Employer. If such remedial action is authorized, revised thickness determinations shall be made by measurements of new cores taken after placing of "Asphaltic Wearing Course" material or as directed by the Engineer-in-Charge. If base course deficiencies are corrected in this manner, full payment for the "Asphaltic Base Course" will be made to the Contractor but no additional payment will be made for the increase in thickness of the "Asphaltic Wearing Course".

21.1.22.5 Weather Limitations

Hot asphaltic mixtures shall be placed only when the air temperature is four (4) degrees centigrade or above and no asphalt shall be laid under foggy or rainy weather or over moist surface.

21.1.22.6 Measurement

The length and width of the finished work shall be measured correct to a cm along the finished surface of the road. The area shall be calculated in square metre, correct to two places of decimal.

The consolidated cubical contents shall be calculated in cubic metres correct to two places of decimal.

21.1.23 ASPHALT CONCRETE WEARING COURSE – PLANT MIX

21.1.23.1 General

The work shall consist of furnishing aggregates and asphalt binder plant, labour, equipment mixing, transporting, spreading, compacting the mixture in an approved manner on a primed or tacked, base, sub-base, sub-grade bridge deck or concrete pavement in accordance with these specifications and in conformity with the lines, grades and typical cross-sections shown in the drawings or as directed by the Engineer-in-Charge.

21.1.23.2 Material Requirements

The materials consisting of Mineral Aggregates, Asphalt Materials shall conform with provisions of Sub-section 21.1.22.2.

21.1.23.3 Asphalt Concrete Wearing Course Mixture

The composition of the asphaltic concrete paving mixture for wearing course shall conform to class A and/or Class B shown in the following table:

Asphalt Concrete Wearing Course Requirements

Mix Designation Compacted thickness	Class-A 50-100 mm	Class-B 35-60 mm
US Standard Sieve size Percent Passing by weight		
1" (25 mm)	100	-
¾" (19 mm)	90-100	100
½" (12.5 mm)	-	75-90
3/8" (9.5 mm)	56-70	60-80
No.4 (4.75 mm)	35-50	40-60
No.8 (2.38 mm)	23-35	20-40
No. 50 (0.300 mm)	5-12	5-15
No. 200 (0.075 mm)	2-8	3-8
*Asphalt Content weight Percent of total mix	3.5 (Min)	3.5 (Min)

The exact percentage of asphalt content shall be determined through JMF.

The asphalt concrete wearing course mixture shall meet the following Marshall Test Criteria:

Description	Standard
Compaction, number of blows each end of specimen	75
Stability	1000 Kg (Min)
Flow, 0.25 mm (0.01 inch)	8-14
Percent air voids in mix	5 - 8
Percent voids filled with bitumen	65 - 75
Loss of Stability	20% (Max)

21.1.23.4 Job-Mix Formula

The Job-Mix Formula (JMF) shall comply with the provisions of Sub-section 21.1.22.3(b).

21.1.23.5 Asphalt Additives

The same as for Sub-section 21.1.22.2(c).

21.1.23.6 Construction Requirements

Construction requirements for this job shall conform to the requirements as specified for Asphaltic Concrete Base Course Plant Mix under Sub-section 21.1.20.4.

a) **Preparation of Base Surface**

Before wearing coat, the surface of the previously and accepted base course on which the mix is to be placed shall be applied a tack coat, or as directed by the Engineer-in-Charge.

b) **Pavement Thickness and Tolerances**

The asphalt concrete wearing course shall be compacted to the desired level and cross slope as shown on the drawing or as directed by the Engineer-in-Charge.

The tolerance in compacted thickness of the wearing course shall be ± five percent (5%) from the desired thickness shown on the drawings. For determination of the average thickness, six cores per kilometre shall be taken. If the average thickness so determined in deficient by more than ± 5%, the Engineer-in-Charge shall decide whether to accept the deficit thickness or to direct reconstruction.

The surface of the wearing course shall be tested by the Engineer-in-Charge using a 3 meter straightedge at selected locations. The variation of the surface from the testing edge of the straightedge between any two contacts, longitudinal or transverse with the surface shall at no point exceed five millimetres. The cross fall (camber shall be within± 0.2% of that specified, and the level at any point shall be within ± 5.0 millimetres of the level shown on the drawings. All humps or depressions exceeding the specified tolerance shall be corrected by removing the defective work and replacing it with new material, by overlaying, or by other means satisfactory to the Engineer-in-Charge.

21.1.23.7 Sand Flushing

Where specified, sand flushing with a mix of sand and bitumen of the specified proportions shall be applied on top of asphalt concrete road. The material requirements the preparation of the mix and application on road surface shall comply with the provisions of wearing course application.

21.1.24.8 Measurement

The length and width of the finished work shall be measured correct to a cm along the finished surface of the road. The area shall be calculated in square metre, correct to two places of decimal.

For item No.21.85, the consolidated cubical contents shall be calculated in cubic metres correct to two places of decimal for item No. 21-85. The quantities for asphaltic leveling / base course will be measured by volume in cubic meters compacted in place. Measurement shall be based on the dimension as shown on plan or as otherwise directed or authorized by the Engineer. No measurement shall be made for unauthorized areas or for extra thickness.

The quantity of asphaltic material used is included in the asphalt concrete mixture and will not be measured separately. Quantities of liquid asphalt, wasted or remaining on hand after completion of the work, shall not be measured or paid for.

The quantities determined as provided above shall be paid for at the contract unit price respectively for each of the particular pay items listed below and shown in the bitt of Quantities, which prices and payment shall constitute full compensation for all the costs necessary for the proper completion of the work prescribed in this item. Asphalt additive or antistripping agent, if allowed and used to meet with JMF requirement shall not be paid directly, payment shall be deemed to be included in the respective pay items.

21.1.24 SHOULDER TREATMENT

21.1.24.1 General

a) The work shall consist of constructing shoulders of the types specified hereinafter in accordance with the specifications and in conformity to the lines, grades thickness and typical cross-section shown on the plans or established by the Engineer-in-Charge.

b) The shoulders consist of that portion of the completed road construction which lies above the elevation of the subgrade or sub-base and which extends from the edge of the wearing course to the point of inter-section with the embankment slopes on either side of the road centreline.

21.1.24.2 Material Requirements

a) Earth Shoulders

The material used for “Earth Shoulders” shall consist of suitable materials from roadway or structural excavation supplemented by additional suitable material from borrow excavation or as designated on the plans and shall be obtained from sources approved by the Engineer-in-Charge.

b) Aggregate Shoulders

Material used for “Aggregate Shoulders” shall be of class designated on the plans and shall conform to all the requirements of 21.1.10 “Granular Sub-base” 21.1.11, “Aggregate Base Course” or 21.1.12 or “Water Bound Macadam Base”.

c) Asphaltic Materials

Materials for surface treatment of shoulders shall be liquid asphalts, emulsified asphalts or asphalt cement as specified or shown on the drawings and in the Bill of Quantities. Asphaltic materials shall conform to all the requirements of 21.1.18 for the type specified.

21.1.24.3 Construction Requirements

a) General

All shoulders shall be formed and compacted as soon as practicable after the asphalt paving on the traffic lanes is completed, however in the case of cement concrete surfacing, shouldering operation shall not be initiated prior to Engineer-in-Charge’s approval.

b) Shouldering and delineation

On Projects that carry traffic through construction, the contractor shall begin shouldering on the second day of the laying of the final roadway surfacing layer, unless weather conditions prevent this operation, in which case the shouldering shall begin as soon as the weather does permit. If the contractor fails to begin the shouldering within a reasonable time after the last layer has been laid, whether the project has a flow of traffic through construction or not, the Engineer-in-Charge may order the contractor to cease paving until the shoulder work has begun. The shouldering shall be a continuous operation from that time until completion, with the weather being the only delaying factor. The Contractor shall, on roads under traffic or as directed by the Engineer-in-Charge, delineate the edge or pavement as soon as the surfacing is begun and maintain the delineation until the shoulders are completed. The delineators shall be approved prior to use and shall be placed at the edge of the surfacing at approximately one hundred (100) meter intervals. The cost of this delineation will be considered subsidiary to other items in the Bill of Quantities and will not be paid for separately.

c) Earth Shoulders

Earth Shoulders shall be constructed in accordance with the applicable paragraphs under item 21.1.8.

d) Aggregate Shoulders

Aggregate shoulders shall be constructed in accordance with the requirements of item 21.1.10, 21.1.11 or 21.1.12.

e) Asphaltic Treatment of Shoulders

The asphaltic treatment of the prepared shoulders shall be either a bituminous surface treatment or seal coat or a layer of asphaltic concrete as shown on the plans or in the Bill of Quantities. Detailed construction procedures for the particular treatment specified are outlined under Sub-Sections 21.1.19, 21.1.23 and 21.1.24.

21.1.25 BIT – MAC

21.1.25.1 General

This work shall consist of furnishing and mixing aggregates with asphalt binder at site in mobile mixing plant, spreading, compacting on an approved primed subgrade, sub base or base course, for potholes, repair, levelling course and wearing course in accordance with the specification and in conformity with the lines, grade, thickness and typical cross-section shown on the Drawings or as directed by the Engineer-in-Charge including sealing of cold bituminous surface cracks with sand-bitumen slurry.

21.1.25.2 Material Requirements

A. Mineral Aggregate

Mineral aggregates for BIT-MAC Construction shall consist of coarse aggregates, fine aggregate and filler material, all conforming to the following specification requirements:-

a. Coarse aggregate which is the material retained on No.4 sieve and passing 1 " sieve, shall consist of crushed rock, crushed boulder, or crushed gravel. It shall be clean, hard, tough, sound, durable, free from decomposed stones, organic matter, shale, clay lumps or other deleterious substances. Rock or boulders, from which coarse aggregates shall be obtained, must be of uniform quality throughout the quarry location.
b. Fine aggregates which are the material passing No. 4 sieve shall consist of crushed sand.
c. When combined gradation of coarse and fine aggregates is deficient in material passing No. 200 sieve, mineral tiller shall be added. The filler material shall consist of finely divided rock dust from sound rock, hydrated lime or hydraulic cement. At the time of use it shall be sufficiently dry to flow freely, free from lumps.
d. Aggregate should be stored on hard clean surface so as to facilitate prompt inspection and control, Private property shall not be used for storage purposes without written consent of the owner or lessee and payment to him by contractor, if necessary. Material shall be stored in such a way as to prevent segregation and coning to ensure proper control of gradation. The equipment and methods used for stockpiling and removing aggregates shall be such that no degradation of aggregate will result and no appreciable amount of foreign material will be incorporated into the aggregate. When aggregates containing a wide range of sizes are to be incorporated, they must be stockpiled separately to prevent intermingling. Mineral Filler must be protected from moisture to eliminate caking and hardening.

B. Bituminous Binder

Asphaltic binder used shall conform to standard specification of petroleum asphalt having grades 60-70 or 80-100 penetration. Generally, it will meet the requirement of AASHTO M-20.

C. Design Characteristics

Optimum grading curves for different types of hot mix asphaltic design related to quantum of repair work and maximum size of aggregates, given in Table 21.1.26(a), must be carefully selected considering average thickness of patches.

Design sheet under Table 21.1.26(a) showing Dense Graded Mix used for levelling courses and potholes should use little asphalt content of such quantity to prevent bleeding through subsequent wearing course or surface treatment. Design sheet under Table No. 21.1.26(b) is suitable for open graded wearing course having rough surface texture with good skid resistance thus having minimum bleeding tendency.

21.1.25.3 Construction Requirements

a) **Mixing Requirement**

Asphalt cement shall be heated to a maximum temperature of 163 degrees centigrade at the time of mixing. Asphalt cement heated above 163 degrees centigrade shall be rejected. Temperature of asphalt shall be checked frequently. Each aggregate ingredient shall be heated to temperature 150-160 degrees centigrade for at least six (6) minutes before mixing of asphalt cement to ensure complete drying of aggregates. The range of heating of aggregates shall be strictly followed to ensure proper coating of aggregates. Fine aggregates shall be introduced into the dryer (mixer) first followed by the coarse aggregates to assure proper mixing. Quantity of aggregates fed to dryer (mixer) must be accurately controlled by suitable measuring device (Iron box) having predetermined volume of one(1) cubic foot or as instructed by Engineer-in-Charge.

Both bitumen and aggregates must be heated before they are combined in the mixer drum. Mixing temperature should be kept within the range of 140-170 degrees centigrade.

To achieve uniform mixing and proper coating, aggregates and asphalt cement must be thoroughly mixed for a minimum duration of ninety(90) seconds. Mixing time shall be prolonged to hundred (100) seconds if coating of aggregates is not proper. After one hundred and twenty (120) seconds if it is still not possible to get good coating, the aggregate drying time must be increased.

b) Deep Patches/Pot Holes

The surfaces of base course thus prepared as mentioned under Sub-Section 21.1.11 shall be primed to receive Bit Mac in a thickness as per drawings or as directed by the Engineer-in-Charge, Bit Mac shall be spread carefully to avoid segregation. Compaction shall be done with equipment suited to the size of job. A vibratory plate compactor is recommended for small patches. Whereas roller may be more practical for larger areas,straight edge or string line shall be used to check riding quality and the alignment of the patch.

c) Levelling Course

All local depressions corrugated surface, ripples across the pavement should be rectified before levelling course is placed. Clean the area free to remove dust or other loose material with mechanical broom or compressed air. Apply light tack coat, 0.2 to 0.7 litres per square meter of A.C 80/100 Penetration grade. After drying dense graded hot Bit-Mac shall be spread in layer not more than seven(7) centimetres in thickness. Spread shall be done carefully to prevent segregation and compact with steel wheeled and pneumatic tyred roller. For small pot holes hand tempers shall be allowed. Use string line to check the riding quality of the levelling course.

21.1.25.4 Wearing Surface

a) Mini Mixing Plant

Local made bitumen aggregate mixer equipment used for preparation of Bit Mac shall be in good working condition of sufficient capacity, capable of being operated to produce a uniform blend with the given ingredients

21.1.25.5 Measurement

The length and width of the finished work shall be measured correct to a cm along the finished surface of the road. The area shall be calculated in square metre, correct to two places of decimal.

For item No.21.85, the consolidated cubical contents shall be calculated in cubic metres correct to two places of decimal for item No. 21-85. The quantities for asphaltic leveling / base course will be measured by volume in cubic meters compacted in place. Measurement shall be based on the dimension as shown on plan or as otherwise directed or authorized by the Engineer. No measurement shall be made for unauthorized areas or for extra thickness.

The quantity of asphaltic material used is included in the asphalt concrete mixture and will not be measured separately. Quantities of liquid asphalt, wasted or remaining on hand after completion of the work, shall not be measured or paid for.

The quantities determined as provided above shall be paid for at the contract unit price respectively for each of the particular pay items listed below and shown in the bitt of Quantities, which prices and payment shall constitute full compensation for all the costs necessary for the proper completion of the work prescribed in this item. Asphalt additive or antistripping agent, if allowed and used to meet with JMF requirement shall not be paid directly, payment shall be deemed to be included in the respective pay items.

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Table 21.1.26 (a)

DESIGN SHEETS FOR DENSE GRADED HOT MIX. FOR LEVELING AND POTHOLES, RELATED TO THICKNESS WITH ASPHALT BINDER 60-70 OR 80-100 PENETRATION GRADE.

AGGREGATE IN MIX	FILLER	FINE AGG.	COARSE AGGREGATES					BITUMEN USED.	REMARKS
Sieve Size Inch (mm)	200 (0.075)	No. 8 (2.36)	No. 4 (4.75)	3/8" (9.5)	1/2" (12.5)	3/4" (19)	1" (25)	4% by Wt. of Mix.	Minimum Layer Thickness:-20 mm Aggr. max size : 9 mm Rate of Aggr. Appl. :-50 Kg/SM
Specification Range	4-12	43-56	55-75	90-100					
Allowed % Passing	9	48	65	100					
% by Weight	57%		43%						
Qty. by Proportion.	4		3						
Specification Range	3-11	30-45	46-60	72-87	87-100			4% by Wt of Mix.	Minimum Layer Thickness: 30mm Aggregate Size:- 12mm Rate of Aggr. Appl.:- 70Kg/SM.
Allowed % Passing	8	36	54	80	100				
% by Weight	46%		54%						
Qty. by Proportion.	3		4						
Specification Range	4-11	32-46	46-60	65-80	75-88	90-100		3.5% by Wt. of Mix.	Minimum Layer Thickness:- 50mm Aggr.size:- 20mm Down Rate of Aggr. Appl.: 115 Kg/SM.
Allowed % Passing	8	38	53	73	82	100			
% by Weight	46%		54%						
Qty. by Proportion.	3		4						
Specification Range	4-12	24-37	34-47	49-61	57-70	70-87	88-100	3.5% by Wt. of Mix.	Minimum Layer Thickness:-50mm Aggr. size:- 20mm Down Rate of Aggr. Appl.: 150 Kg/SM.
Allowed % Passing	8	30	40	54	62	76	100		
% by Weight	46%		54%						
Qty. by Proportion.	3		4						

b) Preparation of Aggregates
Aggregates shall be stored and handled as discussed under 21.1.24.2, Material Requirement.

c) Hauling Equipment
Bit-Mac mixed material shall be delivered in tight, clean and smooth metal bed hand trolleys, or any method as convenient to the Contractor and approved by the Engineer-in-Charge.

d) Preparation of Base or Existing Pavement Surface
Surface of base or existing pavement upon which Bit-Mac mix is to be placed shall be cleaned by means of compressed air to remove dust or as approved by the Engineer-in-Charge.
Priming shall be done in a manner as described in Sub-Section 21.1.20. The rate of application of prime coat shall be 0.8 – 1.5 litres per square meter. Tack coat shall be done in a manner as described in 21.1.22. The rate of application of tack coat shall be 0.2 – 0.4 litres per square meter. When surface of existing pavement or old base is irregular, it shall be brought to uniform grade and cross-section by levelling course as described above. Sand bitumen slurry to seal the cracks in clod bituminous surface shall be injected by pressure pumps with nozzles filled at the end instead of spray pipe in conventional Harris trolley.

e) Spreading and Finishing
Bit-Mac mixture shall be placed on approved surface, struck off to required section manually with rakes or hand tools by experienced foreman, distributed over the entire width or partial width as required. All mixtures shall be spread at temperatures not less than one hundred and forty (140) degrees centigrade. Mixture shall not be placed on any wet surface or when the atmospheric temperature is below five (5) degree centigrade or when the weather is foggy or rainy.

f) Compaction
Roller shall be steel wheel or pneumatic tyre roller. The roller(s) shall be in good working condition, capable of reversing without backlash, capable to be operated at speeds slow enough to avoid displacement of Bit Mac. The number and weight of rollers shall be sufficient to compact the mixture while it is still in workable condition to obtain compaction to the satisfaction of Engineer-in-Charge. The use of equipment which results in excessive crushing of aggregates shall not be permitted.
After spreading and strike off as soon as the mix condition permit the rolling to be performed without excessive shoving or tearing, the Bit Mac mixture shall be thoroughly and uniformly compacted. Rolling will not be prolonged to avoid appearance of cracks. Rolling will be done longitudinally, beginning at the lower side of the spread and proceeding towards the higher side, overlapping successive trips by at least one half (1/2) the width of rear wheels of roller.
To prevent adhesion of mixture to rollers, the wheels of rollers shall be kept properly moist with water, but avoiding excess water. Rolling shall be continued until all roller marks have been eliminated.
Along forms, curbs, headers, walls and other places not accessible to the roller, the mixture shall be thoroughly compacted with hot hand tampers or mechanical tampers. Any mixture that has become cold enough, mixed with dirt or is defective in any way shall be replaced with fresh hot mixture and compacted to conform the requirement.

21.1.26 PORTLAND CEMENT CONCRETE PAVEMENT

21.1.26.1 General

The work specified in this section consists of the construction of Portland Cement Concrete pavement constructed in one course on a prepared sub-grade or base in accordance with these specifications and in conformity with the lines and cross-sections shown on the plan and shall include curves where specified. The concrete shall be composed of mixture of Portland Cement, fine aggregate, coarse aggregate and water with air-entertaining admixture where specified, conforming in general to the requirements contained in Section 5 – Plain & Reinforced Concrete.
When reinforced cement concrete is called for in the contract document, the concrete shall be reinforced with steel bar or steel mesh in accordance with the details shown on drawings.

21.1.26.2 Materials

a) **Portland Cement**

The Portland cement shall conform to the requirement, for Portland cement contained in Section 5, Plain & Reinforced Concrete.

b) **Fine Aggregate**

Fine aggregate shall be natural sand or other approved inert material with similar characteristics, of clean, hard, strong durable, uncoated particles, free from lumps of clay, soft or flaky particles, loam, frost or organic matter, unless otherwise approved, the grading shall meet the following requirements:

Sieve Size	Percentage Passing by Weight
3/8 inch	100
No. 4	95 –100
No. 16	45 – 80
No. 60	10 – 30
No. 100	2 – 10
No. 200	0 – 4

c) **Coarse Aggregate**

The coarse aggregate used shall consist of crushed stone gravel or other approved inert material of similar characteristics having hard, strong, durable, uncoated pieces free from deleterious substances.

Unless otherwise approved coarse aggregate shall be separated into two grading classifications. Each classification shall be stored separately in such a manner as will prevent segregation or combining of the two classifications prior to proportioning. Grading of the two classifications shall be as follows:

Sieve Size	Percentage Passing by Weight
Number 1	
1 ½ inch	100
1 inch	95 –100
½ inch	25 – 60
No. 4	0 – 10
No. 8	0 – 5
Number 2	
2 ½ inch	100
2 inch	95 –100
1½ inch	35 – 70
1 inch	0 – 15
½ inch	6 – 5

These two classifications shall be proportioned by weight at the time of batching or mixing in the proper proportions by volume, to meet the following grading requirements when tested in accordance with AASHTO T-27.

Sieve Size	Percentage Passing by Weight
2 ½ inch	100
2 inch	95 –100
1 inch	35 – 70
1½ inch	10 – 30

No. 4	0 – 5

The percentage of wear of coarse aggregate at 500 revolutions, when tested in accordance with AASHTO T-96 shall not exceed 40%.

d) **Water**

Water for concrete shall conform to the requirements contained for “water” as per Section 5 – Plain & Reinforced Concrete.

e) **Air-entertaining Admixture**

The admixtures when designated to be used in the concrete shall conform to the requirement of AASHTO M-154.

f) **Expansion Joint Fillers**

i) **Soft Wood-board / Expansion Joint Filler:**

a) General Requirements:

The boards shall be of sound heart wood. Occasional small sound knots and medium surface cheeks will be permitted provided the board is free from any defects that will impair its usefulness for the purpose intended. The joint filler may be composed of more-than one length of board in the length of the joint, but no board of a length less than 6 feet long be used and the separate pieces shall be held securely to form a straight joint.

Board joint-materials shall be immersed in water for a period of not less than 24 hours before being installed in the pavement slab. The boards shall not be allowed to dry out, and shall be kept thoroughly wet until installed in the slab.

b) Weight per cubic foot:

The oven dry weight of the soft wood shall not exceed 25 pounds per cubic foot.

c) Dimension shall be as specified or shown on the drawings and tolerance of +1/16 inch thickness, + 1/8 inch depth and +1/4 inch length shall be permitted.

d) Compression:

The load required to compress the material in an oven-dry condition to 50 percent of its thickness for test shall not be more than 1,500 pounds per square inch.

e) Method of Testing:

The sampling and testing shall be in accordance with the standard method of AASHTO T-52.

ii) **Mixed Asphalt and Mineral Filler:**

a) General Requirements:

The mixtures of asphalt and mineral filler are also used for filling joint in the pavement. The filler shall be prepared by mixing approved asphalt with cement and sand as specified. It shall be uniform in appearance and consistency and shall not foam when heated to a temperature of 350^{o}F.

b) Asphalt:

The asphalt used, in the preparation of the asphalt mineral filler mixture shall conform to the requirements of standard specifications for asphalt cement (prepared from petroleum) as specified under Clause 21.1.20.2(c).

c) Cement and Sand:

The cement and sand shall be as specified under Clause 21.1. 19.2(a) & (b) respectively.

iii) **Joint Sealer (Hot-poured Elastic Type):**

a) General Requirements:

The joint sealer shall be as approved and a rubber asphalt compound resilient and adhesive in nature capable of effectively sealing joints in concrete against the infiltration of moisture and foreign material during the expansion and contraction cycles due to temperature changes. It shall not flow from the joint or be picked up by a vehicle tyres in summer high temperatures. Pour point shall be at least 20°F lower than the safe-heating temperature.

Penetration at 77°F, 100 grams, 5 seconds shall not exceed 90.

b) Bond:

The sealer shall be tested at 0°F for five complete cycles. The development of crack, separation or other opening at any point is above 1/4 inch deep, in the sealer or between the sealer and mortar block at any time during the testing procedure, shall constitute failure of the test specimen. The depth of the crack, separation or opening shall be measured perpendicular to the side of the sealer showing the defect.

c) Method of sampling and Testing:

The sampling of the material and the testing of physical requirements specified above shall be done in accordance with the AASHTO designated T-40 and T-187 respectively.

d) PVC Water Stop:

The PVC water stop shall comply with applicable provisions of Section 5 – Plain & Reinforced Concrete.

e) Polythene Sheeting:

Polythene sheeting for placing immediately below concrete slabs shall be 0.065 mm thick or having a minimum weight of fifty (50) grams per square meter (whichever is greater) made from polythene or other approved hydrocarbon thermoplastic resin (produced by the polymerization of ethylene under high pressure and density) and given an anti-static treatment to reduce dust attraction and reduce friction. The sheet shall have the minimum mechanical properties shown in table as follows:

PROPERTIES OF POLYTHENE SHEETING

Properties	Machine Direction	Transverse Direction
Tensile Strength Method ASTM D882-73	140	105
Elongation at Break %	150	500
Tear Strength (Elmendorf Method)	390	310
ASTM D 689-62 (1974) kg/cm^2		

f) Dowel Tie, Reinforcement Bars:

The bars shall be deformed bars of the size shown on the plans and shall conform to the requirements of steel Section 5 – Plain & Reinforced Concrete.

g) Bituminized Water Proof Paper:

The bituminized water proof paper shall comply with the provisions of clause 8.2.3.2 as approved by the Engineer-in-Charge.

21.1.26.3 Construction Details

a) Pavement Base:

The base upon which the concrete pavement is laid shall have been constructed or prepared as specified on drawings and directed by the Engineer-in-Charge.

The base shall be smooth compacted and true to the grades and cross-sections including the cushion of sand, polythene sheet, bituminized paper shown on the plans and shall be so maintained, as provided throughout the period of placing concrete pavement. The base under polythene sheet & bituminized paper shall be moistened immediately prior to placing concrete.

To ensure the proper depth and section, a template to depth and section and resting on accurately set aside forms shall be moved over the surface immediately before placing concrete; and any irregularities shall be immediately corrected. High spots shall be planed down; and the Contractor

shall have the option of either filling low spots to the proper elevation with approved material, which shall be watered, compacted and struck off to the required grade or of placing additional concrete. No measurement or payment will be made for such additional concrete.
For reinforced pavement, the reinforcing bars shall be placed as shown and on drawings complying with the provisions of Section 5 – Plain & Reinforced Concrete.

b) Forms

Forms shall be made of steel, of an approved section; with a base width of at least 8 inches and the depth shall be equal to the thickness of the pavement at-the edge. The forms shall be staked with stakes, and stakes shall be of length satisfactory to the Engineer-in-charge. Batch section of forms shall have a stake pocket at each end and at intervals of not more than 5 feet in between. The stake pockets shall have a device for locking the form to the steel stakes. Each section of forms shall be straight and free from bends and warps at all times. No section shall show a variation greater than 1/8 inch in 10 feet from a true plane surface on the top of the form; and the inside face shall not vary more than 1/4 inch from a plane surface.
Before placing forms, the underlying material shall be excavated to the required grade if necessary and shall be firm and compact. The forms have full bearing upon the foundation throughout their length and shall be placed with exactness to the required grade and alignment of the edge of the finished pavement. They shall be so supported during the entire operation of placing tamping and finishing the pavement so that they will not deviate vertically at any time more than 1/8 inch from the proper elevation.
Forms shall be set to the required lines and grades well ahead of placing concrete; preferably not less than 600 feet. Forms shall not be removed for at least 12 hours after the concrete has been placed. Forms shall be carefully removed in a manner as to avoid damage to the pavement. Under no circumstances will the use of pry bars between the forms and the pavement be permitted.
Forms shall be thoroughly cleaned and oiled each time they are used.
When pavement is placed adjoining old concrete pavement with finishing machine, any irregularities in the old pavement shall be ground down to a true, uniform surface of sufficient width to accommodate the wheels of the finishing equipment if necessary to obtain proper smoothness of the pavement.

c) Proportioning

Proportioning & mixing of concrete shall be by volume as specified and shall be carried out in accordance with the applicable provisions of Section 5 – Plain & Reinforced Concrete. The fresh concrete shall be tested according to the provisions of the same section.
No change in the source, character or grading of the materials shall be made without prior approval of the Engineer-in-charge.

d) Moisture content of Aggregate

The moisture content of the aggregate shall be such that no visible separation of moisture and aggregate will take place during transportation from the proportioning plant or site to the point of mixing. Aggregate containing excess moisture shall be stockpiled prior to use until sufficiently dry to meet the above requirement.

e) Handling of Materials

Materials shall at all-time be handled in such a manner as will preserve their integrity and prevent Ioss. The equipment and methods used for stockpiling aggregates and for moving the aggregates, from the stockpiles to the mixer shall be such in the opinion of the Engineer-in-charge that no degradation or segregation of the aggregate will result and that no foreign material will be incorporated into the aggregate.

Aggregates shall be transported from the proportioning plant in batch boxes, vehicle bodies or other containers of sufficient capacity and adequate construction to carry properly the entire volume required per batch and shall be delivered to the mixer with each batch separate and intact without loss.

Loose cement shall be transported to the mixer either in waterproof compartments carrying the full amount of cement required for the batch.

Where cement is placed in contact with damp aggregates the materials may be rejected unless mixed within one hour of such contact. Cement in original factory packages may be transported on top of the aggregates.

f) Consistency

The slump of the pavement concrete shall be from one to three inches, as determined by the Engineer-in-charge. The slump shall not vary more than one inch from batch to batch.

g) Placing Concrete

Concrete shall be placed on the prepared sub-grade moistened as directed prior to the placement of polythene sheet, bituminized paper as specified. The concrete shall be placed in such a manner as will require as little re-handling as possible and avoid segregation of materials.

If required by the Engineer-in-charge the forms shall be wetted immediately prior to the placing of concrete. All operations shall be in accordance with provisions of Section 5 – Plain & Reinforced Concrete.

i) Cold Weather Concreting

Except by specific written authorization from the Engineer-in-charge concreting operations shall not be continued when air temperature in the shade and away from artificial heat falls below 40°F, nor shall operations be resumed until as ascending air temperature in the shade and away from artificial heat reaches 35°F. Mixing and placing concrete in any day, shall continue not later than the period which allows sufficient time remaining to finish and protect the concrete already poured, before the air temperature drops to 35°F. Concrete shall not be placed on frozen ground.

When concreting is authorized during cold weather the aggregates may be heated by the use of steam coils or dry heat before being placed in the mixer. The aggregates shall be heated uniformly, but not hotter than150°F. The apparatus used shall preclude the possible occurrence of overheated areas which might injure the materials. Water may be heated, but shall not be hotter than 150°F. Unless otherwise authorized the temperature of the mixed concrete shall be not less than 60°F nor more than 90°F when it is placed. After placement of concrete, blanketing material shall be provided and shall be spread over the pavement to a sufficient depth to prevent freezing of the concrete.

The Contractor shall be responsible for protection of the concrete placed during cold weather, and any concrete injured by frost action shall be removed and replaced without additional expense to the Employer.

j) Joint

i) **General Requirements:**

All joints shall be constructed as per to alignment and grade in accordance with the details shown on the drawings and as specified herein. The tie bars and joint assemblies, such stakes, brackets or other devices shall be used as necessary to keep the entire joint assembly in true vertical and levelled position.

ii) **Construction Joints**

At the end of each day's concreting or where an interruption in the work of more than 30 minutes occurs, a construction joint shall be placed as shown on the plans or as desired by the Engineer-In-charge. Construction joints shall be placed only at the location of a contraction joint or at the mid-point of the slab between two adjacent normally spaced transverse joints. Any excess concrete shall be disposed of as directed by the Engineer-in-charge. The spacing of subsequent transverse joints shall be measured from the transverse contraction joints last placed. All transverse joints except mid-point construction joints shall be continuous across the full width of the pavement.

iii) **Longitudinal joints**

Longitudinal joints shall be constructed in accordance with the details shown on the drawings. Where specified, steel tie bars of the dimensions shown and meeting the requirements as specified herein shall be placed across the longitudinal joint as shown on the plans. The tie bars shall be held in position, at the spacing shown perpendicular to the joint and at the correct distance from the surface of the slab by metal chains, pins or other supports. Instead of using supports, the tie bars may be floated in place by approved methods.

When the lanes are poured separately, the tie bars may be set temporarily along the form and then straightened into the correct position before the next lane of pavement is poured.

Where sawed longitudinal joints are required or permitted, the joint shall be sawed after the concrete has hardened, but before traffic of any kind is permitted on the pavement. The joint shall conform to the requirements specified herein under sawed joints.

Where curb and gutter is to be constructed adjacent to new concrete pavement, the curb and gutter shall be placed after the pavement, and the joints in the curb shall be opposite each transverse joint in the adjoining pavement.

iv) **Transverse Contraction Joints**

1. General Requirements:

   Transverse contraction joints shall consist of formed control joints and sawed joints conforming to the requirements of the roadway standards and these specifications.

   Unless otherwise specified on the plan or in the special provisions and except as otherwise provided herein, the first lane poured shall have formed control joints spaced at a maximum of 60 feet and the intermediate joints at 15 feet centre shall be sawed joints. Under certain conditions, if deemed advisable by the Engineer-in-charge he may order that formed control joint be used instead of sawed joints. In lanes adjacent to previously constructed lanes, all contraction joints shall be opposite to joints or cracks which have opened in the previously constructed slab and these joint shall be formed control joints.

2. Formed Control Joints:

   The formed control joints shall be constructed by making a transverse groove in the pavement lane and installing therein steel strips as joint inserts spaced as shown on the roadway standards or on the plans. The joint inserts shall be maintained true to line and grade at an elevation not more than 1/4 inch below the pavement surface. The joint inserts shall consist of steel strips 2¼ inches wide and maximum of No. 12 gauge. Each strip shall be furnished in one piece. Splicing, except by welding, will not be permitted. Any strips damaged in installing or during the finishing of the pavement shall be replaced with undamaged strip.

The joints inserts shall be set following the first pass of the finishing equipment, and may be installed either by a machine or by hand methods as approved by the Engineer-in-charge. If manual methods are used, a groove shall be formed by means of a "T" iron cutter with a blade at least 1/4 inch greater in depth than the joint strip. The joint inserts shall then be placed in the groove by means of a metal installing device with a backup plate extending full depth of the strip on one side and 3/4 inch on the other side and it shall have a gauge resting on each side of form to control the depth to which the strip is set. Mortar shall be floated into the groove around the joint after the installing device is removed and before any finishing equipment passes over the joint.

When it is necessary to place joint inserts temporarily at a depth greater than 1/4 inch below the pavement surface in order to prevent damage to the inserts by finishing equipment, the inserts shall be raised to the required elevation immediately after the last pass of the mechanical float.

3. Sawed Joints:

Sawed joints shall be formed by cutting a groove in the pavement with multiple blade power concrete saw. The grooves for construction joints shall be cut 2 inches deep and the width shall not exceed 3/16 inch.

Preferably all joints shall be sawed before uncontrolled shrinkage cracking takes place, usually four to twenty-four hours after placing, but sawing shall not be done until the concrete has hardened to the extent that tearing and ravelling is not excessive. The exact time for all sawing shall be determined by the Engineer-in-charge. In case it is found impossible to saw all joints before uncontrolled cracking takes place, the transverse contraction joints 30 feet or more apart shall be sawed before uncontrolled cracking takes place and the intermediate joints sawed immediately thereafter.

Any procedure for sawing joints that result in premature and uncontrolled cracking shall be revised immediately by adjusting the sequence of sawing the joints, by adjusting the time interval involved between the placing of concrete and the sawing of the joints, or by placing formed control joints.

In addition to the multiple blade power saw, the Contractor shall keep a stand-by concrete saw on the project at all times while concrete operations are in progress. This saw may be a single blade saw.

4. Transverse expansion joints:

Transverse, expansion joints shall be constructed at the end of bridges and culverts at grade and at all obstructions that extend into or through the pavement, as shown on the roadway standards or on the plans and as specified herein. .

Transverse expansion joints shall be formed by a preformed or redwood joint filler conforming to the requirements specified herein under “Expansion Joint Filler" and as shown on the roadway standards or on the plans. The joint filler shall be held in position by protective means.

k) **Spreading, Finishing and Floating**

a) **General Requirement**

Except as otherwise specified, the striking off, compacting and floating of concrete shall be done by mechanical methods. Where the Engineer-in-charge determines that it is impracticable to use mechanical methods, manual methods of spreading, finishing and floating may be used on pavement lanes of widths less than 10 feet.

b) **Mechanical Methods**

1. Spreading and Finishing:

The concrete shall be spread uniformly between the forms immediately after it is placed by means of an approved spreading machine. The spreader shall be followed by an approved finishing machine equipped with two oscillating or reciprocating screeds. The spreading machine or the finishing machine shall be equipped with vibrating equipment that will vibrate the concrete for the full paving width. Internal vibrators shall be used adjacent to the longitudinal edge of the pavement. These vibrators shall be attached to the rear of the spreading machine or to the finishing machine. Vibrators shall not rest on new pavements or side forms or contact any tie bars and power to the vibrators shall be such that when the motion of the machine is stopped, vibration will cease. The rate of vibration shall be not less than 3,500 vibrations per minute.

The concrete shall be spread full width before being struck off by the finishing machine. The concrete shall be struck off and compacted so that the surface will conform to the finished grade and cross-section shown on the plans and at the same time leave sufficient material for the floating operation. The spreading and finishing machine shall move over the pavement as many times and at such intervals as may be required by the Engineer-in-charge to ensure thorough compaction.

2. Floating:

Except as otherwise specified, after the pavement has been struck off and compacted, it shall be finished with an approved longitudinal float.

The Contractor may use a longitudinal float composed of one or more cutting and smoothing floats, suspended from and guided by a rigid frame. The frame shall be carried by four or more visible wheels riding on and constantly in contact with the forms.

The Contractor may use a longitudinal float which works with a sawing motion, while held in a floating position parallel to the road centre-line and passing gradually from one side of the pavement to the other. Movements ahead along the centre-line of the road shall be in successive advances of not more than 1/2 the length of the float.

Instead of using either type of longitudinal float, a single machine which will affect satisfactory compaction, finishing and floating may be used. This machine may be towed by a spreading machine. This combination finishing-floating machine shall be equipped with screeds and vibrators as hereinafter specified for spreading and finishing machines. Floating shall be accomplished by means of a non-oscillating float held in a suspended position from the frame.

If any spreading finishing and floating equipment is not maintained in full working order or if the equipment as used by the Contractor proves inadequate to obtain the results prescribed, such equipment shall be improved or satisfactory equipment substituted or added at the direction of the Engineer-in-Charge.

c) **Manual Methods**

1. Striking-off and compaction:

When striking-off and compacting by manual methods are permitted, the concrete shall be approximately levelled and then struck-off to such an elevation that when properly compacted, the surface will conform to the required grade and cross-section. The strike board shall be moved forward with a combined longitudinal and transverse motion, the manipulation being such that neither end is raised from the side forms during the process. While striking-off, a slight excess of concrete shall be kept in front of the cutting edge at all times.

Prior to tamping, the concrete along the forms shall be thoroughly spaded or vibrated. The entire area of pavement shall be tamped or vibrated in a manner that will ensure maximum compaction. The concrete shall be brought to the required grade and shape by the use of a tamper consisting of a heavy plank whose length exceeds the width of the pavement by one foot, or by the use of a mechanical vibrating unit spanning the full width of the spread. The tamper shall be constructed with proper trussed rods to stiffen it and prevent sag and shall be shod with a heavy strip of metal for finish as required. The tamper shall be moved with a combined tamping and longitudinal motion, raising it from side form and dropping it so that the concrete will be thoroughly compacted and rammed into place. A small surplus of concrete shall be kept in front of the tamper or vibrating unit and tamping or vibrating shall continue until the true cross-section is obtained and the mortar flushes slightly to the surface.

On grades in excess of 5 percent where manual methods are permitted, a little strike board shall follow from 25 feet to 50 feet back of the heavy strike board, and shall be used in the same way, so as to remove waves caused by the flow of concrete.

Where hand tamping is permitted, not less than two strike boards or tampers shall be used for production in excess of 350 cubic feet per hour. After the concrete has been compacted, it shall be smoothed with a wooden float where necessary in the opinion of the Engineer-in-charge.

2. Longitudinal Floating:

Manual floats shall be at least 12 feet in length, not less than six inches in width and shall be properly stiffened to prevent bending or warping. In using the float, it shall be held parallel to the centre-line of the pavement at all times and shall be moved laterally across the pavement from one side or edge to the other until all high areas are cut down and floated in to level, leaving a surface that is smooth and true to grade. Both transverse passage of the longitudinal manual float shall lap the half of the preceding passage.

3. First Straight Edge Testing:
Immediately following the final floating, entire area of the pavement shall be tested with a 10 feet straight edge. Any depressions found shall be immediately filled with fresh concrete which shall be struck off, compacted and finished. High areas shall be worked down and refinished. The straight edge testing and re-floating shall continue until the pavement has the required surface contour.

4. Burlap (Coarse Canvas) Dragging:
After the first straight edge testing and when most of the water shell has disappeared from the surface and just before the concrete becomes non-plastic, the surface shall be dragged with a strip of burlap (coarse canvas) three feet to 10 feet wide and having a length four feet more than the width of the slab. The burlap shall be dragged along the surface of the pavement in a longitudinal direction. Burlap shall be clean and kept free from coatings of hardened concrete. It shall be moist at the time of use.

5. Second Straight Edge Testing:
After the concrete has hardened sufficiently to permit walking on it, the surface of the pavement shall again be tested with a 10-feet straight edge. Any portion of the pavement which shows a variation from the testing edge of more than 1/8 inch shall be corrected by cutting, or shall be removed and replaced at the expense of the Contractor.

21.1.26.4 Opening Pavement to Traffic

Pavement shall remain closed to traffic until tests show the concrete to have a minimum modulus of rupture when tested in accordance with ASTM C-293 of not less than 600 pounds per square inch but in no case shall the pavement be opened to traffic in less than 14 days after concrete is placed.

21.1.26.4 Measurement

Refer Section 5

21.1.27 BOUNDARY PILLARS

21.1.27.1 General

The boundary pillars shall be of either precast RCC or hard stone of sound and durable quality. These shall be in blocks of size 6 inches x 6 inches x 30 inches (15x15x75 cm) unless directed otherwise by the Engineer-in-Charge. A tolerance of 12.5 mm shall be permitted in the specified size. In the case of boundary stones of hard stone, the upper 30 cm shall be chisel dressed on all the four sides and on the top.

21.1.27.2 Precast Concrete Pillars

The precast concrete boundary pillars shall be cast in cement concrete 1:2:4 (1 cement : 2 coarse sand : 4 graded stone aggregate 20mm nominal size), where specified reinforced with 10mm diameter tor steel bars or as directed. The precast concrete pillars shall be finished smooth with 1:3 cement mortars.

The lower half portion of the boundary pillars or as shown and drawings shall be encased on all sides by at least 15 cm of 1:4:8 foundation concrete (1 cement : 4 fine sand : 8 graded stone aggregates of 40 mm nominal size). The work shall be carried out according to the applicable provisions of Section 5 – Plain & Reinforced Concrete.

21.1.27.3 Hard Stone Boundary Pillars

The hard stone boundary pillars shall be as stated under Clause 21.1.28.1 above. The stone boundary pillars shall be installed as specified for concrete pillars under Clause 21.1.28.2 above.

21.1.27.4 Engraving / Letters

The boundary pillars shall be engraved/written letters for each pillar as specified.

21.1.27.5 Measurement

Boundary Pillar shall be enumerated.

21.1.28 KILLOMETER STONES

21.1.28.1 General

The kilometers stones shall be either precast concrete or of hard durable stone in shape and sizes as specified.

21.1.28.2 Precast Concrete Stones

The precast stones shall be cast in-situ 1:2:4 concrete complying with the provisions of Section 5 – Plain & Reinforced Concrete. To obtain smooth finish, 1:3 cement sand mortar shall be applied. The excavation for foundation as specified for installation shall comply with the provision of Section 3 – Earthwork. The pillar shall be fixed in 1:4:8 concrete of the specified size and backfilled. The letters as specified shall be engraved or painted.

21.1.28.3 Hard Stone Kilometer

The hard stone kilometer shall comply the provisions for boundary stone under Clause 21.28.1 and shall comply with provision of Clause 21.28.3 for installation.
The letters shall be engraved or painted as specified.

21.1.28.4 Measurement

Kilometer stones shall be enumerated.

21.1.29 CONCRETE KERBS, GUTTERS AND CHANNELS

21.1.29.1 General

This work shall consist of kerb, gutter, channel, or combination of kerb and gutter or channel; constructed of the following materials and in accordance with the specifications at the location and of the form, dimensions and designs shown on the Drawings or as directed by the Engineer-in-Charge. The kerb, gutter, channel or in combination may be constructed by one of the following methods.

i) Cast in place concrete kerbing
ii) Precast concrete kerbing
iii) Extruded concrete kerbing

21.1.29.2 Material Requirements

The quality of concrete for cast in place concrete kerb, gutters and channels shall be as indicated on the Drawings and shall conform to the requirements of Section 5- Plain & Reinforced Concrete.
Precast concrete kerbing units shall consist of 1:3:6 concrete conforming to the Section 5 – Plain & Reinforced Concrete and to lengths, shape and other details shown on the Drawings. Kerbing which shows surface irregularities of more than five (5) mm when checked with three meter straight edge or surface pits more than fifteen (15) mm in diameter will be rejected.
Form to hold the concrete shall be built and set in place as described under Sub-Section 5 – Formwork.
Forms for at least sixty meters of kerb or combination of kerb and gutter or channels shall be in place and checked for alignment and grade before concrete is placed. Curved sections shall have

forms of either wood or metal and shall be accurately shaped to radius of curvature shown on the Drawings. Steel Reinforcement if required shall conform to Section 5.4 – “Steel Reinforcement”.

Expansion joint filler shall be either the performed type conforming to requirement of AASHTO-M 153 or shall be precast fiber board packing.

Joint filler shall consist of one part cement and two parts of approved sand with sufficient quantity of water necessary to obtain the required consistency. The mortar shall be used within thirty (3) minutes after preparation.

The Bonding compound when used shall conform to AASHTO M-200.

21.1.29.3 Construction Requirements

i) **Cast-in-Place**

a) Excavation and Bedding

Excavation shall be made to the required depth and the base upon which the kerb or combination of kerb and gutter is to be set shall be compacted to a minimum density of ninety(90) percent of the maximum dry density as determined by AASHTO T-191 Method. All soft and unsuitable material shall be removed and replaced with suitable material acceptable to the Engineer-in-Charge. Where directed by the Engineer-in-Charge, a layer of cinders or clean sand and gravel, or other approved porous material having a minimum compacted thickness of fifteen (15) cm shall be placed to form a bed for the kerb or combination of kerb and gutter.

b) Placing Concrete

Concrete may be placed in the gutter to the full depth required. The top of the kerb or combination of kerb and gutter shall be floated smooth and the edges rounded to the radii shown on the Drawings. Before finishing, the surface of the gutter shall be tested with a three (3) meter straight-edge and any irregularities of more than five(5)mm in three (3) meters shall be eliminated. In finishing concrete only mortar normally present in the concrete shall be permitted for finishing. The use of a separate mortar finishing coat or the practice of working dry cement into the surface of the concrete will not be permitted.

c) Joints

The kerb and gutter shall be constructed in uniform sections of not more than twenty five (25) meters in length except where shorter sections are required to coincide with the location of weakened planes or contraction joints of the concrete pavement or for closures but no section shall be less than two (2) meters long. The sections shall be separated by sheet templates set perpendicular to the face and top of the kerb and gutter. The templates shall be approximately five (5) mm in thickness, of the same width as that of the kerb or kerb and gutter and not less than five (5) cm greater than the depth of the kerb or kerb and gutter. Templates shall be set carefully and held firmly during the placing of the concrete and shall be allowed to remain in place until the concrete has set sufficiently to hold its shape, but shall be removed while the forms are still in place. When pre-cut fiber-board packing is used in the expansion joints, it may be used in place of sheet template referred to above, on the approval of the Engineer in-Charge. In this event the fiber board shall be pre-cut to the shape of the kerb so that its outer edge will be flush with the abutting kerb. Expansion joints shall be formed in the kerb and gutter at intervals of six(6) to ten (10) meters in order to coincide with the expansion joints of cement concrete pavement or as shown on the Drawing.

d) Dowels of Expansion Joints in Channels

At expansion joints in channels and in the channel portion of kerbs and channel built monolithically, painted dowel bars with slip sleeve shall be provided as a load transfer medium at location shown on the Drawings.

The size and spacing of the dowel bars shall be as indicated on the Drawings. Each dowel shall be set accurately parallel to the top surface of the gutter and accurately at right angles to the expansion joint.

e) Contraction Joints

Transverse contraction joints shall be opposite to all contraction joints in abutting concrete pavement and other locations shown on the Drawing spaced to a maximum of four (4) meters.

The construction joints shall be provided by forming grooves in the face and surface of structure at right angle to the kerb alignment and kerb surface. The grooves shall be rectangular in cross-section , five (5) cm deep by five (5) cm wide. The grooves shall be formed in the top of all kerbs and in the exposed roadway face of kerb and in the channel surface of monolithic type kerb and channels and in the surface of channels. The edges of the joints shall be tooled land the joints shall be left clean, neat and of specified width and depth.

f) Removal of Forms and Finishing

The forms shall be removed within twenty four (24) hours after concrete has placed except that the form used against the face of the kerb in a combination of kerb and gutter shall be removed as soon as the concrete has set sufficiently to hold its shape. Minor defects shall be repaired with mortar containing one part of Portland cement and two parts of the fine aggregate. Plastering shall be not permitted on the face of a kerb or kerb and gutter and all rejected kerb or gutter shall be removed and replaced without additional cost. All surface which will be exposed in the finished construction of the kerb and gutter shall be finished, while the concrete is still " green" by wetting a wood block of float and rubbing the surface until they are smooth.

g) Curing

During seventy two (72) hours following placing of concrete, the kerbs channels and gutters shall be protected against premature drying by covering with suitable cotton or Hessian mats and by frequent sprinkling with water, with liquid forming compounds or with waterproof paper or by any other method as mentioned in section 5.3.7 Curing approved by the Engineer-in-Charge.

h) Backfilling

After removal of the forms and sufficient curing has been removed and concrete has been cured as specified, the excavation of kerbs, gutters or channels shall be backfilled with suitable earth or granular material tamped into place in layers of not more than fifteen (15) cms each until firm and solid.

ii) **Pre-Cast**

a) Excavation and Bedding

Excavation shall be made to the required depth as shown on the Drawings. All soft and unsuitable material shall be removed and replaced with a suitable material acceptable to the Engineer-in-Charge. Bedding shall consist of 1:3:6 Concrete or as designated in drawings conforming to the requirements of Section 5 – Plain & Reinforced Concrete and shall be the section and dimension shown on the Drawings.

b) Placing

The precast concrete kerbs shall be set in 1:3 of cement sand mortar to the line, level and grade as shown on the Drawings or as directed by the Engineer-in-Charge.

c) Joints

Joints between consecutive kerbs shall be three (3) to five (5) mm wide and filled with cement mortar to the full section of the kerb.

iii) **Extruded Concrete Kerbs and Channels**

a) Excavation and Bedding

Excavation and bedding shall conform to the requirements as described under (i)(a) above.

b) Placing

Concrete shall be fed to the machine at a uniform rate. The concrete shall be of such consistency that after extrusion it will maintain the shape of the kerb section without support and shall contain the maximum amount of water that will permit this result. The machine shall be operate under sufficient uniform restraint to forward motion to produce a well compacted mass of concrete which requires no further finishing other than light brushing with a brush filled wetted with water only.

The forming tube portion of the extrusion machine shall be readily adjustable vertically during the forward motion of the machine. A grade line gauge or pointer shall be attached to the machine so that a continual comparison can be made between the kerb being placed and the established kerb grade as indicated by an offset guide line.

The top end face of the finished kerb shall be true and straight and the top surface of the kerb shall be of uniform width, free from bumps or surface pits larger than fifteen (15) mm in diameter. When a straight-edge three (3) meters long is laid on the top or face of the kerb, or surface of the gutter, the surface shall not vary by more than five (5) mm form the edge of the straight edge except at grade changes or curves.

Where adhesive is used to bond the kerb to an existing pavement, the surface shall be first thoroughly cleaned of all dust, loose material and oil, the cost of which shall be included in other items of work.

c) Joints

Expansion joins shall be constructed by sawing through the kerb section to its full depth. The width of the cut shall be such as to admit the joint filler with a tight fit. Preformed joint filler shall conform to the provisions of Sub-section 21.1.25.2 and shall be inserted and mortared in place.

If sawing is performed before the concrete has hardened, the adjacent portion of the kerb shall be supported firmly with close fitting shields and the operations of sawing and inserting the joint filler shall be completed before curing the concrete.

Alternatively pre-cut joint fillers shall be permitted to be placed at the location of the expansion joints prior to the placing of the extruded kerb with the approval of Engineer-in-Charge. The joint fillers shall be set firmly in place in a vertical position to the line and grade of the kerb profile.

d) Curing and Backfilling

Curing and backfilling shall be as described under (i) and (ii) of this Sub-Section 21.30.3.

21.1.29.4 Measurement

Cement concrete Kerbs, Gutters and channel shall be measured in metre of length of the completed channel correct upto two places of decimal.

21.1.30 REPAIRING ASPHALT BITUMEN ROADS

21.1.30.1 Preparation

The surfaces and portions to be repaired shall be prepared by brushing cleaning cutting and dismantling as specified and directed by the Engineer-in-Charge.

21.1.30.2 Repairing

The surfaces prepared shall be repaired with the original constructions material as specified following the applicable specifications and directed by the Engineer-in-Charge.

21.1.31 PLACING PIPES

21.1.31.1 EXCAVATION

Excavation of trenches in natural surface and Roads for laying/replacing pipes shall be carried out as shown on drawings in natural surface or roadway in accordance with applicable provisions of Section 3 – Earthwork. Where necessary dismantling shall be done according to applicable provisions of Section 4 – Dismantling.

21.1.31.2 Laying of Pipes

The bed of trenches shall be prepared as specified.

The pipes as designated shall be laid in accordance with applicable provisions of Section 25 – Sewerage& Section 27 – Tube well & Water Supply.

21.2 ROAD STRUCTURES

21.2.1 GENERAL

The following are the major road structures;

a) Bridges
b) Culverts

The bridges are dealt with in a Section 10 – Road Bridges. The culverts and curbs are referred hereunder. The culverts are described various categories. All works shall be constructed according to drawings, specifications and as approved by the Engineer-in-Charge.

21.2.2 SLAB CULVERTS

21.2.2.1 Materials

Cement, fine and coarse aggregates, water and reinforcement steel shall conform to the respective provision of Section 5 – Plain & Reinforced Concrete. The burnt bricks shall conform with the provisions of Section 11 – Brickwork.

21.2.2.2 Excavation

The excavation as required shall conform to the provision of Clause 3.8.4 "Excavation in trenches for pipes cables etc."

21.2.2.3 Construction Requirements

a) The laying cement concrete in foundation. It shall be laid in accordance with provisions of Section 5, Plain & Reinforced Concrete and in conformity with the lines, and grades shown on the plans.

b) The abutment and wing walls shall be constructed in cement mortar in brick masonry, or precast concrete blocks or stone masonry according to the applicable provisions of Section 11 – Brickwork or Section 9 – Block Masonry or Section 12 – Stone Masonry as specified.

c) Laying Reinforced Cement Concrete Slab: It shall be laid in conformity with the lines shown on the plan and in accordance with the provisions of Section 5 – Plain & Reinforced Concrete.

d) Backfilling:
It shall be done in accordance with Clause 3.8.4 – Earthwork.

e) Construction of Parapets:
These shall be constructed in accordance with the lines and grades shown on the plan and in accordance with the provisions of (b) above.

f) Construction of Up-stream and Down-stream toe walls:
These shall be constructed in accordance with the lines and grades shown on the plan and in accordance with the lines and grade shown on the plan and in accordance with applicable provisions of above referred paras.

g) Construction of Floors:
Bricks on edge flooring in cement mortar shall be laid over cement, concrete in conformity with the lines and grades shown on the plan and in accordance with the provisions of the above referred paras.

h) Pre-mix Carpet:
It shall be laid over RCC Slab as shown on the plan in requisite thickness and in accordance with applicable provisions of Clause 21.1.20 – Asphaltic Concrete Road Mix.

i) Plastering:
½" thick plastering shall be done with cement mortar in accordance with Section 11 – Brickwork and in conformity with the lines shown on the plans.

21.2.3 PIPE CULVERTS

21.2.3.1 Description

This work shall consist of the construction or reconstruction of pipe culverts, hereinafter referred to "conduit" in accordance with these specifications and in conformity with the lines and grades shown on the plans or established by the Engineer-in-Charge.

21.2.3.2 Materials

Materials shall meet the requirements specified as under;

i) Cast Iron Pipe:
This pipe shall conform to RS 78 for spigot and socket vertically cast pipe, RS 1211 for spigot and spun iron pipes and RS 2035 for flanged pipes for the specified diameter weight and thickness.

ii) Reinforced Cement Concrete Pipe:
This pipe shall conform to the requirements of ASTM Designation C-76 for Class-IV pipes "Reinforced Cement Concrete Pipes" for the specified diameter, weight, thickness and reinforcements.

iii) Joint Mortar:
Pipe joint mortar shall consist of one part Portland cement and two parts approved sand in accordance with Clause 11.7.2(ii) "Cement Mortar".

21.2.3.3 Excavation

It shall conform to provisions of Clause 3.8.4.

21.2.3.4 Construction Requirements

a) **Trenches:**

Trenches shall be excavated to a width sufficient to allow for proper jointing of the conduit and thorough compaction of the bedding and backfill material under and around the conduit. Where feasible, trench walls shall be vertical.

The completed trench bottom shall be firm for its full length and width. Where required, in the case of cross drains, the trench shall have a longitudinal camber of the magnitude specified.

Where conduits are to be placed in embankment fill, the excavation shall be made after the embankment has been completed to the specified height above the designed grade for those conduits specified on the plans.

b) **Bedding:**

The conduit bedding shall conform to one of the classes specified, when no bedding class is specified the requirements for Class "C" bedding shall apply.

Class "A" bedding shall consist of a continuous concrete base conforming to the plan and details.

Class "B" bedding shall consist of bedding conduit to a depth of not less than 30 per cent of the vertical outside diameter of the conduit plus 4 inches. This bedding material shall be sand or selected sandy soil all of which passes a 3/8 inch sieve and not more than 10 per cent passes a No. 200 sieve. The layer of bedding, material shall be shaped to fit the conduit for at least 15 percent of its total height. Recesses in the trench bottom shall be shaped to accommodate the bell when the bell and spigot type conduit is used.

Class "C" bedding shall consist of bedding the conduit to a depth of not less than 10 percent of its total height, the bed shall be shaped to fit the conduit and shall have recesses shaped to receive the bell.

c) **Laying Conduit:**

The conduit laying shall begin at the downstream end of the conduit line. The lower segment of the conduit shall be in contact with the shaped' bedding throughout its full length. Bell or groove ends of rigid conduits and outside circumferential laps of flexible conduits shall be placed facing upstream. Flexible conduit shall be placed with longitudinal laps at the sides.

d) **Joint Conduit:**

Rigid conduits may be of bell and spigot or tongue and groove design unless one particular type is specified. The method of jointing conduit sections shall be such that ends are fully entered and the inner surfaces are reasonably flush and even.

Joints shall be made with (a) Portland Cement Mortar, (b) Portland Cement Grout, (c) Rubber gaskets or any other type as may be specified.

Mortar joints shall be made with an excess of mortar to form a bed around the outside of the conduit and finished smooth on the inside. For grouted joints, mould or runners shall be used to retain the poured grout. Rubber ring gaskets shall be installed so as to form a flexible watertight seal. When Portland Cement mixtures are used, the completed joint shall be protected against rapid drying by suitable covering material.

Flexible conduits shall be firmly joined by coupling bands. Conduit shall be inspected before any backfill is placed. Any pipe found to be out of alignment, unduly settled, or damaged shall be taken up and re-laid or replaced.

e) **Backfilling:**

After the conduit is installed, the trench shall be backfilled with selected material in accordance with specifications referred above.

When the top of the conduit is exposed above the top of the trench embankment, material shall be placed and compacted for a width on each side of the conduit equal to at least twice the horizontal inside diameter of the conduit, or as shown on drawings. The embankment on each side of the conduit, for a distance equal to inside diameter of the conduit, shall be of the same material and compacted in the manner described for backfilling. The remainder of the fill material shall not contain frozen lumps, stone in excess of 3 inch diameter, or other objectionable material. Compaction shall be achieved as provided for backfill or by rolling. The embankment shall be placed and compacted simultaneously on both sides of the conduit for the full width of the road bed upto an elevation one foot above the top of the conduit. Above this elevation the embankment shall be placed and compacted in normal manner, except where the imperfect trench method is prescribed.

f) **Imperfect Trench:**

Under this method, for rigid conduit, the embankment shall be completed as described above to a height above the conduit equal to vertical outside diameter of the conduit plus one foot. A trench equal in width to the outside diameter of the conduit shall then be excavated to within one foot of the top of the conduit, trench walls being as nearly vertical as possible. The trench shall be loosely filled with highly compactable soil, straw, hay, corn, stalks, leaves, brush or sawdust may be used to fill the lower ¼ to 1/3 of the trench. Construction of embankment above shall then proceed in a specified manner.

21.3 ASPHALT CONCRETE AND CEMENT CONCRETE SIDEWALK

21.3.1 GENERAL

This work shall consist of the construction of sidewalks which can be asphalt concrete, plain Portland cement concrete, or precast Portland cement concrete slabs (450x450) mm or smaller or interlocking concrete blocks all in accordance with these specifications and to the line, grade, levels and dimensions shown on the Drawings or as required by the Engineer-in-Charge.

21.3.2 MATERIAL REQUIREMENTS

a) Cement Concrete

The concrete shall be either 1:3:6 or 1:2:4 as indicated on the drawings and in accordance with Section 5 – Plain & Reinforced Concrete.

b) Asphalt Concrete
Asphaltic concrete shall conform to the requirements of Sub-Section 21.1.24 – Asphalt Concrete Wearing Course.

c) Expansion Joint Filler
Unless otherwise directed, the joint filler shall have a thickness of five (5) mm and conform to the requirements of Sub-Section 21.1.30.2.

d) Forms
Forms shall be of wood or metal as approved by the Engineer-in-Charge and shall extend to the full depth of the concrete. All forms shall be straight, free from warp and of adequate strength to resist bending.

e) Bed Course Material
Bed course material shall consist of sand, slag, gravel, crushed stone or other approved materials of such gradation that all particles will pass through a ½" (12.5mm) sieve.

f) Asphaltic Prime Coat
Asphaltic prime coat material shall conform to the requirements of Sub-Section 21.1.18.3 for Cut-back Asphalt.

21.3.3 CONSTRUCTION REQUIREMENTS

21.3.3.1 Asphalt Concrete Sidewalk

a) Excavation
Excavation shall be made to the required depth and to a width that will permit the installation and bracing of the forms. The foundation shall be shaped and compacted to minimum ninety(90) percent of the maximum dry density as determined by AASHTO T-191 Method. The surface shall be even conforming to the section shown on the drawings. All soft material shall be removed and replaced with acceptable materials.

b) Placing of Bed Course Material
The bed course material shall be compacted in layers not exceeding ten (10) cm to the depth shown on the drawings and to the line and grade of the finished sidewalk surface.

c) Priming the Bed Course Material
The prepared bed course material shall receive an application of prime coat in accordance with the requirements of Item 21.1.7 and approved by the Engineer-in-Charge.

d) Placing the Asphalt Concrete
The asphalt concrete shall be placed on the previously primed prepared bed only when, in the opinion of the Engineer-in-Charge the bed is sufficiently dry and weather conditions are suitable. The mixture shall be placed on one or more course of uniform thickness as shown on the Drawings. Each course shall be smoothed by raking or screeding and shall be thoroughly compacted by rolling with a hand operated roller or a type satisfactory to the Engineer-in-Charge. After compaction, the surfacing shall be of the thickness and section shown on the Drawings, shall be smooth even and of a dense and uniform texture. Forms, if used, shall be removed and the shoulders shaped and compacted to the required section.

21.3.3.2 Cement Concrete Sidewalk

a) Excavation
Excavation shall meet the requirements of Sub-Section 21.3.3.1(a).

b) Placing of Bed Course Material
Where indicated on the drawings the bed course material shall be placed in accordance with Sub-Section 21.3.3.1(b).

c) Forms and Expansion Joints
All forms shall be staked securely in position at the correct line and elevation. Expansion joint filler shall be set in the position shown on the Drawings before the placing of the concrete is started. The joint filler shall be placed 5mm below the top surface of the finished sidewalk.

d) Placing the Cement Concrete Material

The mixing, placing, finishing and curing of concrete shall be as provided in Section 5 – Plain & Reinforced Concrete.

Before the concrete has set, the surface of the concrete shall be trawled until it is of uniform smoothness and is true to the lines, elevations and surface required.

The surface shall be cut through to a depth of one(1) cm with a trowel at intervals of one(1) meter or where required, in straight lines perpendicular to the edge of the sidewalk. The surface shall then be brushed. The edges of the sidewalk and the transverse cuts shall be shaped with a suitable tool so formed as to round the edges to a one and half (1.5) centimeters radius.

e) Precast Elements

Precast concrete slabs or interlocking concrete blocks shall be set on the bed where indicated on the drawings or as directed by the Engineer-in-Charge to provide a smooth top surface without ridges or lumps at joints.

Precast concrete units shall be fair faced cast to the sizes and dimensions as indicated on the drawings.

The concrete used for pre-cast unit shall conform to the specifications laid down in Sub-Section 5 - Plain & Reinforced Concrete. The Contractor shall be required to submit a sample of pre-cast unit for the approval of the Engineer-in-Charge. All pre-cast units shall strictly conform to the approved sample.

A pre-cast unit cracked or damaged before, during or after erection shall be removed from the works and replaced by the Contractor at his own expense. All pre-cast units shall be smoothly finished to the required lines, grades angles etc. Holes, grooves, pockets, hooks shall be provided as shown or as directed by the Engineer-in-Charge.

The units shall be properly stacked on a platform without causing any cracks of damage. Curing of all the pre-cast units shall be done in accordance with Sub-Section 5.3.7. – Plain & Reinforced Concrete.

21.4 BRICK EDGING

21.4.1 GENERAL

This work shall consist of brick installed on vertical edge between the pavement structure and shoulders in such a manner that the brick is laid on compacted shoulders and top of brick is flushed with the slope of road pavement.

21.4.2 MATERIAL REQUIREMENTS

a) Bricks

Quality of Bricks shall meet the material requirement as specified in Section 11 – Brickwork.

b) Construction Requirements

A trench of appropriate dimensions shall be excavated to accommodate brick on vertical edge so that top of the brick becomes flushed with the top of road pavement and to ensure that one face of the brick remains in contact with the pavement structure. The cavities on the other face of the brick shall be refilled with the excavated shoulder material and properly compacted. The brick shall be laid in accordance with the line and grade of the road pavement. It shall be ensured that bricks are installed in vertical positions.

21.5 TRAFFIC ROAD SIGNS AND SAFETY DEVICES

21.5.1 GENERAL

This work shall comprise furnishing and installing traffic signs, permanent safety devices and post assemblies in accordance with these specifications and to the details shown on the Drawings. All sign faces and lettering shall be in accordance with National Highway Authority sign standards or as shown on plans. Prior to manufacture and fabrication of the signs the contractor shall submit to the Engineer-in-Charge for approval detailed drawings showing letter sizes, traffic symbols and sign layout. The permanent safety devices shall consist of road posts and hazard markers and will be provided as per specifications, drawings or as directed by the Engineer-in-Charge.

21.5.2 MATERIAL REQUIREMENTS

1. **Sign Panels**

Sign panels for regulator, warning and informatory signs shall be manufactured from aluminium alloy conforming to ASTM B-209, alloy 6061 T6 or 5052 H38 plates of three(3) mm thickness as shown on the drawings.

The blanks shall be free from laminations, blisters, open seams, pits, holes, or other defects that may affect their appearance or use. The thickness shall be uniform and the blank commercially flat. Perform shearing, cutting and punching before preparing the blanks for application of reflective material. The blanks shall be cleaned, degreased and chromate or otherwise properly prepared according to methods recommended by the sheeting manufacturer.

2. **Reflective Sheeting**

Reflective sheeting used on road sign made of flexible white or coloured, wide angle retro-reflective sheeting (herein after called sheeting), and related processing materials designed to enhance night time visibility. The sheeting shall consist of optical elements adhered to a synthetic resin and encapsulated by a flexible transparent plastic that has a smooth outer surface.

The sheeting shall have either a pre-coated pressure sensitive adhesive or a tack-free adhesive activated by heat applied in a heat vacuum applicator in a manner recommended by the sheeting manufacturer. Both adhesive classes shall be protected by an easily removable liner.

The manufacturer of the sheeting being offered shall furnish the process inks, clears and thinners produced by the sheeting manufacturer recommended for and compatible with the sheeting to meet the performance requirements of this specification and shall further be responsible for technical assistance in the use of these inks or alternatively sheeting can be used on sheeting. The sheeting manufacturer must provide documented evidence to the satisfaction of the Engineer-in-Charge that representative production materials of the type to be supplied has been used successfully in a substantial traffic signing program in similar climatic conditions for at least three years.

a) **Color Requirements**

Color shall be specified and conform to the requirements of Table 21.5(a).

Table 21.5 (a)
Color Specification Limits* and Reference Standards

Color	X	Y	X	Y	X	Y	X	Y	Reflectance Limit Min.	(Y) Max.	Munsell** Paper
White	.303	.287	.368	.353	.340	.380	.274	.316	27.0		5PB 7/1
Yellow	.498	.412	.557	.442	.479	.520	.438	.472	15.0	40.0	1.25Y 6/12
Red	.613	.297	.708	.292	.636	.364	.558	.352	2.5	11.0	7.5R 3/12
Blue	.144	.030	.244	.202	.190	.247	.066	.208	1.0	10.0	5.8PB 1.32/6.8
Orange	.550	.360	.630	.370	.581	.418	.516	.394	14.0	30.0	2.5YR 5.5/14
Brown	.430	.340	.430	.390	.550	.450	.610	.390	3.0	9.0	5YR 3.6
Green	.30	.380	.166	.346	.286	.4288	.201	.776	3.0	8.0	10G 3/8

***** The four pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 Standard colorimetric system measured with standard illumination Source C.

******Available from Munsell Color Company, 2441 Calvert Street, Baltimore, Maryland 21218. Catalog No. MCP-90040.

b) Coefficient of Retro-reflection

The coefficients of retro-reflection shall conform to the minimum requirements of Table 21.5(b).

Table 21.5(b)
Minimum Coefficient of Retro-reflection
(Candelas per Foot-candle per Square Foot)

Observation Angle°	Entrance Angle°	White	Red	Yellow	Green	Blue	Brown	Orange
0.2	-4	250	45	170	45	20.0	12.0	100.0
0.2	+30	150	25	100	25	11.0	8.5	60.0
0.5	-4	95	15	62	15	7.5	5.0	30.0
0.5	+30	65	10	45	10	5.0	3.5	25.0

For screen printed transparent colored areas on white sheeting, the coefficients of retro-reflection shall not be less than 70% of the values for corresponding color in the above table.

The sheeting manufacturer unless otherwise approved shall provide a test report from a recognized laboratory stating that the sheeting meets the requirements according to BSI-873 Part 6, or FP-92 of FHWA. The brightness of the reflective sheeting totally wet by rain, shall be at least ninety (90) % of the above value.

The reflective sheeting shall be sufficiently flexible as to permit application over and adhesion to a moderately embossed surface. It shall not show damage when bent ninety (90) degree over a fifty (50) mm diameter mandrill.

The sheeting shall show no cracking or reduction in reflection after being subjected to the dropping of a twenty five (25) mm diameter steel ball from a height of two (2) meters onto its surface. For heat activated material the adhesive shall permit the reflective sheeting to adhere securely forty eight (48) hours after application, at temperatures of up to ninety (90) degree centigrade.

The reflective material shall be weather resistant and following cleaning, shall show no definite fading, darkening, cracking, blistering or peeling and not less than seventy five (75) % of the specified wet or dry minimum brightness values when exposed to weathering for five (5) years.

c) **Performance Requirements and Obligation**

The sign manufacturer shall submit a certificate from the sheeting manufacturer stating that the sheeting used for finished retro-reflective signs meets all requirements listed herein.

Sheetings processed and applied to sign blank materials in accordance with sheeting manufacturer's recommendation, shall perform effectively for the number of years stated in Table-21.5(c) of this specification. The retro-reflective sheeting will be considered unsatisfactory if it has deteriorated due to natural causes to the extent that; (1) the sign is ineffective for its intended purpose when viewed from a moving vehicle under normal day and night driving conditions; or (2) the coefficient of retro-reflection is less than the minimum specified for sheeting during that period listed in Table 21.5(c).

Table 21.5(c)
Minimum Coefficient of Retro-reflection Candelas per Foot
Candle per Square Foot (.2" OBS, and -4° Entrance)*

Sheeting Color	Minimum Coefficient of Retro-reflection (7 Years)	Minimum Coefficient of Retro-reflection (10 Years)
White	212	200
Yellow	144	136

Green	38	36
Red	38	36
Blue	17	16
Brown	10	9

For screen printed transparent coloured areas on white sheeting, the coefficients of retro-reflection shall not be less than 50% of the values for the corresponding colour in the above table.All measurements shall be made after sign cleaning according to sheeting manufacturer's recommendations.

Where it can be shown that retro-reflective traffic signs supplied and used according to the sheeting manufacturer's recommendations have not met the performance requirements above the sheeting manufacturer shall cover restoration costs as follows for sheeting shown to be unsatisfactory during.

a) For entire seven years the signs manufacturer and sheeting manufacturer will replace the sheeting required to restore the sign surface to its original effectiveness.

b) In addition, during the first five years sign manufacturer and sheeting manufacturer will cover the cost of restoring the sign surface to its original effectiveness at no cost to the Employer for materials and labor. Samples of the reflective sheeting shall be approved by the Engineer-in-Charge prior to the procurement by the Contractor.

3. Metal Posts

Wide flange of 10x10 centimetres metal posts shall be fabricated from structural steel conforming to the Specifications of ASTM A-283 Grade-D. In lieu of wide flange steel posts the Contractor may use tubular steel posts of minimum internal and external diameters of sixty three (63)mm and seventy five (75)mm respectively conforming to the specifications of ASTM A-501.

All posts shall be thoroughly cleaned, free from grease, scale and rust, and shall be given one coat of rust inhibitive, priming paint and two coats of grey paint. Length of the posts shall be such that their top flushes with the top of the sign penal, whereas bottom of sign panel is at least hundred and eighty (180) centimetres above shoulder level.

4. Plates

a) Plates shall be non-porous, smooth, flat, rigid, weather proof and shall not rust or deteriorate otherwise.

It shall be so cut that there are no sharp edges and that the corners are rounded off to a radius of thirty seven and half (37.50)mm. Any trade mark or other printing shall be carefully removed with liquid thinner.

b) The High Intensity Grade sheeting for the background should cover the whole area of the sign plate.

c) Prior to application of the High Intensity Grade reflective sheeting, the sign plate shall be cleaned and shall be wax-free. They shall be degreased by vapour or by alkaline immersion and etched by scrubbing with abrasive cleaner. The plate shall be rinsed thoroughly and dried with hot air before applying the sheets.

d) The sheeting after application to the sign base shall not come off the edges, which shall be sealed, nor shall it peel off nor warp. The surface shall be smooth and free from any bubbles, pimples, edge chipping or edge shattering. It shall be washable and weather-proof.

5. Nuts and Bolts

All Nuts and bolts and metal washers shall be of heavily galvanized (G.I) quality, ten (10)mm diameter or aluminium alloy. The bolt heads shall be such that they do not protrude out too much nor show very much on the front face of the plate. The heads should be flush with the plate face and covered with sheeting galvanized according to ASTM A-153.

6. Rubber Washer

All rubber washers shall have thick walls and shall not get dry and brittle when exposed to weather at the site after they are in position during the life of the sign.

7. Caps over the pipes

These can be heavy plastic or of aluminium well fitted so that they cannot be removed. Any good adhesive can be used with approval of the Engineer-in-Charge.

8. General

a) Very large signs need not be made of one piece and in case, the Aluminium panels shall be used or the various pieces of sheet shall be joined by angle-irons in anti-corrosive materials, and, if necessary, with connecting cross pieces in order to ensure the solidity of the joint and with slanting struts embedded In the concrete as directed by the Engineer-in-Charge.

b) All the nuts and bolts and metal washers must be heavily galvanized, or may be of stainless steel of high quality.

c) Relevant holes to receive 10mm bolts shall be drilled into the pipes and the plates and not punched. These to be drilled through the plates before the application of scotchlite.

d) After the plates are fixed with nuts and bolts, the nuts shall be TACK WELDED to the bolts against pilferage.

9. Concrete Foundation Blocks

The concrete for the foundation blocks shall be in situ 1:3:6 concrete in accordance Section 5, Plain & Reinforced Concrete and shall of the size 450x450x650mm for category 1 & 2 and 600x600x750mm for category 3.

10. Road Posts and Hazard Markers

The road posts and hazard markers used as permanent safety devices shall conform fully with the requirements of the statutory instruments, current British standards and chapter four of the Traffic signs manual. The safety devices shall consist of delineators and detours of verge master, flex master, edge master, passing place post and chevron-flex etc. and will be manufactured from highly durable tough plastic material with standing vehicular impact. These shall be a High Intensity Grade reflective sheeting for maximum visibility by both day and night and consequently be resistant to impact, damage and vandalism.

21.5.3 CONSTRUCTION REQUIREMENTS

1. Excavation and Backfilling

Holes shall be excavated to the required depth of the bottom of the concrete foundation as shown on the Drawings. Backfilling shall be carried out by using the surplus excavated material if approved by the Engineer-in-Charge and shall be compacted in layers not exceeding fifteen (15) cm in depth.

Surplus excavated material shall be disposed of by the Contractor as directed by the Engineer-in-Charge.

2. Erection of Posts

The posts shall be erected vertically in position inside the formwork of the foundation block prior to the placing of the concrete and shall be adequately supported by bracing to the prevent movement of the post during the setting process of the concrete. The posts shall be located at the positions shown on the Drawings.

3. Sign Panel Installation

Sign panels shall be installed by the Contractor in accordance with the details shown on the Drawings. Any chipping or bending of the sign panels shall be considered as sufficient cause to require replacement of the panels at the Contractor's expense.

The exposed portion of the fastening hardware on the face of the sign shall be painted with enamels matching the background colour.

All newly erected traffic road signs shall be covered with burlap or other material until their uncovering is ordered by the Engineer-in-Charge.

4. Categories of Signs

Traffic road signs shall be of three categories according to type of construction.

a. Warning Signs

Constructed with single post and sign of equilateral triangle shape as shown in drawings category-1

b. Regulatory Signs

Constructed with single post and sign of circular shape, as shown in the drawings, category 2.

c. Informatory Signs

These signs shall be rectangular in shape and constructed with one, two or three numbers of posts or as shown on the drawings. Dimensions may vary according to the requirements, however total area of sign shall be as under:

Category 3 a	=	One sq. meter
Category 3 b	=	Two sq. meter
Category 3 c	=	As shown on drawings

d. Additional panel

If any panel is required to be installed, it shall be of the sizes 60x30 cm or 90x30 cm.

5. Installation of Safety Devices

Safety devices comprising of road posts, delineators of various types, fixed/portable safety barriers and hazard markers e.g. verge-master, flex-master chevron-flex, big-max, edge-master and passing place post and other etc., shall be installed in accordance with the techniques and methods laid down in the manufacturer's manual or guide and in conformity to the line and level and locations shown on the drawings or as directed by the Engineer-in-Charge to ensure maximum visibility and safety, even in adverse weather conditions. These shall be constructed strictly with the specifications and full assistance by the manufacturer for installation with precision. These safety devices shall be used as delineators at sharp curves of highways verges, high embankments, culverts, bridges, as a visual and physical deterrent for prohibiting car parking on grass verges and protecting kerb-side areas on public and private roads.

6. Sign Faces

a) Design

All sign faces shall be of the type, colour, design and size as shown in the plans. Size and spacing of letters shall be as under;

1. The Urdu writing shall be in "Persian" character.
2. The Urdu and English writing shall be about the same in length width and spacing.
3. English letters are to be in lowercase except the first letter of the word, which is to be in capital
4. Height of Capital letters — 21 cm
5. Height of lowercase letters — 17 cm
6. Stroke Width and Width of border — 3.5 cm
7. Space between words and border (at least) — 5 cm
8. Space between words — 5 cm
9. Space between digits of numerals — 4 cm
10. Height of numerals same as capital letters — 23 cm
11. Space between lines (at least) — 5 cm
12. Size of letter for km. height — K-23cm 8 cm
13. Width of letters for km including spacing — K-8 cm - 9.6 cm
14. The size and spacing for Urdu letter and Word will generally conform to the dimensions shown above for English letters
15. The spelling of place names in Urdu and in English shall be as written in the Survey of Pakistan maps

b) Shop Drawings

The contractor shall submit to the Engineer-in-Charge for approval, three copies of drawings for all special sign faces and all sign faces bearing messages, showing the design and/or arrangement and spacing of both the Urdu and English signs messages. Official town names and their spelling shall be as provided by the Engineer-in-Charge. Size and style of lettering shall be as shown on the plans or as otherwise approved by the Engineer-in-Charge.

7. Storage of Signs

Signs delivered for use on a project shall be stored off ground and under cover in a manner approved by the Engineer-in-Charge. Any signs damaged, discoloured or defaced during transportation, storage or erection shall be rejected.

21.5.4 MEASUREMENT

Length of the finished work shall be measured in running metres along the edges of the road correct to a cm.

21.6 PAVEMENT MARKING

21.6.1 GENERAL

This work shall consist of furnishing non reflective or reflective chlorinated rubber based or thermoplastic paint material or retro-reflective preformed pavement marking (tape) as specified for sampling and packing, for the preparation of the surface and for the application of the paint to the pavement surface all in accordance with these Specifications. The paint shall be applied in conformance to the size, shape and location of the markings as shown in the Drawings.

21.6.2 CHLORINATED RUBBER PAINT

1. Material Requirements

A standard and acceptable quality of Chlorinated rubber based paint shall be used. The paint shall be ready for application and shall be of a smooth quality. The paint shall be homogeneous, well dispersed to a smooth consistency and shall not cake, liver, thicken, curdle, gel, settle badly or show any objectionable properties after period of storage not to exceed six(6) months.

a) White Traffic Paint – Composition

1.	Pigment	Titanium Dioxide Rutile & extenders	
2.	Vehicle	Modified Chlorinated Rubber Plasticized and Resin Blend	%
		Solvents	%
		Additives i.e. flow leveling, adhesion improving agents, anti-oxidants, siccatives etc.	
3.	Paint Composition	Pigments	% by wt.
		Vehicle Solvent and Additives	% by wt.

b) White Traffic Paint

1.	Pigment	Chrome Yellow and Extenders	100% by wt.
2.	Vehicle	Same as for white traffic paint	
3.	Paint Composition	Pigments	55 ± 4% by wt.
		Vehicle Solvent and Additives	45 ± 5% by wt.

c) Block Traffic Paint

1.	Pigment	Chrome Yellow and Extenders	100% by wt.
2.	Vehicle	Same as for white traffic paint	
3.	Paint Composition	Pigments	55 ± 4% by wt.
		Vehicle	45 ± 5% by wt.

The volatile material shall be of such character that has a minimum solvent action of asphalt and such that the resins and non-volatile components will be entirely dissolved in the volatile material and will not precipitate from the solution on standing. The non-volatile material shall be of such quality that it will not darken or become yellow when a thin section is exposed to the sunlight.

Other pavement marking paint may be submitted by the Contractor as an alternative to the above, for the approval of the Engineer-in-Charge.

2. Ballotini for Reflective Road Paint

The grading of ballotini dispersed in the paint shall be as follows:

Sieve Sizes	Percentage Retained
	0
	30
	50
	80
	100

Glass beads shall conform with AASHTO Designation M-247. At least ninety percent (90%) glass beads shall be transparent, reasonable spherical and free from flows.

The proportion of ballotini to paint shall be not less than five hundred (500) grams per litre of paint.

3. Photometric Requirements for Reflective Road Paint

Other reflective road paints may be considered for use by the Engineer-in-Charge provided they have minimum brightness values at two tenth (0.2) degree and half (0.5) degree divergence expressed as candle power per meter per square meter of surface coating as follows:

		White		Yellow	
Divergence Angle	(Degree)	0.2	0.5	0.2	0.5
Incidence Angles	4 (Degree)	237	118	129	75
Incidence Angles	40	75	43	43	32

4. Construction Requirements

Traffic markings shall be applied with approved equipment capable of applying the paint at the specified width and at the specified rate of application. In no case shall the contractor proceed with the work until the equipment, method of application and rate of application as established by a test section have been approved by the Engineer-in-Charge.

The painting of lane markers and traffic strips and include the cleaning of the pavement surface, the application, protection and drying of the paint coatings, the protection of pedestrians, vehicular or other traffic on the pavements, the protection of all parts of the road, structures or appurtenances against disfigurement by spatters, splashes or smirches of paint or of paint materials, and the supplying of all tools, labour and traffic paint necessary for the entire work. The paint shall not be applied during rain, wet weather when the air is misty, or when in the opinion of the Engineer-in-Charge, conditions are otherwise unfavourable for the work. Paint shall not be applied upon damp pavement surfaces, or upon pavements which have absorbed heat sufficient to cause the paint to blister and produce a porous paint film.

The application of paint shall preferably be carried out by a purpose-made machine but where brushes are used only round or oval brushes not exceeding 10 cm in width will be permitted. The paint, shall be so applied as to produce a uniform, even coating in close contact with the surface being painted. Traffic paint shall be applied to the pavement at a rate of one(1) litre to two and half (2.5) square meters or less. Contractor shall provide adequate arrangements that applied paint is not disfigured by moving traffic, till its complete drying and sticking to road surface.

21.6.3 HOT- APPLIED THERMOPLASTIC ROAD PAINTS

21.6.3.1 Material Requirements

1. Aggregate

The aggregate shall consist of light coloured silica sand, calcite, quartz, calcined flint, or other material approved by the Engineer-in-Charge.

2. Pigment and Extender

a) White Material

The pigment shall be titanium dioxide complying with the requirements of Type-A (anatase) or Type-R (rutile) of BS-1851.

b) Yellow Material

Sufficient suitable yellow pigment shall be substituted for all or part of the titanium dioxide to comply with the other requirements of this specification.

c) All Material

The extender shall normally be whiting (i.e. calcium carbonate prepared from natural chalk) complying with the requirements of BS-1795. The manufacturer may substitute lithopone complying with the requirement of BS 296 for any or all of the whiting.

d) Binder

The binder shall consist of synthetic hydrocarbon resin or with the approval of the Engineer-in-Charge, gun or wood resin, plasticized with mineral oil.

e) Composition of Mixture

The proportions of the constituents of the mixed material as found on analysis shall comply with the requirements of Table 21.6(a)

Table 21.6(a)
Proportions of Constituents of Mixture

Constituent	Percentage by mass of total mixture	
	Minimum	Maximum
Binder (resin and oil)	18	22
Pigment	6*	-
Pigment and extender	18	22
Ballotini	20	-
Aggregate		
Pigment	78	82
Extender and ballotini		

*For titanium dioxide only. No minimum is specified for yellow material.

Where specified, 10% in the case of material to which surface ballotini is to be applied by pressure application.

The grading of the combined aggregate, pigment, extender and ballotine (where specified) as found on analysis shall comply with the requirements of Table 21.6(b).

Table 21.6(b)
Grading of Combined Aggregate, Pigment, Extender and Ballotini

Sieve	Percentage by mass passing Sprayed
2.80 mm	100
600 µm	75-95

21.6.4 SAMPLING AND TESTING

1. Sampling

For the purpose of carrying out the test, it is essential that adequate and representative samples be taken in the manner prescribed in specification BS 3262 at following stages.

a) At the manufacturer's plant

b) After it has been re-melted by the road application contractor.

2. Testing

The samples shall be prepared and tested in accordance with B.S. Specification 3262 (1976) Appendix A to H. The test results shall conform the following properties.

i. Softening Point

The softening point measured in accordance with Appendix C shall be not less than 65^{o}C.

ii. Colour and luminance

a) White Material

The luminance factor of white material as delivered by the manufacturer shall be measured in accordance with Appendix-D and shall not be less than 70 whereas the luminance factor of material obtained from an applicator or melter on site after re-melting measured in accordance with Appendix-D shall not be less than 65.

b) Yellow Material

The colour of yellow material shall be approximately BS 381C Colour No.355, Lemon. The luminance factor of yellow material as delivered by the manufacturer shall be not less than 60 whereas the luminance factor of material obtained from an applicator on melter on site after re-melting measured in accordance with Appendix-D shall not be less than 55.

3. Heat Stability

a) White Material

When tested in accordance with Appendix-E, the luminance factor of white material as measured in accordance with Appendix-D shall be not less than 65.

b) Yellow Material

When tested in accordance with Appendix-E, the luminance factor of yellow material as measured in accordance with Appendix-D shall be not less than 55.

i. Flow Resistance

In testing the flow resistance a cone made and tested in accordance with Appendix-F, shall not slump by more than 25%.

ii. Skid Resistance

When tested in accordance with Appendix-G, the skid resistance of a newly laid marking prepared under the stated conditions shall be not less than 45.

21.6.5 MANUFACTURING, PACKING AND STORING OF PAINT

1. Manufacturing

The paint shall be produced in a plant owned and operated by the manufacturer following a process which has been used by the manufacturer for at least five (5) years to produce paint. The equipment for mixing and grinding shall be clean, modern and in good condition.

2. Packing

i. The material shall be supplied in sealed containers which do not contaminate the contents and which protect them from contamination.

ii. Each container shall be clearly and indelibly marked with the manufacturer's name, Batch number, date of manufacture, re-flectorization (if applicable), colour, chemical type of binder and maximum safe heating temperature.

3. Storing

The material shall be stored in accordance with the manufacturer's instructions and any material that is in damaged containers of which the seal has been broken, shall not be used.

4. Certification

The Contractor shall furnish a certificate from manufacturer that the material he proposes to use has the required properties, stating the maximum and minimum proportions and grading of the constituents, the acid value of the binder, the setting time, the maximum safe heating temperature, the temperature range of the apparatus and the proposed method of laying.

5. Application of Material to the Road

a) Preparation of Site

The thermoplastic paint shall only be applied to surfaces, which are clean and dry. Immediately before the application of paint, the surface shall be cleaned with mechanical broom, compressed air or other approved means to remove surplus asphalt, oils, mud, dust and other loose or adhered material. The material shall not be applied if the road surface is at a temperature of less than 5°C.

b) Preparation of Material on Site

The material shall be melted in accordance with the manufacturer's instructions in a heater fitted with a mechanical stirrer to give a smooth consistency to the thermoplastic material and such that local overheating will be avoided. The temperature of the mass shall be within the range specified by the manufacturer and shall on no account be allowed to exceed the maximum temperature stated by the manufacturer. The molten material shall be used as expeditiously as possible and for thermoplastic material, which has natural resin binders or is otherwise sensitive to prolonged heating the material shall not be maintained in a molten condition for more than 4 hours.

i. After transfer to the laying apparatus, the material shall be maintained within the temperature range specified by the manufacturer and stirred to maintain the right consistency for laying.

ii. On concrete carriageway a tack coat compatible with the marking material shall be applied in accordance with the manufacturer's instructions prior to the application of thermoplastic material.

c) Laying

Carriageway centre lines, lane lines and edge lines shall be laid to a regular alignment by self propelled machine. Other markings may be laid by hand, hand propelled machine or self propelled machine as approved by the Engineer-in-Charge. The Surface produced shall be uniform in texture and thickness and appreciably free from blisters and streaks.

d) Re-flectorization by Surface Application

When surface application of ballotini is required, additional ballotine (400 g/m^2 to 500 g/m^2 from the machine) shall be applied by pressure concurrently with the laying of the line with sufficient velocity to ensure retention in the surface of the line. The bollotini so sprayed shall give uniform cover and immediate reflectivity over the whole surface of the marking.

Ballotini dispensed on the surface of the markings shall conform to the following grading:

Sieve	Percentage by mass passing
1.7 mm	100
600 µ	80 – 100
425 µ	45 – 100
300 µ	10 – 45
212 µ	0 – 25
75 µ	0 – 5

Not less than 90% by mass of the bollotini shall be of transparent glass spherical in shape and not more than ten percent (10%) shall be oval in shape or have other flaws. The ballotini shall be made of soda glass.

e) Thickness

Unless otherwise approved by the Engineer-in-Charge, the material shall be laid to the following thicknesses.

a) Sprayed lines other than yellow not less than 1.5mm
b) Sprayed yellow edge lines not less than 0.8mm

The minimum thicknesses specified are exclusive of surface applied ballotini. The method of thickness measurement shall be in accordance with Appendix-H of BS 3262 (1976).

6. Trial Section

In no case shall the contractor proceed with the work until the equipment, method of application and rate of application conforming, the required thickness (as established by a test section) have been approved by the Engineer-in-Charge.

21.6.6 RETRO-REFLECTIVE PREFORMED PAVEMENT MARKINGS

1. Materials Requirements

The performed markings shall consist of white or yellow films with pigments selected to conform to standard highway colours. Ceramic and glass beads shall be incorporated to provide immediate and continuing retro-reflection. Ceramic skid particles shall be bonded to a top urethane layer to provide a skid resistant surface.

The preformed markings shall be capable of being adhered to asphalt cement concrete (ACC) or Portland Cement Concrete (PCC) by a pre-coated pressure sensitive adhesive. A primer may be used to precondition the pavement surface. The preformed marking film shall mold itself to pavement contours by the action of traffic. The pavement marking film wearing courses during the paving operation in accordance with the manufacturer’s instructions, approved by the Engineer-in-Charge. Following proper application and tamping the markings shall be immediately ready for traffic. The bidder, when bidding, shall identify proper solvents and/or primers (where necessary) for proper application and recommendation for application that will assure effective product performance. The preformed markings shall be suitable for use for one year after the date of receipt when stored in accordance with the manufacturer’s recommendations.

The marking film shall be durable retro-reflective plisot polymer pavement marking film for performed longitudinal markings subject to low to medium traffic volumes and moderate wear conditions such as repeated shear action from crossover or encroachment on channelization lines.

The retro reflective pavement marking film shall consist of mixture of high quality pigmented polymeric material, with a reflective layer of ceramic and glass beads and a layer of skid resistant ceramic particles bonded to the top urethane wear surface. The film shall have a pre-coated pressure sensitive adhesive. The edges of the preformed tape shall be clear cut and true.

2. Colour

The daytime colour of the white film shall provide a minimum initial Luminance factor, Y of 80 and shall conform to the following chromaticity requirements:

X = 0.290, Y = 0.315; X = 0.491, Y = 0.435; X = 0.512, Y = 0.486; X = 0.536, Y = 0.463.

Measurements shall be made in accordance with ASTM E-1349, using illuminant “C” and 0/45 (45/0) geometry, Calculations shall be in accordance with ASTM E-308 for the 2^{o} standard observer.

3. Reflectance

The white and yellow films shall have the following initial minimum reflectance values as measured in accordance with the testing procedures of ASTM D-4061. The photometric quantity to be measured shall be specific luminance (SL), and shall be expressed as millicandals per square foot per foot-candle (mcd. ft^{2}), fc^{-1}). The metric equivalent shall be expressed as millicandals per square meter per lux (mcd. m^{-2}), lx^{-1}).

Description	White	Yellow
Entrance Angle 86.00^{o}	86.5^{o}	86.5^{o}
Observation Angle	1.0^{o}	1.0^{o}
Specific Luminance SL [(mcd. ft^{-2}), fc^{-1}]	300	175

4. Skid Resistance

The surface of the retro-reflective films shall be shall provide an initial minimum skid resistance values of 55 BPN as measured by British Portable Skid Tester in accordance with ASTM E-303.

5. Patch ability

The pavement marking film shall be capable of use for patching worn areas of the same type of film in accordance with the manufacturer’s instructions.

6. Reflectance Retention

To have a good, effective performance life the ceramic and glass beads must be strongly bonded and not be easily removed by traffic wear. The following test shall be employed to measured reflectivity retention.

7. Taber Abraser Simulation Test

Using a Taber Abraser with an H-18 wheel and a 125 gram load, the sample shall be inspected at 200 cycles, under a microscope, to observed the extend and type of bead failure. No more than 15% of the beads shall be lost due to pop-out and the predominant mode of failure shall be “wear down” on the beads.

8. Beads

The size, quality and refractive index of the ceramic and glass beads shall be such that the performance requirements for the marking shall be met. The bead adhesion shall be such that beads are not easily removed when the material surface is scratched.

9. Bead Retention

The film shall be ceramic and glass bead retention qualities such that when a 2”x6” (5.08cm x 15.24cm) sample is bend over a ½ inch (1.27 cm) diameter-mandrel, with the 2 inch dimension perpendicular to the mandrel axis, microscopic, examination of the area on the mandrel shall show no more than 10% of the beads with entrapment by the binder of less than 40%.

10. Thickness

The film without adhesive shall have a minimum thickness of 0.030 inch (0.76mm).

11. Effective Performance Life

The film, when applied according to the recommendations of the manufacturer, shall provide neat, durable marking that will not flow or distort due to temperature if the pavement surface remains stable. The film shall be weather resistant and through normal traffic wear shall show no fading, lifting or shrinkage which will significantly impair the intended usage of the marking throughout its useful life and shall show no significant tearing, roll back or other signs of poor adhesion.

12. Installation

The markings shall be applied in accordance with the manufacturer’s instructions.

21.6.7 CEMENTITIOUS MARKING COMPOUND

Cementitious marking compound shall be used for concrete, surface dressing and bitumen to provide enhanced night and wet, weather visibility. This compound will be applied at following locations:

- Kerbs – Pavements and car park area.
- Roundabout – vertical and sloping faces.
- Traffic Islands – vertical edges and bull noses, etc.
- Traffic Dividers – black and white chevrons.
- Concrete wall and faces – on high speed intersections and traffic merging.

21.6.8 MEASUREMENT

The markings shall be measured in sq. metres of actual area marked (excluding the gaps, if any) correct upto the two places of decimal.

21.7 REFLECTORIZED PAVEMENT STUDS

21.7.1 GENERAL

The work shall consist of furnishing and installing reflectorized pavement studs set into the travelled way of the type in accordance with the specifications and at the locations shown on the Drawings or as directed by the Engineer-in-Charge.

21.7.2 MATERIAL REQUIREMENTS

1. Reflectorized Studs

Reflectorized studs shall be "cat-eyes" either the 'Flush Surface' type for Raised Profile type having the following characteristics.

a) 'Flush Surface' Type

The 'Flush Surface' reflector shall be the short base type having a maximum base area of 18 cm x 14 cm or as shown on the Drawings.

The base shall be formed in cast-iron with adequate webbing to ensure a firm key to the road when installed.

The pad shall be highly resilient and durable rubber reinforced with canvas and shall have an anticipated life of at least five years. The pad shall be so designed as to produce a self-whipping action of the reflector when depressed.

The reflectors shall be made of impact and abrasion resisting glass and shall be hermetically sealed into a copper socket.

b) 'Raised Profile' Type

The 'Raised Profile' reflectors shell consist of an acrylic plastic filled with an adherent epoxy compound moulded from methyl methacylate into the shape of a shallow frustum of a pyramid having base dimension of approximately 10cm x 10cm and thickness not more than two(2) cm or as shown on the drawings.

The shall contain one or two prismatic reflector each inclined at an angle of thirty(30) degree to the horizontal and having an area not less than twenty(20) square cm or as indicated on the plans. The reflectors shall attain the following standards for their photometric and physical qualities:

i) Photometric Requirements

The reflectors shall have the following minimum specific intensity values (S.I) expressed as candle power per foot candle of illumination at the reflector on a plane perpendicular to the incident light.

Description	C O L O U R		
	Crystal	Yellow	Red
Divergence Angle(in degree)	0.20S.I.	0.20S.I.	0.20S.I.
Incidence Angle			
0	3.00	1.80	0.75
20	1.20	0.72	0.30

The reflector for testing shall be located with the center of the reflecting face at a distance of one and half (1.5m) from a uniformly bright light source having an effective diameter of half (0.5) centimetre. The width of the photocell shall be 1.27 cms and shall be shielded from stray light. The distance from the centers of the light source and photocell shall be 0.53 cms.

Failure of more than 4% of the reflecting faces shall be cause for rejection for the lot.

ii) Strength Requirements

The reflectors shall support a vertical load of 1000 kg when tested in the following manner.

A reflector shall be centered horizontally over the open end of a vertically positioned hollow metal cylinder 75 mm internal diameter, 25 mm high and wall thickness of 6 mm. The load shall be applied to the top of the reflector through a 6mm diameter by 6mm high metal plug centered on top of the reflector.

Failure shall constitute either breakage or significant deformation of the marker at any load less than 1000 kg.

2. Adhesive

When 'Raised Profile' types of reflectors are used, adhesive in two parts having the following ingredients shall be applied to the stud for bonding to the pavement surface.

Package A	Kg/Liter
Epoxy Resin	0.94
Titanium Dioxide	0.07
Colloidal Silica	0.05
Talc	0.345
Package B	Kg/Litre
Modified Asphaltic Amine	0.24
Modified Asphaltic Amine	0.472
Carbon Black	0.0022
Colloidal Silica	0.04
	0.650

Equal volumes of Package A & B should be mixed together until a uniform colour is obtained. Not more than one quart of adhesive shall be prepared at one time.

3. Cement Mortar

Cement mortar shall consist of one(1) part Portland Cement to three(3) parts of fine aggregates.

21.7.3 CONSTRUCTION REQUIREMENTS

1. Flush Surface Type

The stud shall be installed into the pavement in accordance with the manufacturer's instructions but shall also comply with the following requirements;

Cavities in the pavement shall be clearly cut to the dimension of the pavement stud and shall allow a clearance of one(1) cm around the stud base. The longitudinal center line axis of the cavity shall be the same as that required for the pavement study when laid to correct line and direction. The walls of the cavity shall be splayed back at an angle of approximately thirty(30) degree to the vertical to facilitate a "dove-tail" joint after the mortar has set.

The bottom of the cavity shall be leveled with asphalt concrete prior to placing the stud base, which shall be pounded into position with Pounder Foot attached to a pneumatic drill.

The depth of cavity shall be such that when the stud base and reflectors have been installed, the elevation of the floor of the lens socket shall not be greater than two(2) mm or less than one mm above the pavement surface.

The stud shall be grouted into position with asphalt concrete containing fine aggregate only or with a cement mortar as described in Sub-Section 21.7.2(3) above when the studs are installed into a cement concrete pavement.

2. Raised Profile Type

The pavement studs shall be installed in accordance with the manufacturer's instructions or to the requirements of the Engineer-in-Charge.

21.8.4 MEASUREMENT

The quantity of deep patching to be paid for shall be measured in Nos. or approved by the Engineer.

21.8 DEEP PATCHING

21.8.1 GENERAL

This work shall be carried out in patches of roads where the existing road base material has moved and is lying in loose condition. Requirement under this item is to remove the existing road base and to strengthen it to take new layer of aggregate or water bound macadam base.

21.8.2 MATERIAL REQUIREMENTS

Fresh aggregate base or water bound macadam base may be required to be added to existing road base. Specification for such material shall conform to materials requirements of Sub-Section 21.1.11.2 or 21.1.12.2.

21.8.3 CONSTRUCTION REQUIREMENTS

Patches of roads in which surface courses have broken and road base has moved, the material which has lost its compaction shall be removed. Next layer shall be watered and compacted, thereby the removed material shall be placed back duly screened to remove plastic contamination, by hand picking and passing through sieve No.4 after properly watering and mixing. Material will be re-compacted in layers not exceeding fifteen (15) cms (6 inches) thick with approved equipments. Additional material will be added, if needed particularly non-plastic fines passing sieve No.4.

21.8.4 MEASUREMENT

The quantity of deep patching to be paid for shall be measured in square meter of the area demarcated or approved by the Engineer. The minimum area will be taken as 0.5 square meters irrespective of the size of the pot hole.

21.9 IMPROVED SUBGRADE

21.9.1 DESCRIPTION

This work shall consist of the formation of the roadbed, under sub-base or base course as the case may be, with an approved blend of materials, uniformly mixed, compacted, shaped and finished to the lines, grades and typical cross-sections shown on the Drawings, or in thickness as directed by the Engineer-in-charge .

Improved sub-grade as herein referred to may be defined as material suitable for embankment to which better quality of material is blended improper proportion to improve its strength properties or performance.

21.9.2 MATERIAL REQUIREMENTS

The major component of improved sub-grade shall consist of material conforming 21.1.8. The blending material shall be any soil that classifies as A-1(a), A-1(b), A- 2-4 or A-3 according to AASHTO M-145 with PI of not more than 6.

The blended mixture when compacted to ninety five (95) percent of the maximum dry density determined by AASHTO T 180-0 Method, shall exhibit a laboratory soaked CBR (96 hours) of not less than 20, or as specified in the drawings.

21.9.3 CONSTRUCTION REQUIREMENTS

21.9.3.1 Preparation

The surface of the roadbed on which the improved sub-grade is to be constructed shall be compacted to the density specified under 21.1.8.3(a).

21.9.3.2 Proportioning of Materials

Prior to start of construction, the proportion of each material to be incorporated for improved sub-grade shall be established as approved by the Engineer-in-Charge. The Engineer-in-Charge shall specify a single percentage of each material to be blended and shall establish. The gradation of the resulting mixtures along with the ranges of permissible gradation tolerances to obtain the required CBR for the' improved sub-grade.

The blend proportions thus established shall apply only when each material to be used is obtained from same source. Should a change in source of material be made, a new proportion shall' be established. When unsatisfactory results or other conditions make it necessary, the Engineer-in-charge may require additional laboratory tests.

21.9.3.3 Mixing and Spreading

Improved sub-grade may be constructed with any combination of machines or equipment that will yield results meeting these specifications.

a) Stationary Plant Method

The soil ingredients and water shall be mixed in an approved mixing plant (Pug Mill). The plant shall be equipped with feeding and metering devices that will add the materials to be blended in the specified quantities. Water shall be added during the mixing operation in the quantity required for proper compaction, which is approximately optimum moisture content plus or minus two (2) percent. The mixing time shall be such that to secure a uniform mixture. After mixing, the blended material shall be transported to the job site while it contains the sufficient moisture and shall be placed on the roadbed by means of an approved mechanical spreader. The mixture shall be spread at rate that will produce a uniform compacted thickness conforming to the required grade and cross-section. Compaction shall start as soon as possible after spreading and shall continue until the specified relative compaction is achieved.

b) Travelling Plant Method

The travelling plant shall be either a flat transverse shaft type or a windrow type pug-mill. After the materials have been placed by a mechanical spreader or windrow sizing device, the materials shall be uniformly mixed by the travelling mixing plant. During the mixing operation, water shall be added as necessary to bring the moisture content of the mixture to the percentage suitable for proper compaction

c) Road Mix Method

The materials shall be transported to the site and spread in layers on the roadbed in the quantities required to produce the specified blend. After the materials for each lift have been spread, the materials shall be mixed by motor graders and other approved equipment until the mixture is uniform throughout. During mixing operation, water shall be added as necessary to bring the moisture content to the proper compaction.

21.9.3.4 Compaction

Unless otherwise permitted by the Engineer-in-Charge based on the performance of the compacting equipment used as determined from the trial section each layer of improved sub-grade shall be placed in horizontal layers of uniform loose thickness not exceeding twenty (20) centimetres. Each layer shall be compacted to the density conforming to the requirements specified 21.1.8.3(a).

In-place density determinations of 'the compacted layers shall be made in accordance with AASHTO T-191, T-238 or other approved methods.

21.9.3.5 Trial Sections

Prior to the formation of the improved sub-grade, the Contractor shall construct three trial sections of 200 meter length one (1) for each blend of improved material proposed to be incorporated for improved sub-grade, or as directed by the Engineer-in-Charge. The compacting equipment to be used in the trial sections shall be the same equipment that the Contractor intends to use for main work, accepted by the Engineer-in-Charge.

The object of these trials is to' determine the proper moisture content, the relationship between the number of passes of compacting equipment, density obtained for the' blended material, and to establish the optimum lift thickness that can be effectively compacted with the equipment used. No separate payment will be made for this work, which will be regarded as a subsidiary obligation of the Contractor under pay Item No. 110.

21.9.3.6 Protection of Completed Work

Any part of the completed improved sub-grade shall be protected and well drained and any damage shall be repaired as directed by the Engineer-in-Charge without additional payment.

The Contractor shall be responsible for all the consequences of traffic being admitted to the improved sub-grade. He shall repair any ruts or ridges occasioned by his own traffic or that of others by reshaping and compacting with rollers of the size and type necessary for such repair. He shall limit the improved sub-grade preparation to an area easily maintained with the equipment available. Sub-grade preparation and placement of succeeding layer to follow each other closely. The improved sub-grade, when prepared too soon in relation to the placing of the layer above it, is liable to deteriorate and in such case the Contractor shall, without additional payment, repair or re-compact the improved sub-grade as may be necessary to restore it to the state specified herein.

21.9.3.7 Templates and Straightedges

The Contractor shall provide for the use, of the Engineer-in-Charge, satisfactory templates and straightedges in sufficient numbers to check the accuracy of the work, as provided in these specifications and no subsequent work shall be permitted until the improved sub-grade level have been checked and approved by the Engineer-in-Charge.

21.9.3.8 Tolerance

The allowable tolerances for the finished improved, sub-grade surface prior to placing the overlying sub-base, base or asphaltic concrete course are given in the relevant, Table for Allowable Tolerances in these specifications.

21.9.3.9 Measurement

The unit of measurement for payment shall be cubic meter of the compacted and accepted subbase/base material as measured in place. Measurement shall not include any areas in excess of that shown on the drawings except the areas authorized, in writing, by the Engineer.

Measurement of cement content used shall be the number of metric Ton consumed to stabilize subbase/base. This quantity of cement used shall not exceed the theoretical percentage established in the laboratory.

Bituminous curing material shall be measured by the metric Ton. The Contractor shall furnish in duplicate certified weigh tickets from the batch scales of commercial plants

21.10 BITUMEN STABILIZED SUBGRADE

21.10.1 DESCRIPTION

The work shall consist of performing all operations in connection with, construction of bitumen stabilized sub-grade and all incidentals in accordance with the specifications in conformity with the lines, grade, thickness and typical cross-sections shown on the plans or as directed by the Engineer.

21.10.2 MATERIAL REQUIREMENTS

21.10.2.1 Soil

This method will only apply to sites with naturally occurring non plastic material such as sand, if the material is brought at site, it shall be non- plastic having uniform gradation.

21.10.2.2 Bitumen

Bituminous material used for sub-grade stabilization shall comply with the requirement as per relevant tables specified in 21.1.18 "Asphaltic Materials" for hot mix asphaltic concrete or can be viscous cut back that requires heating in areas where moisture content of sand is high, necessitating heating and drying of sand.

In dry areas, where natural moisture content of sand is low, the bituminous binder shall be fluid cut back conforming the requirements as given 21.1.18 “Asphaltic Materials".

Bitumen emulsion or foamed penetration grade bitumen can also be used subject to the approval of Engineer after trial test.
Bitumen-sand mixture for the grade of bitumen selected shall be ascertained by trial mixes using Marshall Test to determine the quantity of bitumen required using either heated or unheated sand. The quantity of bitumen required will generally lie between three (3) to six (6) percent by weight of dry sand, the higher proportions being required with fine-grained materials.

21.10.3 CONSTRUCTION REQUIREMENTS

Equipments, tools, and machines used for bitumen stabilized sub-grade shall be subject to the approval of Engineer-in-Charge and shall be maintained in satisfactory working conditions all the times. Mix in place method of bitumen stabilization will be subject to the approval of Engineer-in-Charge to ensure full control of bitumen content, uniform and thorough mixing and satisfactory processing of the material to the full depth of the layer, For scarification of in situ material and spreading of Bituminous material, grader with blade and bitumen distributor shall be used.
The stabilized soil shall be left un-compacted after pulverization and mixing to allow for evaporation of volatile materials thus increasing stability and decreasing water absorption particularly in fine grained sand when temperature is low.

21.10.3.1 Compaction

Immediately after completion of spreading, aeration and shaping operation, the mixture shall be thoroughly compacted with rubber or pneumatic tyred rollers. Compaction shall continue until entire width and depth of sub-grade is uniformly compacted to give soaked (96 hours) unconfined compressive strength according to design requirement to meet traffic loading. Steel wheeled tandem roller shall be used to carry out final rolling of compacted surface to eliminate the tyre marks.
To determine the efficiency of mixing, spreading, degree of compaction of equipment and suitability of construction method, trial sections as directed by the Engineer-in-Charge, shall be prepared by the contractor before main work of stabilization is started.
If thickness of compacted layer is less than 20 centimetres, it shall be laid as single operation where as if thickness of compacted stabilized layer is more than twenty centimetre, material shall be placed in two or more layers, each within the range of eight (8) to twenty (20), centimetres in compacted thickness.
The results of CBR test for measuring the strength of bitumen stabilized materials or cone stability test for designing bitumen-sand mixture shall not supersede those of Marshall Test unless agreed by the Engineer. In-situ density of compacted layer shall be determined using method as described by AASHTO - T-191, AASHTO - T-205 or AASHTO - T-238 and shall be minimum ninety five (95) % modified AASHTO according to the above mentioned methods.
Frequency of testing in field and in laboratory will be according to relevant schedule for sampling and testing of these specifications.

21.10.3.2 Tolerance

Compacted layer shall comply with the tolerance requirements as specified in relevant, "Table for Allowable Tolerances" in these specification.

21.10.3.3 Weather Limitation

The laying of bituminous courses shall be avoided as for as practicable during wet weather and shall be suspended when free standing water is present on the surface. The stabilized material shall not be laid' on any surface, which is frozen or covered with ice or snow and laying shall cease when the air' temperature reaches five (5) degree C on a falling thermometer. Laying shall not commence until the air temperature is at least five (5) degree C on a rising thermometer unless otherwise directed by the Engineer-in-Charge and also if wet weather threatens to be prolonged the preparation and laying of stabilized mix shall be suspended.

21.11 DRESSING AND COMPACTION OF BERMS

21.11.1 DESCRIPTION

This work shall consist of scarification of berms, which are undulated or out of level. The existing material shall be scarified,· watered, mixed and properly levelled and compacted according to specification described here under or as directed by the Engineer-in-Charge .

21.11.2 MATERIAL REQUIREMENTS

In this item no fresh material is required, however, if fresh material is used it shall be measured and paid under other relative items of works.

21.11.3 CONSTRUCTION REQUIREMENTS

21.11.3.1 Dressing of berm without the use of extra material

In case the berms show undulation of more than 5 cms in level from the reconstructed pavement structure, the berms shall be scarified to a depth of 15 cm and material will be watered, mixed and compact with appropriate equipment approved by Engineer-in-Charge.

21.11.3.2 Dressing of berm with the use of extra material

In case the difference of elevation of existing berm with respect to reconstructed road structure is less than 15 cm than additional material (to be measured under other items of work) shall be added to bring the level of berms in conformity with the lines and grades of the existing road. Existing and fresh material shall be properly mixed, watered and compacted as directed by the Engineer-in-Charge.

21.11.3.3 Compaction requirement

Compaction requirement of the fresh and existing material shall be in accordance with the type of material used in berms, as under:

Depth in cms	Compaction requirement as per AASHTO'T-180 (D)
0- 15	95% for common earth material
0 - 15 (T	100% for sub-base material

21.11.3.4 Compaction of slopes

While reinstating/dressing of berms, it shall be ensured that compaction requirements are observed on slopes of the berms. The degree of compaction shall be as per direction of the Engineer-in-Charge.

21.11.3.5 Measurement

The unit of measurement for payment shall be cubic meter upto second decimal place for the compacted and accepted bitumen stabilized subbase/base course as measured in place. Measurement shall not include any area except the area authorized in writing by the Engineer. Measurement of bitumen binder used shall be the number of metric Ton used to stabilize sub base or base course. The quantity of bitumen used shall not exceed the theoretical percentage established in the laboratory.

21.12 PAVEMENT WIDENING

21.12.1 DESCRIPTION

This work shall consist of the widening of the existing pavement and finishing of the completed work in accordance with the specifications and in conformity with the lines, grades, thickness of each pavement component and typical cross-sections shown on the plans or as directed by the Engineer-in-Charge.

21.12.2 MATERIALS

Materials for the construction of "Pavement Widening" shall conform to the requirements specified in relevant items of Sub-base .and Base course in these specifications.

21.12.3 TRENCHING

The contractor shall excavate along the edge of the existing pavement for the full depth and width as indicated on the Drawings or as directed by the Engineer-in-Charge. The bottom of the trench shall be compacted with rollers and/or tampers approved by the Engineer-in-Charge to minimum ninety five (95) % of the maximum dry density as per AASHTO T-191 method. If the plans do not call for a specific type of compaction, the sub-grade, sub-base or base shall be compacted by rolling with an approved type trench roller until the entire surface is smooth, firm and at the designated elevation. Adequate provisions shall be made for drainage of the trench to prevent damage to the sub-grade. Prior to placing any widening material, the trench shall be cleaned of all loose Material. The edge of the existing pavement .shall be thoroughly cleaned. The trench must be approved by the Engineer-in-Charge, before placing any widening material. All subsequent layers shall be compacted to the degree as shown under relevant item of these specifications

21.12.4 SPECIAL PROVISIONS FOR HANDLING TRAFFIC

Widening operations shall be permitted on only one (1) side of the pavement at a time and excavation of trenches shall be permitted only sufficiently in advance of other operations to ensure a continuity of the operations of excavating, placing widening material and rolling.

Re-flectorized barricades shall be placed along open trenches day and night. Lighting shall be placed at each barricade at night. Barricades and lights shall be approved by the Engineer-in-Charge. The barricades shall be placed at intervals not to exceed one hundred (100) meters or as directed by the Engineer-in-Charge. The Contractor shall make adequate provision to enable traffic to cross open trenches at intersecting roads; streets and private entrances.

21.13 SCARIFICATION OF EXISTING ROAD / BREAKING OF ROAD PAVEMENT STRUCTURE

21.13.1 DESCRIPTION

This item shall consist of scarification of existing road surface or breaking of existing road pavement structure to ensure bondage of new layer with the existing road pavement and to ensure drainage of water below the surface of freshly laid aggregate base. The surface on which the base material is to be constructed shall be approved and accepted by the Engineer-in-Charge prior to placing the crushed stone base aggregate.

21.13.2 CONSTRUCTION REQUIREMENTS

The method of scarification of road surface or breaking of pavement structure shall be proposed by the contractor and approved by the Engineer-in-Charge in accordance with the requirements under site conditions.

After the existing pavement structure has been broken off, the material shall be removed and disposed off outside the right of way, according to the satisfaction of the Engineer-in-Charge. The surface obtained after scarification or breaking the existing pavement shall be compacted to the density prescribed under 21.1.8.3.

21.13.3 MEASUREMENT

The quantity for road pavement structure broken and removed, to be paid for shall be measurement in Cu. meter to a depth as shown in the drawings/cross sections or as specified by the Engineer and in the area earmarked by the Engineer for such purpose.

The quantity for road pavement structure scarified, to be paid for shall be measured in Sq. meter as shown in the drawings/cross sections or as specified by the Engineer and in the area earmarked by the Engineer for such purpose.

21.9 PAYMENT

21.9.1 COMPOSITE RATE

The measurement and payment for the items of the work of Road and Road Structures hereof shall be made corresponding to the applicable CSR item as provided in Contract Agreement and shall constitute full compensation, for procurements, transportations, performance in all respect and completion of work as specified including the site clearance as approved by the Engineer-in-Charge.

21.9.2 LABOUR RATE

The measurement and payment for the items of the work of Road and Road Structures hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurements transportations, performance in all respect and completion of work as specified including site clearance, as approved by the Engineer-in-Charge except the cost of materials to be provided by Department at designated location as defined in the Contract Agreement.

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22. SHEET PILING

22.1 GENERAL

This work shall consist of performing all operations in connection with furnishing driving, cutting off complete in place and strictly in accordance with these Specifications and as shown on the Drawings.

A detailed proposal for the piling shall be delivered by the Contractor to the Engineer-in-Charge well in advance of the start of work. The proposal shall include full details of materials, equipment and method to be used in the construction of piles. Work on piling shall not commence until the Contractor's proposals have been approved by the Engineer-in-Charge and communicated to him.

The kind and type of piles shall be as shown on the Drawings and/or as specified and shall not be changed, except with the approval of the Engineer-in-Charge.

22.2 MATERIAL REQUIREMENTS (STRUCTURAL PILES)

Structural steel piles shall be rolled steel sections of the type, weight and shape called for on the Drawings. The piles shall be structural steel conforming to the requirements of ASTM A-36, except that steel produced by the Acid Bessemer process shall not be used.

The steel piles shall be coated with red lead paint conforming to AASHTO M-72, unless otherwise specified or as directed by the Engineer-in-Charge.

22.3 HANDLING OF PILES

All piles shall be lifted by means of suitable bridle or sling attached to pile at marked pick up points to avoid damage to piles. They shall be properly loaded and carted to the specified place and unloaded in workman like manner and sorted at specified place(s) for further use. Piles which may have been injured during handling, loading or unloading or carriage by the contractor will be rejected and replaced by the contractor at no cost to the employer.

22.4 CONSTRUCTION REQUIREMENTS

a) Location and Site Preparation

Piles shall be used where indicated on the Drawings or as directed by the Engineer-in-Charge.

All excavations for the foundation in which the piles are to be driven shall be completed before the driving is begun, unless otherwise specified or approved by the Engineer-in-Charge. After driving is completed, all loose and displaced materials shall be removed from around the piles by hand excavation, leaving clean solid surfaces to receive the concrete for foundations.

b) Determination of Pile Length

The criteria for pile length and bearing capacity will be determined by the Engineer-in-Charge according to the results from test piles and load tests. The piles shall be driven to such depths, that the bearing loads indicated on the Drawings are obtained.

The criterion for pile length may be one of the following:

1) Piles in sand and gravel shall be driven to a bearing value determined by use of the pile driving formula or as decided by the Engineer-in-Charge.
2) Piles in clay shall be driven to the depth ordered by the Engineer-in-Charge. However, the bearing value shall be controlled by the appropriate pile driving formula if called for by the Engineer-in-Charge.
3) Piles shall be driven to refusal on rock or hard layer when so ordered by the Engineer-in-Charge.

   The Contractor shall be responsible for correct pile lengths and bearing capacities according to the criteria given by the Engineer-in-Charge.

c) Pile Driving

All piles shall be driven accurately to the vertical or the batter as shown on the Drawings. Each pile shall, after driving, be within fifteen (15) cm from the theoretical location underneath the pile cap or underneath the super-structure in the case of pile bents. All piles pushed up by the driving of adjacent piles or by any other cause shall be driven down again. Piles shall be used only in places where a minimum penetration of three (3) meters in firm materials; or five (5) meters in soft materials can be obtained. Where a soft stratum overlies a hard stratum, the piles shall penetrate to hard material upto a sufficient distance to fix the ends rigidly.

All pile driving equipment shall be subject to the Engineer-in-Charge's approval. The Contractor shall be responsible for sufficient weight and efficiency of the hammers to drive the piles down to the required depth and bearing capacity. Hammers shall be gravity hammers, single acting steam or pneumatic hammers or diesel hammers. Gravity hammers shall not weigh less than sixty (60) percent of the combined weight of the pile and driving head and not less than 2,000 Kg. The fall shall be adjusted so as to avoid injury to the pile and shall in no case exceed one (1) m unless otherwise specified or approved by the Engineer-in-Charge. The plant and equipment furnished for steam hammers shall have sufficient capacity to maintain, under working conditions, the pressure at the hammer specified by the manufacturer. The boiler or pressure tank shall be equipped with an accurate pressure gauge and another gauge shall be supplied at the hammer intake to determine the drop in pressure between the tank and the hammer. When diesel hammers are used, they shall be calibrated with test piling and/or test loads.

Water jets shall be used only when permitted in writing by the Engineer-in-Charge. When water jets are used, the number of jets and the nozzle volume and pressure shall be sufficient to erode the material adjacent to the pile freely. The jets shall be shut-off at a depth not less than three (3) M before final tip elevation is reached, and the piles driven solely by hammer to final penetration as required by the Engineer-in-Charge.

Piles shall be supported in line and position with leads while being driven. Pile driving leads shall be constructed in such a manner as to afford freedom of movement of the .hammer, and shall be held in position by guys or steel braces to ensure rigid lateral support to the pile during driving. The leads shall be of sufficient length to make the use of a follower unnecessary, and shall be so designed as to permit proper placing of batter piles. The driving of piles with followers shall be avoided if practicable and shall be done only under written permission from the Engineer-in-Charge.

The method used in driving piles shall not subject them to excessive and undue stresses producing deformation of the steel. Manipulation of piles to force them into proper position, if considered by the Engineer-in-Charge to be excessive, will not be permitted.

The doll-eying of the piles shall be done by protecting tops with driving heads, caps or cushions in accordance with the recommendations from the manufacturer of the pile hammer and to the satisfaction of the Engineer-in-Charge. The driving head shall be provided to maintain the axis of the pile in line with the axis of the hammer and provide a driving surface normal to the pile.

Full-length piles shall be used where practicable. Splicing of piles when permitted shall be done as shown on Drawings or approved by the Engineer-in-Charge. All piles shall be continuously driven unless otherwise allowed by the Engineer- in-Charge.

22.5 PILE RECORDS

The contractor shall keep records of piles driven or installed. A copy of the record shall be given to the Engineer-in-Charge within two (2 days) after each pile is driven;

- Pile Type & Dimension
- Driving Equipment type, weight and efficiency of hammer etc.
- Depth Driven and tip elevation.
- For gravity and single acting hammers the height of drop.
- For double acting the frequency of blows.
- Final set for last 20 blows for every ten piles and when the Engineer-in-Charge so requires the penetration along the whole driven depth shall be recorded.

- Details of any interruption during driving.
- Level of top of pile immediately after driving and the level when all piles in the group are driven.
- Details of Re-driving.
- Any other relevant information.

22.6 DAMAGED OR MISPLACED PILES

Any pile which is cracked or broken because of internal defects or by improper handling or driving or which is otherwise injured so as to impair it for intended use, or any pile driven out of proper location shall be removed and replaced.

The Engineer-in-charge may require the contractor to pull certain selected piles after driving for test and inspection to determine to conditions of the piles. Any pile so pulled and found to be damaged to such extent in the opinion of the Engineer-in-charge, would impair its usefulness in the completed structure, shall be removed from the site of the work and contractor shall furnish, drive a new pile to replace the damaged pile. Piles pulled and found to be sound and in a satisfactory conditions be re-driven.

22.7 MEASUREMENT AND PAYMENT

22.7.1 COMPOSITE RATE

The measurement and payment for the items of the work of Sheet Piling hereof shall be made corresponding to the applicable CSR item as provided in Contract Agreement and shall constitute full compensation, for procurements, transportations, performance in all respect and completion of work as specified including the site clearance as approved by the Engineer-in-Charge.

22.7.2 LABOUR RATE

The measurement and payment for the items of the work of Sheet Piling hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurements transportations, performance in all respect and at designated location as defined in the Contract Agreement.

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23. PLUMBING, SANITARY AND GAS FITTINGS

SCOPE

The work shall include, furnishing and supplying as required all labour, materials, fittings, fixtures, accessories, equipment and services for the execution, completion, testing and commissioning of plumbing, sanitary installation & Gas fitting works as shown on drawings, specified herein or as directed by the Engineer-in-Charge.

PLUMBING & SANITARY INSTALLATIONS

23.1.1 SUBMITTALS

The Contractor shall submit samples of materials such as fittings, fixtures and accessories to be incorporated into the works to the Engineer-in-Charge for approval.

23.1.2 SOIL, WASTE AND VENT PIPES

All cast iron soil, waste and vent pipes and fittings shall be truly cylindrical, of the clear internal diameter as specified of a uniform thickness, smooth with strong and deep sockets and free from flaws, air bubbles, cracks, holes and other defects. They shall not be brittle but shall allow cutting, chipping or drilling without damage. These shall conform with BS-416 and BS-437 or approved equivalent.

Internal Diameter (mm)	Thickness of Metal not less than (mm)	Weight per 2m length including socket & headed spigot or flanges not less than (Kg)
50	7.0	34
75	8.0	50
100	9.5	73
150	9.5	105

23.1.3 SEWER PIPES

23.2.3.1 Cast iron pipes shall conform to BS-78 for spigot and socket for vertically cast pipes; BS-1211 for spigot and socket spun iron pipes of and BS-2005 for flanged pipes.

23.2.3.2 Non reinforced cement concrete pipe shall conform to the requirements of Clause 25.3.2 of Section 25, Sewerage.

23.2.3.3 RCC pipes shall conform to the requirements of Clause 25.3.3 of Section 25 Sewerage. All RCC pipes shall be first class quality truly circular of uniform thickness and free from irregularities, honey combing and other defects. The pipe shall be suitable for sewerage and drainage purposes.

23.2.3.4 Asbestos pipes shall conform and laid according to provisions of Clause 27.3.1.1(b) and 27.3.2.6(d) of Section 27 – Tubewell and Water Supply.

23.2.3.5 PVC pipes shall conform and laid according to the provisions of Clauses 27.3.1.1(e) and 27.3.2.6(e) of Section 27 – Tubewell and Water Supply.

23.1.4 TRAPS AND CLEANOUTS

23.1.4.1 FLOOR TRAPS

Traps shall be of self-cleaning design, provided with water seal. Traps of the specified size used for underground installation shall be cast iron (C.I) generally in accordance with BS-416 and BS-437 or an approved equivalent. The average thickness of wall shall be 5mm and at no point shall thickness be less than 4mm. All waste traps shall have grating or cross bars formed integrally. The grating shall be of suitable design so as not to unduly restrict the flow of waste water.

23.1.4.2 GULLEY TRAPS

Base of the gulley traps shall be in plain concrete and walls in brick masonry internally plastered. The top shall be in RCC as shown on the drawings. The C.I gulley trap shall be of specified size and shall have manhole with C.I frame and cover 300 mm square or circular in shape.

23.1.4.3 FLOOR CLEAN OUTS

All cleanouts in the sewerage system shall be closed with brass screw caps. All brass screw caps shall be extra heavy and not less than 3 mm thick. Each screw cap shall have solid square or hexagonal nut not less than 25 mm high, with a minimum diameter of 38 mm. The body of the clean out ferrule shall be at least equal in weight and thickness as of the caulking ferrule for the same size of pipe as shown in the following table: The engaging parts of the screw cap shall not have less than six threads and shall be of cast iron pipe size and tapered.

Nominal pipe size (mm)	Actual pipe size (mm)	Length (mm)	Weight (kg)
50	56	113	0.45
75	81	113	0.79
100	106	113	1.14

The pipe and fittings shall be bitumen coated as per BS-416.

23.1.4.4 MEASUREMENTS

Traps and Cleanouts shall be measured in numbers

23.1.5 FIXTURES

23.1.5.1 WASH BASINS

a) Basin

The wash basins shall be glazed earthen ware in sizes and colours as specified. The wash basins shall be of specified make and the following shall generally be provided at the time of manufacture;

- A slot for the overflow shall be 6.3 cm (2.5") Iong and 13 mm (0.5") deep so designed as to facilities cleaning.
- Soap tray or sinking shall be provided as to drain into the basin.
- Tap holes shall be square to fit pillar taps shall be bevelled around the opening. They shall be so situated as to allow supply pipes to be clear of waste and vent pipes and shall have enough space to prevent the users striking the head on the tap.
- Waste hole shall have a minimum diameter of 6.3 cm (2.5"). The outlet shall be bevelled or rebated. The hole shall be square in shape and each side shall be 2.86 cm (1-1/8") length.
- Plug chain stay hole shall not be lower than the over flow slot. Back skirting shall be true to receive splash back.

- Stud slots shall be monolithically cast with the wash basin. These shall receive the brackets on the inside of the basin, shall be so situated that the brackets remain 5 cm (2") away from the face. These shall not exceed 13 mm (1/2") in dia 8 mm (5/16") in height and shall be 13.5 cm (12") from the back of the basin to the centre of the side.

b) Brackets

The length of the brackets shall be such as to enable 10 cm (4") embedding in the wall or fixed to the wall with the help of screws. Bracket shall be of painted iron on white porcelain enameled.

c) Pillar Taps

Pillar taps shall be manufactured from gun metal and shall be chromium plated. These shall be of screw type with jam nut. Internal dia of the tap shall be 13 mm (1/2").

d) Plug and Chain

Plug shall be of rubber. The diameter of the plug shall be such as to fit snugly in the waste hole. The chain shall be of brass, chromium plated, one end fixed to the plug and the other held in the chain stay hole.

e) Combined (Mixes) Supply and Waste Fitting

This shall comprise of 13 mm (1/2") combine taps with discharge nozzle and 3.17 cm (1-1/4") pop up waste. Waste outlet shall be screwed 3.17 cm (1-1/4") to B.S pipe male. All of these fittings shall be of gun metal with chromium plating.

f) Waste Pipe

This shall be either of PVC, nickel or C.P Brass and shall have diameter to fit at the bottom of the waste fitting flange. Its length shall extend from the bottom of waste flange to the floor.

g) Pedestal

Pedestal shall conform to the corresponding specifications of wash basin for composition, manufacture and quality. It shall be completely recessed at the back for the reception of supply and waste pipes. It shall be such that the basin is tightly and adequately supported and shall be so arranged that the height from the floor to the top of the rim of basin is 79 cm (31").

The Wash Basin shall be supplied complete with fittings and accessories as specified.

23.1.5.2 MIRROR (LOOKING GLASS)

One beveled edge glass mirror of first class quality and make as specified securely fixed on bard board packing required to be fixed on the wall for wash basin shall be at least 6 mm thick and shall be of requisite dimensions.

23.1.5.3 KITCHEN SINKS

a) Sinks

Kitchen sink shall be stainless steel or glazed earthenware of approved make, single or double bowl with integral drain board. The sizes of the sinks shall be either 61 cm x 45 cm x 25 cm (24"x18"x10") or 51 cm x 101 cm x 25 cm (20"x40"x10") or 51 cm x 122 cm x 25 cm (20"x48"x10") or 82.5 cm x 4.5 cm x 2.5 cm (33”x18”x10”).

b) Brackets

The Brackets shall be either of such a length as to enable 10 cm (4") embedding in the wall or shall be such as to be fixed to the wall with the help of screws. The bracket shall be of painted iron or porcelain enameled.

c) Pillar Taps

Pillar taps shall be manufactured from gun metal and shall be chromium plated. These shall be of screw down type with jam nuts. Internal diameter of the taps shall be 13 mm (1/2").

d) Plug

The rubber or vulcanite plug shall fit in the waste pipe.

e) Waste Fitting Flanges

The waste fitting flanges shall be 85 mm (3-3/8) diameter, the tail 87 mm (3-1/2") long, screwed with 37 mm (1-1/2") B.S parallel thread and the sliding flange of back-nut of 81 mm (3-1/4") diameter.

f) Waste Pipe

This shall be either of PVC, nickel of C.P Brass and shall have diameter to fit at the bottom of the waste fitting flange. Its length shall extend from the bottom of waste pipe flange to the floor.

23.1.5.4 WATER CLOSETS

a) European Type Water Closets

The W.C shall be pedestal type white glazed earthen ware or of color as specified durable non-absorbent material with a water pool of good effective seal not less than 5 cm (2"). There shall be no sharp angles, the surface shall be so rounded as to be easily cleaned. The closets shall be of syphonic action or washed down type or as directed by the Engineer-in-Charge. Four holes 6 mm (0.25") shall be provided in the pedestal for fixing the W.C to the floor.

b) Indian Type Water Closets (Orisa Type W.C)

The water closets shall be of glazed earthen ware of color as specified nonabsorbent durable material. There shall be no sharp angles, the surface shall be so rounded as to be easily cleaned. The closets shall be embedded below the flow in lean concrete with its stop level with the floor. The foot rest shall be either integral part of the W.C or shall be provided separately in which case shall be of the same material as the pan.

c) Trap

The trap P or S for European type W.C shall be self- cleaning with a minimum water seal of 50 mm (2") and made of the same materials as the pan. For squatting type W.C it shall be of cast iron.

d) Seat

The seat for the European type W.C shall be of approved quality backlite plastic seat with lid hinged and fixed to the closets by pillar bolts. The hinged device and pillar and nuts shall be of non-corrosive material. The pillar bolts shall be 6 cm (2-3/8") long and shall be held securely by the nuts underneath the pan seat plugs. The backlite seat should have rubber buffers securely fixed to the under-side to prevent damage to the pan. The seat cover shall be of the same material as that of the seat. The backlite cover shall have rubber buffers.

e) Flushing Cistern

i) Low Level Flushing Cistern

The low level cistern shall be of 10 liters (2.9 gallons) capacity. It shall be either of glazed earthen ware or PVC as approved by the Engineer-in-Charge, complete with all internal fittings. The bottom of the cistern shall be 30 cm (2.5 feet) above ground level.

The inlet to the cistern shall be controlled by 13 mm (1/2") ball wall and 13mm (1/2") stop cock both made from gun metal or brass. The cistern shall be silent filling with an over flow arrangement.

The cistern shall be supported on M.S or C.I cantilever brackets and painted with approved enamel paint with 10 cm (4") support in the wall or it may be attached to the wall with the help of rowl plugs.

The flush pipe shall be 30 mm (1-1/4") G.I or PVC painted with approved paint. Moulded rubber cone shall be provided for connection with the pan.

ii) High Level Flushing Cistern

High level cistern shall be manufactured from cast iron or pressed steel. It shall be painted with corrosion resisting paint. It shall discharge at the rate of 9 liters in 5 seconds.

The inlet to the cistern shall be controlled by 13 mm (1/2") ball wall and 13 mm (1/2") stop cock both made from gun metal or brass. The cistern shall be silent filling with an over flow arrangement 5 ft. – 6 inches from top of pan to bottom of cistern unless otherwise.

The cistern shall be supported on M.S or C.I cantilever brackets on wall at 5 ft. 6 inches from top of pan to bottom of cistern unless otherwise shown on drawings or approved by the Engineer-in-Charge and painted with approved enamel paint with 10 cm. (4") supports in the wall.

The flush pipe shall be 30 mm (1-1/4") G.I or PVC painted with approved paint. Moulded rubber cone shall be provided for connection with the pan.

The flush shall be operated by pulling a chain handle preferably by a thin rod with as few joints as possible.

a) **Soil Connection**

Ordinarily in case of European type W. C the closet shall have trap above the floor and the connection with the soil pipe through an external wall.

b) **Size of Closet**

Ordinarily the closet shall be 40 cm (16") on shorter side. For schools, nurseries 35 cm (14") 30 cm (12") and 25 cm (10") be adopted as per instructions of the Engineer-in-Charge.

c) **Connection of Water Closet with Soil Pipe**

If the trap is of earthen ware, it shall be connected with the water closet with 1:2 cement sand mortar joint. If the trap is of cast iron, it shall be connected with gaskets and 1:2 cement sand mortar joint.

d) **Connection between Trap and Soil Pipe**

Soil pipe is the pipe leading from trap to manhole.

If the trap is of earthen ware and the soil pipe is of cast iron then it shall be connected through C.I piece the joints between earthen ware and C.I piece be as per para (h) above. If the trap is of C.I it shall be connected with C.I soil pipe with ordinary lead metallic joint through a C.I connecting piece.

23.1.5.5 BIDETS

Bidets is washer for spray cleaning after use of W.C.

Bidets shall be of glazed earthenware of colour as specified of durable, nonabsorbent material with horizontal inlet to flushing rim, standing waste and overflow and ascending spray or jet.

The hot and cold supplies shall be controlled by a mixing valve so that any desired temperature may be obtained from the jet. By passing heated water through the hollow rim it may be warmed.

23.1.5.6 TOILET PAPER HOLDER

The toilet paper roll holder shall be wooden/ plastic with either glazed earthenware or CP brass or plastic brackets and screws etc and shall be fixed in the wall adjacent to water closet.

23.1.5.7 URINALS

a) **Squatting Type Urinals**

These shall be glazed channel 10 cm (4" high) for front and side walls in colour as specified. The channel, if separate shall be of superior quality glazed fire clay of colour as specified with circular projection for fitting in trap. The latter shall be 62 mm (2.5") to 75 mm (3"), depending on the number of seats. The inlet end of the trap shall be provided with CP brass discharge of removable type. The urinal slab shall be of the design with back flush. The flushing cistern shall be of C.I plastic automatic type. The capacity of the cistern shall be according to the number of stalls to be flushed. A connection from the flushed pipe shall be provided with spreader (one to each seat) to flush the front.

Traps shall be of self- cleaning design provided with 25 mm (1") puff pipe. The specifications for these shall be the same as for W.C soil waste and vent pipes.

The height of squatting urinal from ground level shall be as required for floor level. The minimum spacing shall be four feet unless otherwise directed by the Engineer-in-Charge.

b) **European Type Stall Urinals**

These shall be in colour as specified and glazed fire clay and of the following dimensions:

Height from treads to top of division - 45 cm (1.5 feet).

Width center to center of divisions - 60 cm (2 feet).

The urinal range shall be provided with automatic or hand pulled flushing cistern in glazed fire clay or PVC in colour as specified of the capacity according to the numbers of stalls to be flushed. The flush pipe and spreader shall be of C.P brass. The trap shall be of C.I 62 mm (2.5") to 75 mm (3") depending on the number of stalls in the range and approved by the Engineer-in-Charge.

23.1.5.8 SHOWERS

A shower head shall consist of corrosion resisting cast or fabricated sheet metal rose having perforations and shall be adjustable to give varying degrees of spray. Shower unit shall be complete with or without hot and cold water mixing arrangements and stainless steel rigid or flexible pipe extension and an additional low down water trap.

23.1.5.9 BATH TUBS

These shall be of porcelain enameled cast iron or fibre glass as specified. The bath tub shall be provided with 27 mm (1-1/2") trap, overflow and antisyphonic arrangements and connected to the waste and antisyphonic stacks on the outside wall. Waste water may be allowed to discharge through over flow trap, if directed by the Engineer-in-Charge. The bath shall be fitted with two CP pillar cocks and CP chain with a plug. The approximate dimensions of the bath tubs shall be as per table 23.2.5(a).

TABLE 23.2.5(a)
Dimensions of Bath Tubs

Description	Pattern					
	Magna		Rectangular		Parallel	
	cm	inch	cm	inch	cm	inch
Length overall	168	66	183	72	168	66
Width overall	71	28	1	28	71	29
Depth inside at waste	44	17-1/2	4	17-1/2	43	17
Height overall – exclusive feet & waste	46	18	6	18	44	17-1/2

Height overall - with feet for 38 mm (1-1/2”) seal trap	58	23	8	23	57	22-1/2
High overall for 76mm (3”) seal trap top holes 35mm (1-3/8”) square centered	62	24-1/2	2	24-1/2	61	24
On-roll-Hole distance part	18	7-1/8	8	7-1/8	18	7-1/8
Waste hole 57mm (2-1/4) clear diameter distance from edge of roll at tap & to centre of waste hole	29	11-1/4	9	11-1/4	25	10
Overflow centre-distance below top edge	10	4	0	4	9	3-1/2
Capacity	118 L	26 Gal	127 L	28 Gal	122 L	27 Gal

The fall along the bottom from head end to outlet should be adequate for complete emptying. The feet shall be suitable for bath tubs with traps having 27 mm (1-1/2") seal or for bath tubs with taps having 75 mm (3") seal.
Bath tub outlets may be rebated or tapered to receive the outlet piece. The later comprises a chamfered flange 7.3 mm (2-7/8) diameter with tail 35 mm (1-3/8") long provided at the end having an integral grating. A riding flange 7.3 cm (2-7/8") diameter for tightening to the bottom of the bath tub is also provided.

The overflow holes on magna/rectangular bath tubs shall be 10 cm (4") from top of bath tub to centre and on parallel bath tubs 9 cm (3-1/2") from top to centre.

Overflow holes on parallel bath tubs shall be 4.4 cm (1-3/4") in diameter intended for 3.1 cm (1-1/4") overflows.

A grating shall be fixed in the overflow hole. A brass bend 5.7 cm (2-1/4") long shall be attached to the grating. The tail of which shall have threads 3.18 cm (1-1/4") for connection to outflow pipe.

23.1.5.10 TAPS, COCKS AND MUSLIM SHOWER

All the taps, cocks and muslim shower shall be of brass, gun metal or other equally suitable corrosion resisting alloy conforming to BS 1010 and shall be chrome plated. The nominal size specified shall be the nominal bore of the seating. The water area of the way throughout the body shall be not less than the area of a circle of diameter equal to the nominal size of tap/cock/muslim shower. Washers for cold water cocks shall be of specially selected leather, rubber asbestos composition or other equally suitable material.

Washers for hot water cocks shall be of good quality fibre, rubber – asbestos composition or other equally suitable material. Every tap/cock shall be tested, complete with its component parts, to a hydraulic pressure of at least 1.96 MPa (284.4 psi). During test it shall neither leak nor sweat. The connecting pipe of muslim shower shall be of C.P Chain or of make approved by the Engineer-in-Charge.

23.1.5.11 TOWEL RAIL, SOAP DISH& TUMBLER HOLDER

The towel rail shall be ¾ inches round or square C.P brass or stainless steel rod with end brackets and screws of similar material. Soap dish shall be straining type heavy duty glazed earthen ware, chromium plated stainless steel or plastic complete with screws. Tumbler holder shall be of glazed earthen ware, chromium plated, stainless steel or plastic complete with screws. Tooth brush holder with tooth paste dish shall be of glazed earthen ware, chromium plated stainless steel or plastic complete with screws etc.

23.1.5.12 ABLUTION TAP/ SPRINKLER

Adjacent to the water closet, a water connection of ½ inch diameter for ablution will be either a C.P brass water tap or a water sprinkler with flexible pipe armoured with stainless steel strip.

23.1.5.13 GLASS SHELVES

Glass shelves may be provided below the mirror above the wash basin. The length of the shelf shall depend on the size of the mirror its width shall be 5 inches (130 mm) & thickness 6 mm and shall be held by 2 Nos. CP brackets. The shelf may be provided with CP railing.

23.1.5.14 MEASUREMENTS

All fixtures shall be measured in numbers

23.1.6 INSTALLATION INSTRUCTIONS

23.1.6.1 GENERAL

i) The contractor shall be responsible for the safety of his work and shall replace any material and equipment that may be damaged or lost without any additional cost to the employer until the works are completed and taken over by the employer.

ii) All openings left in floor for passage of lines of soil, waste, vent etc shall be covered and protected. All open ends of pipes shall be properly plugged to prevent any foreign material from entering the pipe.

iii) Before erection all pipes, valves, fittings etc. shall be thoroughly cleaned of oil, grease or other material.

All metal fixture trimmings shall be thoroughly covered with non-corrosive grease which shall be maintained until all work completed.

Upon the completion of the work, all fixtures and trimmings shall be thoroughly cleaned polished and left in first class condition.

iv) All pipes shall be properly installed as shown on the drawings and/or as directed by the Engineer-in-Charge and shall be as straight as possible forming right angles and parallel lines with the walls and other pipe lines as far as possible. The position, gradients alignment and inverts shall be 2% for pipes of 200 mm or larger dia or as shown on the drawings and/or as directed by the Engineer-in- Charge.

v) The arrangement, positions and connections of pipe fittings and appurtenances shall be as shown on the drawings. The Engineer-in-Charge reserves the right to change the location etc. Special precautions shall be taken for the installation of concealed pipes as shown on the drawings and/or as required. Should it be necessary to correct piping so installed the contractor shall be held liable for any damage caused to other works in the correction of piping.

vi) A minimum distance between different services shall be maintained as shown on the drawings and/or as approved by the Engineer-in-Charge. Pipes should be installed in such a manner that minimum distance is always maintained between the pipes and the walls, beams, columns etc as shown on the drawings and/or as approved by the Engineer-in-Charge

vii) Waste-water outlet from each fixture or a battery of fixtures directly connected to the sewerage system shall be equipped with a water-seal trap.

viii) Each vent terminal shall extend to the outer air and terminate in cowl or wire mesh balloon and be so installed as to prevent the possibilities of clogging and the return of foul air to the building. Vent and waste stacks should extend 300 mm above roof if not used by occupants and 2000 mm if used by occupants.

ix) When the roughing in is completed, the plumbing system shall be subjected to test prior to concealing the roughing-in, in order to ascertain that all threads and connections are gas and watertight.

x) Cast iron soil and drainage fittings for change in direction shall be used as follows:

- VERTICAL TO HORIZONTAL: short sweep or long-turn for diameter 75 mm and larger; long sweep or extra-long-turn for less than 75 mm dia.
- HORIZONTAL TO VERTICAL: quarter bend or short-turn.
- VENTING IN ANY DIRECTION: quarter bend or short-turn.

xi) All fittings with hubs shall be aligned so that the hub faces upstream.

xii) No drainage or vent piping shall be drilled or tapped.

xiii) No structural member shall be weakened or impaired by cutting notching or otherwise, except to the extent allowed by the Engineer-in-Charge.

xiv) All exterior openings provided for the passage of piping shall be properly sealed with snugly fitting collars of metal or other approved rat-proof material securely fastened into place.

xv) Joints at the roof around vent pipes shall be made watertight by the use of lead or other approved flashing material. Exterior wall openings shall be made watertight.

xvi) Bolts and nuts for wall hanging fixtures shall be of heavy construction steel to fully carry the weight that will be placed on the carrier by the fixture and users.

xvii) Where different sizes of pipes, or pipes and fittings are to be connected, the proper size reducers or reduced fittings shall be used between the two sizes. Bush fittings shall not be used.

xviii) Any fitting or connection, which has an enlargement, chamber or recess with a ledge, shoulder or reduction of pipe area that offers obstruction to flow through the drain is prohibited

xix) The vertical distance from the fixture outlet to the trap weir shall not exceed 600 mm.

xx) Each fixture trap shall have a water seal of not less than 50 mm and not more than 100 mm.

xxi) Full S, bell, crown vented traps and traps depending for their seal upon the action of moveable parts are prohibited. No fixture shall be double trapped.

xxii) Where fixture comes in contact with wall and floors, the joint shall be watertight.

xxiii) Pipes in ground shall be laid on a firm bed for its entire length.

xxiv) Pipes in the plumbing system shall be installed without undue strains and stresses. Vertical piping shall be securely held to keep the pipe in alignment and carry the weight of the pipe and contents. Horizontal piping shall be supported to keep it in alignment and prevent sagging. Hangers and anchors shall be of metal of sufficient strength to maintain their proportional share of pipe alignments and prevent rattling. Hangers and anchors shall be securely attached to the building. The contractor shall be fully responsible for hangers and supports and shall obtain prior approval of design as to the shape, material, dimensions, spacing etc.

xxv) Pipes in concrete or masonry walls or footings shall be placed or installed in sleeves, which will permit access to the piping for repair or replacement. All holes/slots made in the walls, roofs, ceiling and floors for installation of pipes shall be properly made good and finished to original conditions to the satisfaction of the Engineer-in-Charge.

xxvi) The indirect waste pipes from food handling equipment, water cooler and dish washer etc shall so discharge that the air gap between the indirect waste and the building drainage system is at twice the effective diameter of the drain served.

23.1.6.2 INSTALLATION OF FIXTURES

i) Plumbing fixtures shall be installed in a manner to afford easy access for cleaning. The space between the fixture and the wall shall be closely fitted and painted so that there is no chance for dirt or vermin to collect.

ii) Where practical, all pipes from fixtures shall be run to the nearest wall.

iii) Where fixtures shall be rigidly supported by metal supporting members so that no strain is transmitted to the connections. Flush tanks and similar appurtenances shall be secured by approved non-corrosive screws or bolts.

iv) Fixtures shall be set level and in proper alignment with reference to adjacent walls. No water closet shall be set closer than 400 mm from its center to any side wall. No urinal shall be set closer than 300 mm from its center to any side wall or partition nor closer than 1200 mm center to center. No wash basin shall be set closer than 100 mm to the side wall or partition nor closer than 600 mm center to center.

v) The supply lines or fittings for every plumbing fixture shall be so installed as to prevent backflow.

vi) All cuttings and holes shall be made good.

23.1.6.3 LAYING OF SEWER PIPES

Sewer pipes shall be laid as per Clause 25.3 of Section 25 – Sewerage. The following conditions shall be taken care of particularly.

i) Each length of pipe between manholes shall be in straight line and true to the alignment, position, gradient and levels.

ii) Sewer laying shall proceed in all uphill direction, laying spigot end into already laid bell end. Reverse laying shall not be allowed and any such work so carried shall be rejected.

iii) Each length of sewer pipe shall be checked for cracks and defects before placing in the line. Each pipe shall be placed carefully to the requisite line and grade and jointed perfectly with connecting pipes.

iv) Pipes shall be cut only where directed by the Engineer-in-Charge in order to complete a length between manholes. All pipes shall be cut neatly and at right angles to the axis of the pipe and the cut of the pipe' shall be smooth and truly circular.

v) The top of bedding material shall be shaped to fit the pipe barrel, with pits left for the bells. When laying is not in progress, the open end shall be closed with a tapered wooden plug to keep out foreign matter.

23.1.6.4 INSTALLATION OF TRAPS, DRAINS AND CLEAN OUTS

i. Floor traps shall have openings for connection of inlet pipes from fixtures. The invert level of inlet pipes shall be at least 25 mm above the trap weir level.

ii. Floor traps shall be well set in position so that there is no leakage at the joint between trap and the floor. The requirements specified above for floor traps are equally applicable for floor drains except that no water seal is required and it shall be of the specified size.

iii. Roof drain shall have strainers extending at least 10mm above the roof surface immediately adjacent to them when installed on flat part. Bottom of strainer shall be flush with the roof surface when installed on vertical part. Strainer shall have an available inlet area, above roof level, of not less than 1-1/2” times the area of the down-pipe to which the drain is connected. The connection between roof and roof drain shall be made watering by use of proper flashing material.

iv. Clean outs shall be turned up through floors by long sweep fittings, wherever the space so permits. Top finish of clean outs shall be flush with the floor when located in open area. They may not be flush with the floor when installed near wall and levels are not deep enough to make them flush.

   Clean out shall be so installed that there is a clearance of at least 300 mm for pipe less than 75 mm diameter and at least 450 mm for pipes of 75 mm and larger diameter for the purpose of rodding. Permanent finishing material shall not be placed over clean out plug.

   Clean out in open areas shall be placed in concrete boxes with access cover of heavy duty 300 x 300 mm size. The access cover and frame shall be cast iron.

   Clean out near wall shall be embedded in concrete, and excepting cast iron pipe used with cleanout all other work of ferrule, plug, concrete work, frame and cover etc. shall be included under clean out item.

v. Gulleys shall be fixed on concrete foundation 300 mm square and not less than 150 mm thick. A brick curb in cement mortar about 75 mm high from the ground level shall be built round top edge of gulley in such a manner that surface water shall not be allowed to enter the gulley. It shall be used for waste water only before entering into the manhole.

23.1.6.5 INSTALLATION OF SOIL, WASTE AND VENT PIPE

i) All soil waste and vent pipes and fittings shall be installed plumb and true to lines and grades shown on the drawings or as directly by the Engineer-in-Charge.

ii) Where installed vertically, pipes shall be supported from wall by metal clamps of approved type and make at each floor just below the Horizontal branch pipe connection and at intermediate levels.

   The spacing of vertical and horizontal pipe supports shall be 1.5 mm to 3 mm respectively and dia of steel support shall be 13 mm.

iii) Pipes passing through walls, floors or roof shall be placed in metal sleeves of approved design. The annular space between the sleeve and pipe shall be at least 15 mm. The space shall be packed with approved filler (Oakum or Hemp) and shall be sealed at both ends with approved sealant (Bituminous material or mastic).

23.1.7 MANHOLES

i) The type, size and shape of the manholes shall be as shown in the drawings, invert and other shall be directed by the Engineer-in-Charge.

ii) The manhole shall be constructed according to the provision of Clause 25.4 Section 25 – Sewerage.

WATER & GAS UTILITY SERVICES

23.1.8 SCOPE

The work for piped utility services in buildings shall include furnishing of all labour, plant, equipment, materials and services and supplying, installing, testing and commissioning of cold and hot water supply and gas supply systems in the buildings as shown in the drawings, required as per specifications and or directed by the Engineer-in-Charge.

The gas pipeline and fittings shall be carried out strictly complying with the regulations of Gas Authority. Where required, the Contractor shall be responsible for their acceptance certificate for gas connection.

23.1.9 SUBMITTALS

The Contractor shall submit samples of fittings, fixtures and accessories to be incorporated into the works.

23.1.10 G.I. PIPES

i) The galvanized iron pipes shall conform to BS specifications No. 1387 for "Steel tubes and Tubulars, suitable for screwing to BS-21 pipe threads".

ii) All screwed tubes and sockets shall have threads in accordance with BS-21. In order to prevent damage to the leading thread, the end of the sockets shall be chamfered internally.

iii) A complete and uniform adherent coating of zinc shall be provided for galvanized iron pipes.

iv) Every tube shall be tested at the manufacturer's works to a hydraulic test pressure of 5 MPa and shall be maintained at the test pressure sufficiently long for proof and inspection.

v) The threads of all tubes shall be effectively covered with good quality grease or other suitable compound, and each tube above 50 mm nominal bore shall have a protecting ring affixed to the un-socket screwed ends.

23.1.10.1 MEASUREMENT

G.I. Pipes shall be measured in Running Meters correct to cm.

23.1.11 FITTINGS AND SPECIALS

23.1.11.1 G.I FITTINGS

i) Malleable Iron Galvanized Fittings (i.e. coupling, elbows, tees etc.) for G.I pipes of diameter lower than 75 mm shall conform to BS-143/BS-1740 and shall be at least same thickness and quality as G.I. pipe.

ii) Cast Iron Threaded Flanges for joining G.I pipe of dia 75 mm and above shall conform to BS-4504.

iii) Cast Iron Flanged Fittings for G.I. pipe 75 mm and above shall conform to BS-2035, a working pressure 122 meters of water.

23.1.11.2 MEASUREMENTS

Cost of G.I fittings and Specials is included in cost of Pipes

23.1.11.3 VALVES

- Sluice Valve shall have (i) cast iron body; (ii) gunmetal spindle; (iii) cast iron gate with gunmetal sealing wings for size 75 mm and above; (iv) solid gunmetal gate for size lower than 75 mm and (v) shall pass a test pressure of 1.5 MPa or equivalent to NP-16 (16 kgs/sq. cm).
- Peet Valve threaded/flanged shall be of copper alloy and shall pass a test pressure of 1.5 MPa or equivalent to NP-16.
- Cast Iron Check Valves size 75 mm and above shall have cast iron body, gun- metal door and a test pressure of 1.5 MPa or equivalent to NP-16 (16 kgs/sq. cm).
- C.I. Globe Valves size 75 mm and above shall be similar to Cast Iron Sluice Valves.
- Copper Alloy Globe Valve size lower than 75 mm threaded shall pass a test pressure of 1.5 MPa or equivalent to NP-16(16 kgs/sq. cm).
- The working pressure on valves shall not be less than the working pressure of the system on which they are installed, but in no case it shall be less than NP-6 (6 kgs/ sq.cm) or 0.6 MPa.\

23.1.11.4 FIRE HYDRANTS

Fire hydrants shall confirm to BS-750 with a body of cast iron and spindle of manganese-bronze. The direction of closing shall be by clockwise rotation and the outlet shall have screwed joints for accommodating hose connections.

23.1.11.5 MEASUREMENTS

Fire Hydrants shall be measured in numbers

23.1.11.6 PIPE STRAINERS

The strainer flange shall confirm to the specification of BS-4504. The pipe strainer shall have cast iron or bronze bodies suitable to withstand the working pressure, removable screens of copper, brass, nickel or stainless steel, flanged bodies with taping for size 37mm above and of such a design as to allow blowing out of accumulated dirt and easy removal and replacement of straining screen without disconnecting the main piping.

23.1.11.7 PUDDLE FLANGE

Puddle flanges of specified dia. Shall be provided where the pipe crosses RCC wall, retaining water or soil. For metal pipes a 10mm thick MS square plate of size shown on plan, cut with a hole equal to external dia. Of pipe, shall be welded with the pipe with both ends of G.I pipe provided with flanges, and the whole assembly shall hot-dipped galvanized before being cast in RCC wall.

23.1.11.8 FLOAT VALVE, LEVEL CONTROLLER, FLOW SWITCH

Float Valves, Level Controllers and Flow Switches shall conform to the specimens submitted by the Contractor and approved by the Engineer-in-Charge and shall be the best quality available locally.

23.1.11.9 MEASUREMENTS

Float Valve, Level Controller, Flow Switch shall be measured in numbers

23.1.12 FIXTURES AND EQUIPMENTS

23.1.12.1 TAPS AND STOP COCKS

All bib, pillar and stop cocks and mixers shall be of high quality screw down, made of CP brass and shall comply with BS-1010 or any other requirements as specified. Spindles, glands, crutches, washer plates and nuts shall be of brass or manganese. Taps shall have crutches or cap-stab leads as required by the Engineer-in-Charge. The waterway shall not be less than the area of a circle equal to the nominal size of the tap. Working pressure of taps, stocks shall not be less than pressure in the system but not less than 0.6 MPa or NP-6 in any case.

23.1.12.2 WATER HEATER

Electric and gas water heater shall be of specified capacity and of storage type with adjustable thermostatic range of 40^0C to 80^0C. It shall be of approved manufacturer. All controls are to be automatic.

It shall automatically shut off (electric) or come to pilot (gas) when temperature of hot water reaches 80^0C and restart when temperature drops below 40^0C.

The vessel of water heater shall be constructed of steel with welded joints. The vessel shall be lined with copper on the inside and painted with baked stove enamel on the outside. The annular space between the copper and steel cylinders shall be filled with insulation material of thermal conductivity not more than 0.045 Watts/ Sq.m ^{0}C. The heater vessel shall be rated for a working pressure of 0.6 MPa and test pressure of 1 MPa.

In electric water heater the electric heating elements shall be withdrawable, mineral insulated, metal clad copper rods. In gas water heater the gas supply shall be controlled by a regulator allowing at least 4 volumes of gas supply including arrangements for a pilot.

The capacity of the heating equipment shall be sufficient to raise the temperature of water from +10 ^{0}C to + 70 ^{0}C in not more than one hour.

Water Heater shall be provided with the following accessories and control:

- Thermostat
- PE pipe

Pressure Relief Valve

- Thermometer
- Pressure Gauge
- Drain Valve
- In electric water heaters Automatic High Temperature Cut-off
- In Gas Water Heaters, a Regulator & a Pilot.

23.1.12.3 MEASUREMENT

Float Valve, Level Controller, Flow Switch shall be measured In numbers

23.1.13 LAYING OF PIPES IN TRENCHES

23.1.13.1 EXCAVATION OF TRENCHES AND REFILLING

The trenches shall be set out to suit alignment of the pipe lines. The trenches shall be carefully trimmed on sides and bottom so that pipe lines when laid shall rest on the firm bed throughout the length. Shallow joint holes shall be left for the joints, where necessary. Where pipe line is to be laid in plains the depth of cover, i.e. the normal distance from ground level to the top of the pipe be kept at about 800 mm and shall not be less than 750 mm except due to special reasons where the Engineer-in-Charge directs in writing to the contrary.

Backfilling of trenches shall be carried out in accordance with the provisions of Sub-Section 3.8.4(ii).

23.1.13.2 FLANGES

Flanged joints shall be provided at intervals of not more than 150 m or as directed by the Engineer-in-Charge. Each flanged joint shall be made by inserting an accurately cut disc of tough multiply rubber insertion about 3 mm thick of approved quality between the flanges. The bolt holes in the rubber insert as well as in the flanges shall be drilled to template. The bolts and nuts for all flanged joints shall conform to British Standard 10 and shall be of mild steel, hexagonal, round and diagonal. The bolts shall be pulled up gradually and evenly by the use of standard spanners of the approved make, so as to ensure a perfect joint.

23.1.13.3 BENDS, TEES AND OTHER SPECIALS

Bends, tees, reducers and other specials shall be provided and jointed at points as shown on the drawings or as directed by the Engineer-in-Charge. All changes in direction shall be effected by means of bends wherever practicable and the use of elbows shall be restricted only to cases where there is no room for bends. In such cases only round elbows will be allowed.

23.1.14 PIPES ANCHORED TO WALLS OR CEILINGS

Suitable and substantial hangers or fixings shall be provided for all horizontal and vertical lines of approved types and special vibration eliminating and flexible hangers shall be provided for all pipe work affected by moving machinery or expansion and contraction including building expansion joints.

Hot and cold horizontal piping shall be supported in accordance with the schedule given as under:

Pipe dia in mm	Maximum spacing of Fixings in meters		Rod size for Hangers dia in mm
	In Vertical run	In Horizontal run	
G.I and Flexible			
15 – 25	3.0	2.5	10
31 – 50	3.6	3.0	10
62 – 75	4.5	3.6	13
100 – 150	4.5	4.0	13
Cast Iron			
All sizes	3.0	1.5	13

One fixing shall be provided for each fitting.

iii) Hanger shall be supported from approved concrete inserts in concrete slabs for all pipes 50 mm and above. Insert shall be as approved by the Engineer-in-Charge and shall have space for nuts of all size. All inserts shall have a reinforcing rod of specified diameter to be installed through slot provided for this purpose, and the Contractor shall be responsible for its being in place when concrete is poured.

If any pipe has to be hung where no inserts have been provided, the Contractor shall drill holes from below through concrete slabs and provide rods and hangers attached to not less than two approved type expansion shield each one capable of taking full maximum load. The rods and complete hangers shall be of adequate size to support the load, which they carry.

iv) Approved roller supports, floor stands, wall brackets, masonry, etc. for all lines running above the floors, and which can be properly supported by the walls shall be provided. Pipe lines near walls may also be hung by hangers, carried from approved wall bracket at a higher level than the pipe.

v) Pipes shall not be hung from the pipes of other trades or other pipes except for small water branches in toilet where no other practical means support can be found, in which case specific approval for the installation shall be obtained from the Engineer- in-Charge. Hangers shall not be fastened by means of vertical expansion bolts. Hanger shall be of heavy construction suitable for the size of pipe to be supported. All materials, except roller shall be a malleable iron or steel. Rollers shall be cast iron. Hanger shall be swivel split ring, wrought pipe clamp, or adjustable type or as approved.

vi) Special cares shall be taken in the placing of hangers at the top, bottom and in offsets of hot water risers so as to allow for expansion of the vertical piping. Vertical risers shall be securely supported from the building construction by means of pipe clamps at every floor.

vii) For cast iron hub and spigot pipe and fittings hangers shall be provided on not more than 1.5 meters centers or a minimum of one hanger for each length of pipe. Where excessive number of fittings are installed between hangers, the Contractor shall provide additional hangers or reinforcing as required to the satisfaction of the Engineer-in-Charge. Fittings shall be securely anchored to the building construction at changes of direction to eliminate all horizontal movement. The Contractor shall furnish and install steel channels and angles for piping support. These supports will be required where there is not roof slab or where the building structure is not directly usable for pipe support.

23.1.15 PIPE SLEEVES

Pipe line laid through any wall, floor, ceiling or roof may be arranged to pass through proper hot dipped galvanized sleeve pipes of ample diameter embedded therein to enable the pipe lines to pass easily and freely. The length of every such sleeve pipe shall be of the full width or thickness of the wall and in the case of roof, ceiling or floor, shall be at least 40 mm longer than the thickness thereof and shall project to that extent above the upper surface thereof unless the Engineer-in-Charge orders to the contrary. Inside diameter of sleeves shall be at least 25 mm greater than the outside diameter of pipe passing through it. Space between pipe and sleeve shall be lead caulked and made water tight wherever required.

23.1.16 HOT WATER SYSTEM

All Hot Water supply piping shall be insulated as specified herein. Prior to insulation the pipes shall be thoroughly cleaned of all rust, scales and other containments by wire brushing, sand blasting etc and by using aromatic solvents complying with ASTM D-3734 to remove oil, grease etc. Subsequent to the cleaning operation the pipe, shall be coated with two coats of approved, temperature resistant, anti-corrosion paint. Insulation shall be applied to the painted pipe only after hydraulic testing as specified and shall be of a thickness shown as under:-

Nominal pipe dia mm	Insulation thickness (mm)
15 – 20	20
25 – 40	25
50 – 100	32

The insulation, covering and jacket canvas shall be suitably fixed and an approved temperature resistant adhesive shall be used. The circumferential and longitudinal joints for the kraft covering and canvas jacket shall be lapped at least 40 mm.

Further reinforcement shall be provided by the use of 20 mm wide soft aluminum bands, generally spaced at 450 mm and on either sides of elbows, tees, valves and other piping specialties. All butt joints shall be sealed with self -adhesive type of approved quality adhesive tape.

All valves, fittings and other specials shall be insulated with plain glass fibre wool blanket of thickness equal to the adjoining pipe insulation and shall be covered by kraft paper and canvas jacketing as specified earlier. Two coats moisture proof approved paint shall also be applied. The adjoining insulation near these fittings shall be trimmed into suitable sections to fit closely around the valves, flanges and fittings. All trimmed sections shall be secured by wrapping of approved type of self-adhesive tape to form a complete waterproof seal. All work shall be done in a neat and workman like manner and must reflect recommended practice.

23.1.17 EMBEDDED PIPELINES

Chassis shall be left in concrete or masonry walls where pipe lines are to be embedded. The cavity shall be deep enough so that after installation of pipes sufficient space is available for cover. Pipes shall be laid before plastering walls or laying of concrete floors so that no joint or cover is visible. Hot and cold lines shall be laid in separate chassis or cavities and wherever specified shall be painted with two coats of bitumen and wrapped in hessian cloth or polythene sheet.

23.1.18 INSTALLATION OF GAS PIPES

All pipes from gas regulator to the consumption point shall be laid as G.I pipes for water supply. Two coats of hot bitumen shall be given all around to the entire length of pipe and hessian cloth wrapped around it. There shall be no pressure on the joints to obviate the possibility of leakage later on.

23.1.19 PAINTING OF EXPOSED PIPES

All exposed pipes for cold, hot and mixed water and gas supply shall be painted if required in different colours as specified. One coat of red oxide primer and two coats of synthetic paint shall- be given to all M.S hangers, brackets and pipes.

23.1.20 DISMANTLING OF GI PIPES SYSTEM

Whenever dismantling of GI pipe system is required all the joints shall be carefully opened and the components such as pipes, sockets, specials, valves & fittings and holder bats etc. shall be carefully removed, cleaned, all the usable materials shall be sorted out and stacked properly for subsequent use.

23.1.21 INSTALLATION OF FIXTURES

23.1.21.1 TAPS, STOP COCKS AND VALVES

All taps, stop cocks and valves shall be eased and grease before fixing. The washers and gland packing shall be equally suitable for hot & cold water.

23.1.21.2 CHAMBERS FOR STOP COCKS AND VALVES

Chambers for stop cocks and valves shall be of brick mortar and plaster as specified and shown on drawings. The work shall be carried with applicable provisions of Section 11, Brickwork & Section 5, Plain and Reinforced Concrete.

23.1.21.3 GAS ROOM HEATERS & GAS LAMPS

The gas room heaters & gas lamps shall be of type and make as specified and shall be provided and installed as approved by the Engineer-in-Charge.

23.4 PAYMENT

23.4.1 COMPOSITE RATE

The measurement and payment for the items of the work of Road and Road Structures hereof shall be made corresponding to the applicable CSR item as provided in Contract Agreement and shall constitute full compensation, for procurements, transportations, performance in all respect and completion of work as specified including the site clearance as approved by the Engineer-in-Charge.

23.4.2 LABOUR RATE

The measurement and payment for the items of the work of Road and Road Structures hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurements transportations, performance in all respect and completion of work as specified including site clearance, as approved by the Engineer-in-Charge except the cost of materials to be provided by Department at designated location as defined in the Contract Agreement.

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24. SURFACE DRAINAGE

24.1 SCOPE

The work covered by this Section consists in furnishing all plants, labours equipments, appliances and materials and performing all operations in connection with the construction of Surface Drainage in accordance with the Drawings and this Section of Specifications.

24.2 RELATED WORKS/SPECIFICATIONS

- i) Earthwork – Section 3 – Earthwork
- ii) Concrete – Section 5 – Plain & Reinforced Concrete
- iii) Block Masonry – Section 9 – Cement Concrete Block Masonry
- iv) Rubble Masonry – Section 12 – Stone Masonry
- v) RCC Pipes and Construction – Section 25 - Sewerage

All works shall be carried out according to the applicable provisions of the Sections referred above.

24.3 CONSTRUCTION REQUIREMENTS

24.3.1 PUNJAB STANDARD TYPE DRAINS

Punjab Standard Type Drains Types IV to VIII shall be constructed and shall be made of cement concrete 1:2:4 with 1:4:8 bedding or as specified concrete mix. The exposed surfaces of all inverts and drains including side slabs and bullnoze shall be applied a thin skin of about 6 mm thick 1:1 cement sand mortar immediately after the concrete has been placed and floating the same to clean smooth finish. The slabs for the side walls shall be moulded separately and shall be laid in 1:2 cement sand mortar on the concrete backing, previously prepared, not less than 14 days after being made. All joints being carefully struck perfectly clean and flush with the faces of the slabs. Where specified the walls shall be constructed of brick masonry, concrete block masonry or rubble masonry as shown on Drawings according to the applicable Sections referred in Sub-Section 24.2 above.

The preparation of the trench, aligning and grading shall be carried out in the same manner as required for sewers.

No extra shall be payable for curves, bends, falls, junctions, inlets, outlets and all other special work in connection with the drains and the cost of all such special work shall be included in the rates as given in the schedule.

24.3.2 CROSSING OVER DRAINS

RCC slab 15 cm as specified shall be provided over the drains where shown on drawings or directed by the Engineer-in-Charge.

24.3.3 APPROACHES TO THE CROSSINGS

The approaches in the street to the crossing shall be laid in herring bone pattern either flat or on edge as directed in first class bricks. The base shall be of cement concrete as specified and the bricks shall be laid on a 6 mm layer of plaster. Any special cutting or curved work, boundary corners, curves, slopes and changes of slopes, cambers, cutting shaping and wastage of bricks to fit irregular area and all other special work is also included. The joints shall be struck flush and smooth. All profiles and strips shall be provided by the contractor at his own costs. Unless cement pointing is required by the Engineer-in-Charge, the external surface of the joints shall be struck flush as the work proceeds and left perfectly flushed and smooth.

24.3.4 CONNECTION WITH SEWERS

The surface drains shall be connected with sewers through gully gratings or as shown on drawings.

24.3.5 HOUSE OUTLET CONNECTIONS

The house outlet is connected through a khurra by means of connection drain to the main drain. The size of the khurra shall be according to the size of the outlet. The standard sizes of khurras are 30 cm x 30 cm, 30 cm x 23 cm and 23 cm x 15 cm. Khurras shall be made in the space between the house wall and the reimbursement or side wall of main drain and if there shall be no space available then khurra shall be constructed on the reimbursement. The house connection drain shall join the main drain at 45 degree to provide smooth flow.

24.3.6 TESTING OF DRAINS

After completion the drain shall be tested for flow by filling upto the full section.

24.3.7 REIMBURSEMENT

The reimbursement is bricks laid in cement mortar 1:5 on both sides of the roads sloping towards the drain (3 mm in 229 mm slope) on a 6 mm layer or mortar over specified thickness of base concrete. The work shall include any strips, sides and edging of narrow width area to be paved with dry bricks on edge or flat. The work shall also include all extra works involved in laying narrow strips I6 mm, 114 mm or 229 mm in width along sides of the drains and for all curves, bends, slopes and changes of slopes and other work involving added labor and material for irregular areas, cutting, fixing and wastage of bricks required for such works.

All joints between the bricks and along outer end and inner side of the reimbursement shall be completely filled with specified mortar.

24.3.8 TEGA

The house walls shall be protected by 76 mm or 114 mm thick Tega (i.e. brick on end) laid in cement mortar projecting to a maximum height of not more than 150 mm above the drain and the work shall include all excavation, cutting and wastage of bricks. The external surface of the joints must be flushed as the work proceeds.

24.3.9 FOUNDATION FOR REIMBURSEMENT AND TEGA

76 mm or as specified cement concrete shall be provided under reimbursement and Tega.

24.3.10 RCC PIPES

RCC pipes shall be laid as specified and shown on Drawings. The work shall be performed complying with the provisions of Sub-Section 25.3 - RC Pipes under Sewerage.

24.4 MEASUREMENT AND PAYMENT

24.4.1 COMPOSITE RATE

The measurement and payment for the items of the work of Surface Drainage hereof shall be made corresponding to the applicable CSR item as provided in Contract Agreement and shall constitute full compensation, for procurements, transportations, performance in all respect and completion of work as specified including the site clearance as approved by the Engineer-in-Charge.

24.4.2 LABOUR RATE

The measurement and payment for the items of the work of Surface Drainage hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurements transportations, performance in all respect and at designated location as defined in the Contract Agreement.

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25 SEWERAGE

25.1 SCOPE

The work covered by this section of the specifications consists in furnishing all reinforced concrete pipes, plant, labour, equipment, appliances and materials and in performing all operations required for installing and testing the sewer pipes in strict accordance with the specifications of this section and the applicable drawings and subject to the terms and conditions of the contract.

25.2 RELATED WORKS SPECIFICATIONS

- Section 3 – Earthwork
- Section 5 – Plain & Reinforced Concrete
- Section 11 – Brickwork
- Section 27 – Tube-well & Water Supply
- Section 28 – Iron Steel & Aluminum Works

25.3 SEWER LINES

25.3.1 MATERIALS

All materials used in the manufacture of reinforced cement concrete pipes for use shall conform to ASTM Designation C-76-03 or latest revision and also with the following specifications.

a) Cement

The Portland cement to be used in the manufacture of reinforced concrete pipes shall conform to the requirement of BS-12/ASTM Designation C-150 (latest revision).

b) Aggregates

The coarse/fine aggregate to be used in the manufacture of concrete pipes to be furnished and installed shall be generally in accordance with the provisions of Section 5 – Plain & Reinforced Concrete.

c) Water

Water to be used in the manufacture of pipes shall be in accordance with the provisions of Section 5 - Plain & Reinforced Concrete approved by the Engineer-in-Charge.

d) Steel Reinforcement

The material shall conform to the specifications contained in Section 5 – Plain & Reinforced Concrete.

e) Brick Ballast

Brick ballast shall have a maximum gauge of 1½ inch and shall be graded down to ¾ inch and shall not contain more than 10% which will pass through screen made of ¼ inch diameter bars spaced at ¾ inch centre to centre.

25.3.2 NON-REINFORCED CEMENT CONCRETE PIPES

The non-reinforced cement concrete pipes shall conform to ASTM C-14, latest revision Class II equivalent. Pipe ends shall be thus tongue and groove or bell and spigot. The physical dimensions shall be as described in applicable provisions of ASTM C-14.

25.3.3 REINFORCED CONCRETE PIPES

25.3.3.1 CLASSES OF PIPE

The reinforced cement concrete pipes to be furnished and installed shall be of the strength Class II or specified otherwise on the Drawings.

Following technical criteria shall be adhered to:

Class of Pipe	:	Class-II
Concrete Strength	:	4000 Psi (Cylinder Test)

The design requirements for these classes of reinforced cement concrete pipes shall be as described in ASTM Designation C-76, Table 1 to 5 for the respective strength classes. Unless otherwise called for in other parts of these Technical Specifications or as ordered, all reinforced cement concrete pipes shall comply with the Wall-B design requirements as set forth in said Table 1 to 5 of ASTM Designation C-76-82 or latest revision.

For pipes smaller than 12 inches dia BSS 556, Class-L shall be strictly followed:

25.3.3.2 BASIS OF ACCEPTANCE

Acceptance of reinforced cement concrete pipes will be on the basis of three edge bearing and material tests as per ASTM Designation C-76-79 or latest revision and inspection of manufactured pipes for defects and imperfections. The Contractor shall bear the cost of such tests and pay fees etc., and also pay for the carriage of such samples and all other expenses contingent to tests.

25.3.3.3 PIPE DIMENSIONS

The internal diameters and wall thicknesses of reinforced concrete pipes under this contract shall be as set forth in ASTM Designation C-76-82 or latest revision in Tables 1 to 5 for "Wall-B" pipes as required and shown on the Drawings.

For Class II Pipes, the Wall Thickness for various dia pipes is as under:

12 inch dia pipe	**:**	2.00 inch
15 inch dia pipe	**:**	2.25 inch
18 inch dia pipe	**:**	2.50 inch
21 inch dia pipe	**:**	2.75 inch
24 inch dia pipe	**:**	3.00 inch
27 inch dia pipe	**:**	3.25 inch
30 inch dia pipe	**:**	3.50 inch

The lengths of reinforced concrete pipes shall be as required to provide the designated laying length plus any overlap needed for the pipe joint. Pipe shall be of standard length of 8 ft. unless otherwise approved in writing by the Engineer-in-Charge. Only one laying length shall be permitted for each size of reinforced concrete pipe and pipes not of the approved uniform laying length shall not be used in the work.

For 9 inch dia RCC pipes following data in addition to ASTM-76 shall be applicable:

1.	Wall thickness	1 inch
2.	Reinforcement square inches per linear foot of pipe wall	0.05
3.	Concrete strength	4000 Psi (Cylinder Test)
4.	Inside diameter at the mouth of socket	12½ inch
5.	Depth of socket	2¼ inch
6.	Longitudinal Steel	As stated below

"*Each layer of circumferential reinforcement shall be assembled into a rigid case supported by 4 Nos. longitudinal bar of quarter inch diameter*".

The strength test requirements in pounds per linear foot of pipe under the three-edge-bearing method shall be either the D-Load (test load expressed in pounds per linear foot per foot of diameter) to produce 0.01 in crack, or D-loads to produce the 0.01 in crack and the ultimate load as specified below, multiplied by the internal diameter of the pipe in ft.

D - Load to produce a 0.01 in crack	=	1000 pounds
D - Load to produce the ultimate load	=	1500 pounds

Lift holes in the walls of reinforced cement concrete pipes will not be permitted for the purpose of handling and laying. Other approved lifting methods shall be employed.

25.3.3.4 CERTIFIED DRAWINGS AND DATA SHEETS

The Contractor shall submit in triplicate, for approval by the Engineer-in-Charge certified drawings and data sheets as required to provide complete information on all concrete sewer pipes, dimensions, type and dimensions of pipe ends, joint details proposed concrete design mix for each different strength class of reinforced pipe and any other information needed to demonstrate full compliance with these specifications.

No concrete sewer pipe shall be delivered to the work site until the Engineer-in-Charge has formally approved the certified drawings and data sheets and until all test requirements called for in the respective ASTM Standard Specifications C-76 or latest revision have been met.

25.3.3.5 JOINTS FOR CONCRETE PIPE SEWERS

The joints for concrete pipes shall be as specified and could be as follows:-

a) Rubber Gaskets Joints

Rubber gasket joints shall be used for either tongue and groove or bell and spigot pipes.

Rubber gasket joints shall be made using specially designed rubber gaskets, made to fit the applicable tongue and groove or bell and spigot pipes and adequately tested under operating conditions. Special care must be taken in the selection and handling of the concrete pipes for use with rubber gasket joints, to ensure that pipe ends shall be smooth and concentric with tolerances which closely conform to the requirements of the manufacturer of the rubber gaskets. The tongue or spigot end of each pipe shall be specially designed to perform groove or offsets to fit the manufacturer's rubber gaskets design.

The rubber gasket joints shall conform to all applicable requirements of the latest revision of ASTM Designation C443, entitled "Joints for Circular Concrete Sewer and Culvert pipe, using Flexible Watertight Rubber Type Gaskets" except that the test pressure need not exceed 10 feet of head at which the complete sewers shall meet the infiltration or exfilteration limits set forth hereinafter.

The groove end of tongue and groove pipes shall have at least one line of wire reinforcement of 8 gauge size placed in the centre of the groove.

The rubber gasket shall be installed on the pipe in accordance with the instructions of the gasket manufacturer. In general the gaskets shall be pre-assembled at the pipe manufacturing plant. The pipes shall be handled with special care at all times to prevent damage to the pipe ends. A lubricant shall be used for jointing the pipes as recommended by the rubber gasket manufacturer. Care shall be taken to avoid contamination of the gasket and lubricated surfaces with earth or other undesirable material during installation.

For either tongue and groove or bell and spigot pipes, mechanical means shall be used to pull the pipe home for all sizes of 12 inches or larger diameter in accordance with the recommendations of the rubber gasket manufacturer. Pipes of 9 inches diameter may be coupled manually using a cross member and bar. Under no circumstances will bars alone be used nor shall any motor driven equipment be used to force the pipe home.

b) Cement Mortar Joints

Cement mortar may be used where called for. This type of joint will normally be permitted only for sewers laid above the water table. Bell and spigot joints with cement mortar shall be made as follows:

The first pipe shall be in place to the established line and grade. The interior surface of the bell (socket) shall be thoroughly cleaned with a wet brush, and a sufficient layer of stiff mortar shall be applied to the lower portion of the bell. The spigot of the second pipe shall be thoroughly cleaned with a wet brush, and uniformly fitted into the bell so that the interiors of the two pipes are closely fitted and accurately aligned. The remaining annular space in the bell shall then be solidly filled with mortar in sufficient amount to form a head around the out side of the spigot. The interior surface of the pipe at the joint shall be cleaned of all surplus mortar and brushed to a smooth finish. The Contractor may at his own option, use jute firmly caulked into place for holding the bell and spigot joint in proper position.

Tongue & groove joints with cement mortar shall be made as follows:

The first pipe (downstream) shall be in place to the established line and grade with groove upstream. The groove of the first pipe shall be thoroughly cleaned with a wet brush and a layer of soft mortar shall be applied to the groove in the entire lower half of the pipe. The tongue end of the second pipe shall be thoroughly cleaned with a wet brush and, while it is in the horizontal position, a layer of soft mortar shall be applied to the entire upper half of the pipe. The tongue end of the second pipe shall then be inserted into the groove of first pipe until mortar is squeezed out on the exterior surface. The Contractor will use hamper jute gasket soaked in cement slurry, for holding the two pipes in proper position. The joints shall then be completely and solidly filled with stiff mortar on the outside of the pipe. The Interior surface of tile pipe at the Joint shall be cleaned of all surplus mortar and brushed to a smooth finish. The out side mortar joint shall be rubbed smooth with a moist rag and not trowelled.

The Portland cement mortar used for making joints shall consist of one part cement and one part clean sand, thoroughly mixed dry with sufficient water slowly added to give proper consistency. The mortar shall be promptly used after it is made. The completed joints shall be immediately protected on the outside with an initial covering of moist earth canvas or burlap.

25.3.3.6 HOUSE CONNECTIONS

House Connections shall be made through manholes as indicated in the drawing or as directed by the Engineer-in-Charge.

House connection shall be provided individually for each plot by means of a 6 inch dia RCC sewer pipe and a dead end, laid at an average depth of 2.0 feet below NSL level and in such a manner that other services such as water supply, telephone and gas lines are not disturbed or interfered. The work of laying the sewer pipe shall conform to the specifications laid down in the relevant section of this contract.

Tile inlet of each house connection shall be plugged with brick masonry 4½ inches thick in 1:6 cement sand mortar both in the manhole and the pipe in the plot.

25.3.3.7 GULLY GRATING

Gully grating shall be made through manholes as indicated in the drawings or as directed by the Engineer-in-Charge.

Gully grating shall be provided on the road junctions on as mentioned in the drawings by means of a 9 inch dia RCC sewer pipe connecting the nearest manhole with the chamber of size l ft – 6 inches x 1 ft – 6 inches. The pipe is laid in such a manner that other services such as water supply and sewerage system are not disturbed or interfered. The work of laying RCC pipe shall conform to the specifications laid down in Sub-section 25.3.3.8. Mild steel grating shall be fixed at the top.

25.3.3.8 INSTALLATION

a) Handling of Pipes

Concrete sewer pipes shall be handled with special care at all times during the manufacture, while transporting to the site of work, and while installing. Each pipe shall be carefully inspected before being laid and no cracked, broken or defective pipe shall be used in the work. Chipping of the tongue and groove or bell and spigot pipe ends, which in the Engineer-in-Charge's opinion may cause defective joints, shall be sufficient cause for the rejection of any concrete pipe.

b) Excavation and Backfill

The excavation and backfill for sewer installations shall be as specified in applicable provisions of Section 3 - Earthwork and will be paid for under separate contract items as classified.

c) Placing of Bedding

i) Brick Ballast Bedding

The brick ballast shall be clean material of 1 to 1½ inch gauge broken from first class bricks or bats, or from dense over burnt bricks. No under-burnt bricks or bats nor those which have become spongy of porous in the process of burning shall be broken up for brick ballast.

The material shall be evenly spread over the full width of the formation in 4 inches loose layers and compacted with hand or mechanical rammers until the full thickness as shown on the drawings for the particular pipe size has been built up and finished no more than ¼ inch below required level. The Contractor shall note that it is essential that the material at the sides of the pipes is adequately compacted. Before the subsequent placing of pipe surrounding material, pipe joints shall be protected. Protection may take the form of a twist of yarn lightly pressed into the annular joints space or other equal protection approved by the Engineer-in-Charge.

ii) Crushed Stone Bedding

Crushed stone bedding shall be from an approved source. It shal1 be obtained from a dark colored igneous rock such as granite etc. It shall be strong durable, hard and impervious, having crystalline structure. The broken stone shall have sharp edges and clear fractured faces, shall be free from thin elongated or laminated pieces.

The crushed stone shall have a maximum gauge of 1½ inch and shall be graded down to ¾ inch when sifted through a screen made of ¼ inch diameter bars spaced ¾ inch center to center, it shall yield not more than ten percent (10%) by volume of fine materials.

d) Laying of Sewers

Neither any sewer pipe nor the bedding shall be laid or placed till the alignment of the sewer and its levels and gradients have been carefully checked and tested with the trench excavation and found correct.

Each length of sewer pipe shall be checked for cracks and defects before placing in the line. Defects which in the opinion of the Engineer-in-Charge indicate imperfect placing, shall make, the pipe liable to rejection. Each pipe shall be placed carefully to line and grade and in close contact with adjoining pipe. These specifications require rejection of the work, if the sewer invert varies as much ½ inch from the proper elevation. As shown on Drawings, the bottom of the trench must be shaped to fit the pipe barrel, with holes left for the bells. If excavation has been carried below the correct grade, refilling must be done with satisfactory materials as approved by the Engineer-in-Charge at no extra cost. The concrete pipe joints shall be of the type specified above and shall be made in accordance with the aforesaid specifications.

When laying is not in progress, the open pipe shall be closed with a tapered wooden plug to keep out foreign matter.

25.3.3.9 TESTING OF SEWER LINES

a) General

All sewer built shall be tested for infiltration or ex-filtration as specified below. The tests shall be made at times selected or approved by the Engineer-in-Charge. Sections of the completed sewer shall be isolated and measurements of the infiltration or ex-filtration shall be made by approved method. The contractor shall furnish all labor, material and equipment required for making the tests with no extra compensation over and above the agreed contract prices for the laying of sewer lines.

b) Infiltration Test

The sewers which are constructed with the ground water level above the invert level of the pipe shall be tested for infiltration after the sewers have been installed and backfilling has been substantially completed. The tests and measurement shall be performed by the Contractor in the presence of the Engineer-in-Charge as follows in accordance with ASTM C 969-02.

Conduct testing from manhole to manhole or between more than two manholes. The length of main tested shall not exceed 700 ft

.

i) Stop all dewatering operation and allow the groundwater to return to its normal level. Infiltration testing shall not be used unless the groundwater level is at least 2 ft above the crown of the pipe for the entire length of the test section.

ii) Plug all pipe outlets discharging into the upstream manhole.

iii) Measure the groundwater elevation and determine the average head over the test section.

iv) Measure infiltration leakage at the outlet of the test section. Because leakage allowances are small, measurements are best made by either timing the filling of a small container of known volume, or by directing flow into a container for a specified time and measuring the content, or by using small weirs.

v) If the measured rate of leakage is less than or equal to the allowable leakage in accordance with (d) hereafter the section of sewer tested is acceptable.

vi) If the test section fails, it is not prohibited that it be repaired and retested in accordance with this practice.

vii) The allowable leakage limit including manholes is 500 gallon/ inch of internal diameter (mile of sewer) (24 h) when the average head on the test section is 6 ft or less.

viii) The average head on the test section is the head above the crown of the pipe at the upstream manhole plus the head above the crown of the pipe at the downstream manhole divided by two.

ix) When the average groundwater head on the test section is greater than 6 ft. the allowable leakage shall be increased in proportion to the ratio of the square root of the average groundwater head to the square root of the base head of 6 ft.

x) Manholes shall be tested separately and independently or with the pipeline with the allowance of 0.1 gallon (ft of diameter) (ft of head) (h). If building or house leads are connected to the main line being tested, allowance shall be made for permissible leakage in such leads.

c) Ex-filtration Test

i) Conduct testing from manhole to manhole or between or between more than two manholes. The length of main tested shall not exceed 700 ft.

ii) Determine the groundwater elevation at both ends of the test section. If the groundwater level is less than 2 ft above the crown of the pipe measured from the highest elevation of the sewer, the ex-filtration test shall be used.

iii) Plug all pipe outlets discharging into the upstream manhole and the test section outlet. Fill the sewer line with water.

iv) At the upstream manhole the test head shall be established as minimum of 2 ft above the crown of the pipe, or at least 2 ft above existing groundwater, whichever is higher.

v) Allow the pipe to remain saturated for a period long enough to allow water absorption in the pipe, a minimum of 4 h and up-to a maximum of 72 h. After the absorption period, refill the pipe to the required test head.

vi) Measure the leakage loss over a timed test period. The minimum test period shall be 15 min and the maximum shall not exceed 24 h.

vii) If the measured rate of leakage is less than or equal to the allowable leakage in accordance with (d) the section of sewer tested is acceptable.

viii) If the test section fails, it is not prohibited that it be repaired and retested in accordance with this practice. The groundwater elevation shall be re-determined prior to a second test and the test head adjusted, if necessary in accordance with (iv).

ix) For ex-filtration testing the allowable leakage limit including manholes is 500 gal. (in. of internal diameter) mile of sewer) (24 h) when the average head on the test section is 3 ft or less.

x) When the average head on the test section is greater than 3 ft. the allowable leakage shall be multiplied by the ratio of the square root of the average test head and the square root of the base head of 3 ft.

xi) Manholes shall be tested separately and independently or with the pipeline with an allowance of 0.1 gal. (ft of diameter) (ft of head) (h).

d) Allowable Infiltration or Ex-filtration

The calculated amount of infiltration or ex-filtration over a 24 hour period shall not exceed 500 gallons per inch of pipe diameter per mile of sewer which rate shall be applied to the actual sewer size and length tested to determine the allowable infiltration or ex-filtration over the 24 hour period.

If the measured infiltration or ex-filtration exceeds the specified allowable limit, then the Contractor shall locate the points of leakage and make necessary repairs so as to reduce the leakage to less than the permission maximum stated above.

e) Cleaning of Sewer Lines

The Contractor shall clean all the sewer lines at no extra cost with the method approved by the site Engineer-in-Charge prior to handing it over to the Owner.

25.3.3.10 MEASUREMENT

The lengths of pipes shall be measured in running metres nearest to a cm as laid or fixed, from inside of one manhole to the inside of the other manhole. The length shall be taken along the centre line of the pipes over all fittings such as bends, junctions, etc. which shall not be measured separately.

Excavation, refilling, shoring and timbering in trenches, and cement concreting wherever required shall be measured separately under relevant items of work.

25.4 UN PLACTICIZED POLYVINYL CHOLRIDE PIPES

The UPVC pipes to be furnished and installed shall be of the Class B to Class E, as specified on the Drawings. The design requirements for these classes of UPVC pipes shall be as described in Pakistan Standard Designation PS 3051 or British Standard BS 3505.

25.4.1.1 CERTIFIED DRAWINGS AND DATA SHEETS

The Contractor shall submit in triplicate, for approval by the Engineer-in-Charge certified drawings and data sheets as required to provide complete information on all concrete sewer pipes, dimensions, type and dimensions of pipe ends, joint details proposed concrete design mix for each different strength class of reinforced pipe and any other information needed to demonstrate full compliance with these specifications.

No concrete sewer pipe shall be delivered to the work site until the Engineer-in-Charge has formally approved the certified drawings and data sheets.

25.4.1.2 PRESSURE TESTING

It is recommended to test the pipeline in accordance with PS standards 3051 and BS 3505.

25.4.1.3 MEASUREMENT

The lengths of pipes shall be measured in running metres nearest to a cm as laid or fixed. The length shall be taken along the centre line of the pipes over all fittings such as bends, junctions, etc. which shall not be measured separately.

Excavation, refilling, shoring and timbering in trenches, and cement concreting wherever required shall be measured separately under relevant items of work.

25.5 MANHOLES

25.5.1 MATERIALS

Brick masonry, Portland cement concrete, and other materials shall meet the specified requirements of the relevant sections of the specifications, listed under clause 25.2 and elsewhere as necessary. Cast iron frame shall conform to the specifications as per B.S.S. 497, Manhole steps shall be of galvanized mild steel.

25.5.2 CONSTRUCTION REQUIREMENTS

Manholes shall be constructed with brick masonry laid in 1:3 cement sand mortar, built on 1:2:4 concrete base slab and as specified. The cover slab shall be 1:2:4 reinforced cement concrete, fitted with cast iron frame which shall have reinforced cement concrete cover as shown in the drawing. Reinforcement and concrete shall conform to the requirements or Section 5 – Plain & Reinforced Concrete. The outside and inside of the walls shall be plastered (½ inch thick) with 1:3 cement sand mortar and two coats of hot PB-4 bitumen shall be applied outside. At the bottom of manholes for sewers, a proper channel as per Drawings, shall be constructed in the whole length of the manhole along the centerline of the sewers, to lead the sewage from one sewer to the other. Galvanized mild steel steps shall be installed at 12 inches interval inside the manhole during the construction of the manhole walls. Cutting holes into the wall for the steps after construction will not be permitted. Top rung shall be 18 inches below the manhole cover and the lowest not more than 12 inches above the benching (floor).

Depth of manhole shall be from invert level of sewer to the top of manhole.

Where specified cast iron manhole covers conforming to the dimensions and weights as shown on drawings shall be used.

25.5.3 DROP MANHOLE

The Contractor shall construct drop manholes wherever shown in the drawings or ordered by Engineer-in-Charge. The Contractor shall make the drop connection as shown on the drawings or ordered by the Engineer-in- Charge.

25.5.4 MEASUREMENT

The manhole covers shall be enumerated under relevant items.

Manholes shall be enumerated under relevant items. The depth of the manhole shall be reckoned from the top level of C.I. cover to the invert level of channel. The depth shall be measured correct to a cm. The extra depth shall be measured and paid as extra over the specified depth.

25.6 CAST IRON VENTILATING SHAFTS

Cast Iron Pipes & specials shall conform to BS-78 for spigot and sockets vertically cast pipes; BS-1211 for spigot and socket spun iron pipes and BS-2035 for flanged.

The work shall carried as specified shown on drawings and approved by the Engineer-in-Charge in accordance with applicable specifications.

25.6.1 MEASUREMENT

The Cast Iron ventilating shafts shall be measured in Kgs upto two decimal place.

25.7 CLEANING OF LINES

The lines shall be cleared of silt and other clogged material in the pipeline as directed by the Engineer-in-Charge.

25.8 PAVEMENT RESTORATION

The paved surfaces which are cut shall be restored to the original condition according to drawings and as approved by the Engineer-in-Charge.

25.9 MEASUREMENT AND PAYMENT

25.9.1 COMPOSITE RATE

The measurement and payment for the items of the work of Sewerage hereof shall be made corresponding to the applicable CSR item as provided in Contract Agreement and shall constitute full compensation, for procurements, transportations, performance in all respect and completion of work as specified including the site clearance as approved by the Engineer-in- Charge.

25.9.2 LABOUR RATE

The measurement and payment for the items of the work of Sewerage hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurements transportations, performance in all respect and completion of work as specified including site clearance, as approved by the Engineer-in-Charge except the cost of materials to be provided by Department at designated location as defined in the Contract Agreement.

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26. WELL SINKING

26.1 SCOPE

The works to be done under Well Sinking, consist of all such related works which extend below the ground specified in the Contract or as directed by the Engineer-in-Charge. Those works shall include constructing brick masonry reinforced brick masonry wells with reinforced concrete well curbs and steel angle cutting edges including bottom and top concrete plugs and sand filling as shown on the Drawings and specified herein. The works to be done shall include constructing reinforced concrete well curbs with steel cutting edges, brick masonry walls (Unless reinforced brick Masonry has been specifically specified or directed by the Engineer-in-Charge) dredging and sinking the wells, placing the bottom and. top concrete plugs and sand filling, and all incidental operations required to construct and sink the well foundations as shown on the Drawings or specified herein.

26.2 GENERAL

a) All operations of the Contractor for well sinking and all materials used shall be subject to the approval of the Engineer-in-Charge.

b) The Contractor shall sink the well at the designated locations in accordance with the lines and grades shown on the Drawings or established by the Engineer-in-Charge.

26.3 MATERIALS & WORKMANSHIP

The Contractor shall furnish all materials for the complete construction and sinking of the wells and all materials and workmanship shall meet the following requirements.

a) Brick masonry shall conform to the applicable requirements of Section 11- Brick Work.

b) Concrete shall conform to the applicable requirements of the Section 5, Plain & Reinforced Concrete.

c) Reinforcement for Concrete shall be as shown on drawings and shall conform to Sub-Section 5.4, Plain & Reinforced Concrete.

d) Sand filling shall be approved unprocessed river bed sand or, at the option of the Contractor approved river bed gravel, cobbles or brick bats mixed with sufficient river bed sand to completely fill the interstices in the coarser material.

26.4 CONSTRUCTION

The wells shall be constructed and sunk as open caissons as specified herein. Unless otherwise authorized by the Engineer-in-Charge, the Contractor will not be permitted to sink the well by any method which does not utilize the dredging and sinking principle substantially as follows:

a) The area at which the well is to be sunk shall be excavated to the approximate top elevation of the completed well foundation, In case spring level is higher than the top elevation of the completed well, the excavation shall be maintained in a dry condition by utilizing cofferdams and un-watering methods.

   The excavation shall comply with provision of Section 3 - Earthwork.

b) The well curb shall be constructed in place in the proper position, or if a pre-cast curb is used it shall be set in proper level position at the surface below which well sinking is to be carried. If a precast curbs is used it shall be set in proper level position. Precast curb shall not be handled until they have been cured for at least 14 days. The vertical bars for masonry reinforcement (wherever reinforced brick work has been specified or specially directed by the Engineer-in-Charge) shall be attached to the steel angle cutting edge by means of nuts and washers as shown on the Drawings.

c) After placing of precast curbs; or not earlier than three days after placing of Concrete for cast-in-place curbs, brick Masonry walls with an approximate height of 1.5 meters shall be constructed on the curbs as shown on the Drawings. Two straight edges as approved by the Engineer-in-Charge shall be rigidly attached to each of the outside faces of the well for the purpose of ensuring that the brick masonry courses are laid truly plumb and level and to provide a means by which the departure of the well from plumb and the drift of the well from its correct position during sinking may be determined, The well height in decimeters above the cutting edge as well as the level of each course of masonry shall be marked on the straight edges,

Wherever reinforced brick masonry walls have been specified or directed by the Engineer-in-Charge, vertical reinforcing and horizontal bond steel flats shall be embedded in the masonry as shown on the Drawings, Splices in the vertical reinforcing bars shall be made by welding or the screwing of sleeve nuts. Each strip shall be in place and drilled or punched to permit vertical reinforcing bars to pass through) horizontal bars,

d) The well shall be sunk by dredging (defined as removal of material from inside the well) until the top of the masonry is approximately 0.7 meters above the ground, whereupon straight edges for another lift of masonry shall be set and a second lift of masonry up to 3 meters in height constructed. Care shall be taken that the exterior faces of succeeding masonry lifts are constructed parallel to the axis of the well rather than plumb so as to indicate any uneven sinking of the well and permit remedial action to be taken. Each successive lift of masonry shall be allowed to set for three days before sinking of the well is resumed.

   In caser spring level is high, then operation shall be maintained in a dry condition using coffer dams and dewatering methods.

e) Dredging shall be accomplished in such a manner that the hole within the well shall not be extended below the cutting edge by more than 1.25 meter and that, when the well is sunk to its final position, the material outside of the well will not have been disturbed. Except when specifically authorized by the Engineer-in-Charge, explosives shall be used in conjunction with dredging. Dredged material shall be used for backfill or placed in spoil banks adjacent to the locations of work as approved by the Engineer-in-Charge.

f) Each well shall be frequently checked for plumb by means of plumb lines and mason's level or other approved means. Corrective action, consisting of dredging from the high side until the well rights itself, shall be taken immediately if the well is found to be sinking unevenly. If required, weights shall be added at the top of the well masonry on the high side or the Contractor may be required to employ shoring or tension rigging on the upper body of the well foundation to assist in plumbing the well foundation. The corrective force shall be applied concurrently with sinking of the well. Completed well foundations shall not depart from plumb by more than 2.5 cm in 1.27 m which shall be the only deviation allowed from the true position of the well as shown on the Drawings. .

g) Each well shall also be frequently checked for longitudinal and lateral drift during sinking by the use of a suitable sighting device, or other means approved by the Engineer-in-Charge, and by establishing satisfactory control points a safe distance from the construction so as to remain undisturbed, from which the straight edges outlined in sub-clause (b) above may be clearly sighted. The longitudinal and lateral centerlines of the top of any well foundation shall not deviate from the centerlines established on the Drawings by an amount greater than an equivalent tilt of 2.5 cm in 1.27 m. The vertical distance used to establish the equivalent tilt shall be the vertical distance from the level shown on the Drawings to the top of the well. The deviation may consist of tilt. drift, or combination thereof; however, the completed well shall not depart from plumb by more than 2.5 cm in 1.27 m.

h) If the well does not sink as the dredging is advanced, a greater height of masonry, weighting or running shall be employed. Running, defined as the practice of removing water from within the well to reduce buoyancy and thereby increase the effective weight of the well, shall not be employed without. the approval of the Engineer-in-Charge.

i) If for any reason a well is cracked either vertically or horizontally, the masonry shall be removed insofar as practicable to eliminate the crack and rebuilt. A crack or portion thereof, which cannot be eliminated practicably by' rebuilding in the opinion of the Engineer-in-Charge, shall be grouted to the satisfaction of the Engineer-in-Charge.

j) When a well has been sunk to its indicated elevation, the bottom interior of the well shall be carefully sounded to detect the presence of any material within the space to be occupied by the bottom plug, and any material so detected shall be removed. The false masonry if constructed to increase the weight for sinking shall also be removed.

2. Where specified:

a) Without un-watering, the bottom plug concrete shall be placed by means of a tremie, bottom dump buckets, or other approved means which will preclude any free fall of the concrete in the water. The concrete shall be worked under the masonry corbelling and carried at least to the height indicated on the Drawings.

b) After the bottom plug concrete has set at least one day, and without unwatering the well, the sand filling shall be placed in lifts not exceeding one meter in depth and with a 24-hour elapse of time between placement of the lifts to permit settlement of the fill.

c) After the sand filling is placed to the demarcated elevation within the well, the top plug concrete shall be placed and screeding level at the elevation of the top of the brick masonry, If the well is titled within the permissible limits, the masonry at the top of the well shall be constructed, so that the top surface of the masonry around the perimeter of the well meets the specified elevation.

26.5 LOG RECORD OF EXCAVATION

The Contractor shall furnish to the Engineer-in-Charge log of the Sinking of each well. The log record the day and hour at which sinking commenced, suspended, resumed and completed, a description of materials dredged; time during which each lift of brick masonry is built; the height of the lift; the daily record of sinkage obtained, deviation of the well from plumb position and description of action .to plumb the well, and any unusual occurrences or data as is required to document the progress of well sinking. The form of the log shall be approved by the Engineers-in-Charge.

26.6 ALTERNATIVE PROCEDURE FOR SINKING

Sinking of the well by any other of the so called traditional methods employed in Pakistan may be utilized when approved by the Engineer-in-Charge provided the essential requirements of these Specifications are met.

26.7 MEASUREMENT AND PAYMENT

26.7.1 COMPOSITE RATE

The measurement and payment for the items of the work of Well Sinking hereof shall be made corresponding to the applicable CSR item as provided in Contract Agreement and shall constitute full compensation, for procurements, transportations, performance in all respect and completion of work as specified including the site clearance as approved by the Engineer-in-Charge.

26.7.2 LABOUR RATE

The measurement and payment for the items of the work of Well Sinking hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurements transportations, performance in all respect and completion of work as specified including site clearance, as approved by the Engineer-in-Charge except the cost of materials to be provided by Department at designated location as defined in the Contract Agreement.

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27. TUBE-WELL AND WATER SUPPLY

27.1 CONSTRUCTION OF TUBE-WELLS

27.1.1 SCOPE

The work covered shall consist of well drilling, installation of components, shrouding, development and testing including all plant, labour, equipment & other miscellaneous works necessary for the satisfactory completion of the tube-well as specified and approved by the Engineer-in-Charge.

Before proceeding with the work the Contractor shall submit a complete work plan for performing the work. This will include but be not limited to manpower, Plant and equipment and schedule of performance for completion of work.

The Contractor shall employ at site a fulltime competent Superintendent for overall supervision of the work.

27.1.2 DRILLING

27.1.2.1 GENERAL

The Contractor shall drill bore hole for the tube-well at the designated location established by the Engineer-in-Charge, The Contractor shall prepare the site for the construction of the tube-well and shall provide for water for construction requirements, the disposal of water, cuttings and refuse from the operations away from the tube-well.

27.1.2.2 DRILL CONDITIONS

General overall conditions related to the ground water at the site of tube-well if available will be made known to the Contractor. The contractor is expected to make his own assessment of the character, quality and the conditions that may be encountered and shall take full responsibility for performance of work as specified.

27.1.2.3 DRILLING PROCEDURE

The bore hole shall be drilled either by direct or reverse circulation rotary method, The diameter of the drilling bit shall depend on the bore size as specified on drawings or as directed by the Engineer-in-Charge. The bore hole shall be drilled straight and plumb so that the pump and tube-well casing may, be installed concentric with the hole and within the tolerance specified for plumpness of the casing. Waste materials from the drilling operation shall be disposed of in a manner approved by the Engineer-in-Charge.

The Contractor shall be responsible for protecting the tube-wells from contamination with foreign materials until the completion of the tube-well. The Contractor shall bear any expense that may result from any damage to tube-well, tools, or equipment that may be caused by caving, washing, or other disturbances within the tube-wells.

To prevent sloughing and caving of surface material and/or the hole, the Contractor shall furnish and install a boring casing pipe with a minimum diameter 2 inches greater than the bit diameter from not less than 6 inches above the ground surface to bottom of the hole. The casing pipe shall be new or used pipe of adequate strength for the purpose. After the drilling is completed, the casing pipe shall be removed by the Contractor and shall remain his property.

The use of drilling fluid additives or other suitable materials specially approved by the Engineer-in-Charge may be applied in stabilizing the bore hole. The casing shall be removed by the Contractor after the installation of pump housing pipe along with the strainer in the bore hole. However in case of the tube-wells where shrouding material is to be provided around the periphery of the strainer (or around the strainer and the pump housing pipe) and the inner walls of the bore hole the casing shall be removed in 1.5 to 3 meters stages as shrouding is placed.

If in the opinion of the Engineer-in-Charge, it is necessary to discontinue work on any bore hole because it is out of line more than the specified limit or on account of jammed tools, or caving ground, or because of negligence on the part of the Contractor, the Contractor shall drill another bore hole at an alternative location designated' by the Engineer-in-Charge. The Contractor will not be entitled to payment for any work done or materials furnished for bore holes abandoned as a result of his operation or negligence.

27.1.2.4 DATA AND RECORDS

The Contractor shall keep an accurate drilling log of each bore hole including a description of all materials encountered and their location in the bore hole.

All records and data shall be kept by the Contractor on forms approved .by the Engineer-in-Charge. The Contractor shall deliver to the Engineer-in-Charge the original of all records completed in all respects.

27.1.2.5 SAMPLING

Representative ditch samples or cuttings of the material penetrated shall be taken at every 5 ft. (1.5 m) depth of borehole or at each change in litho-logy encountered whichever is less. Special care shall be exercised to determine the thickness and location of each change in material encountered and to obtain satisfactory samples. Immediately upon taking the sample, each sample shall be placed in a plastic or cloth bag or specified partitioned wooden box, or other approved container, properly marked for identification, and plainly labelled with the depth of the top and bottom of the section of the bore hole represented. The containers shall be furnished by the Contractor. The method of obtaining, processing, and storing the samples will be subject to approval by the Engineer-in-Charge. The Contractor shall deliver all samples to the Engineer-in-Charge at the site of the tube-wells, except that when requested to do so by the Engineer-in-Charge, the Contractor shall deliver specified samples to the Engineer's field headquarters.

27.1.2.6 MEASUREMENT

Dimensions shall be measured nearest to a cm. Measurement of length on completion shall be along the axis of boring. No allowance shall be made for bulking, shrinkage, cut off tolerance, wastage and hiring of tools, equipment for excavating, driving

27.1.3 INSTALLATION OF TUBE-WELL COMPONENTS

27.1.3.1 GENERAL

Installation shall consist of all work required in connection with the erection of pumping housing pipe, blind pipe, reducer, screen and bail plug/ sand trap required. for each tube-well as specified herein or on the Drawings or as directed by the Engineer-in-Charge and shall include, but not be limited to storing, fabricating and installing all the tube-well components including concentric reducers.

27.1.3.2 MATERIALS

i) Pump Housing Pipe

The housing pipe made of mild steel or PVC may have the same diameter as that of the other components or it may be bigger in which case tapered joint/reducer shall be used for connection of the housing pipe with the lower part of tube-well.

The mild steel pump housing pipes shall be new and shall be either seamless (Type S Grade 8 ASTM A-53), longitudinal welded (Type E Grade 8 ASTM A-53) or special seam fusion welded (Grade 8 ASTM A-139) mild steel of designated diameters and thickness indicated in the drawings.

PVC housing pipe shall conform to BSS-3505/1968.

All these pipes shall be free from dents, injuries, scars and ovalties. The pump housing pipe shall be installed to extend above ground level as approved by the Engineer-in-Charge in addition to the housing as specified below ground level.

ii) Well Blind Pipes

Well blind pipes shall be of designated diameters as indicated in the drawings, which shall be fabricated in conformity with the specifications designated here above for pump housing pipes.

iii) Reducer

In case where the size of the pump housing pipe is larger than the size of the strainer, the Mild steel pump housing pipe is connected with strainer or blind pipe by means of a reducer. The reducer shall be provided and made of the same material and of the same thickness as used for pump housing pipe specified above. The upper end of the reducer shall be suitable for welding to the pump housing pipe and the lower end shall be designed for connection to the specified size and type of the well blind pipe.

iv) Bail Plug/Sand Trap

Bail plug/Sand trap shall be of the same material and thickness as followed for well casing. Sand trap shall be provided with a base plate, welded at one end of the pipe. A steel hook bent in the form of 'U' shall be bolted to the base plate to sustain suspended length casing including the strainer and blind pipe. Bail plug/Sand trap shall be one to three meters long in size or as indicated in the drawing.

v) Well Screen

Well screen shall be either brass, PVC suitable for gravel pack tube-well and strong enough for location at a depth as shown' on the drawings, below ground level.

The strainer shall have smooth, sharp edged slots free of burrs, chipped edges, or broken areas on the interior or exterior surfaces of the pipe. The slots shall be machine cut having not more than 1.6 mm width. The width of the slot shall be dependent on the particle sizes of the sand. The open area of slotted casing shall be as approved by the Engineer-in-Charge. The slots or groups of slots shall be distributed in a uniform pattern around the periphery of the pipe. The openings shall be free from jagged edges irregularities or anything that will accelerate or contribute to clogging or corrosion.

27.1.3.3 FABRICATION

The depth of pump housing pipe will be established by the Engineer-in-Charge depending on the future water levels and draw down anticipated. Length of the specified diameter of steel pipe shall be provided to extend the pump housing/casing from the elevation of the top of the pump housing pipe to the depth established by the Engineer-in-Charge.

Adjoining sections of Mild steel pump housing pipe shall be assembled by field welding. The ends of the casing sections shall be lathe turned or other-wise prepared for joining. All fields welding shall be performed by the electric arc method, using heavily coated welding rods suitable for all position welding. After being welded, the welds shall be cleaned of slag and shall show uniform smooth surface without over- lap, porosity and clinker. The pump housing pipe shall be connected to the tube-well casing (slotted and blind pipe) by means of a concentric tapered reducer.

The length and sizes of tube-well casing (slotted and blind pipe) to be installed shall be specified for the tube-well by the Engineer-in-Charge and shall be sufficient to extend from the bottom of the housing pipe to the top of the bail plug. Bail plug shall be provided at the bottom of the tube-well casing. The tube-well casing shall consist of sections for installation opposite water yielding formations and plain pipe sections or bail plug opposite non-water yielding formations as directed by the Engineer-in-Charge.

27.1.3.4 INSTALLATION

The Contractor shall install the entire pump housing and tube-well casing assembly straight, plumb, and concentric in the drilled hole to permit the installation of the pump in such a manner that it will operate satisfactorily and without damage. The methods employed by the Contractor in the installation of the casing and in obtaining or correcting the verticality & straightness of the pump housing/ casing shall be subject to the approval of the Engineer-in-Charge. Centralizers, spacers or other suitable devices shall be attached to the tube-well casing so that it will be cantered in the drill hole throughout its entire length and held in such position while gravel shrouding is being placed. Centralizers shall be attached to the pipe in a manner that ensures that the pipe is accurately cantered in the drill hole. The detailed design of centralizers and the method of attachment to the pipe shall be subject to the approval of the Engineer-in-Charge. Unless otherwise directed centralizers shall be spaced not more than 60 ft. along the overall length of screen and casing assembly.

The Contractor shall install the pump housing casing so that the deviation of its axis from the vertical shall not exceed 4 inches (100 mm) at the bottom of the pump housing casing. Measurements for determination of verticality and straightness of the pump housing casing shall be made by the Contractor in the presence of the Engineer-in-Charge upon completion of the gravel shrouding.

Straightness shall be determined by lowering a section of pipe 40 ft. long or a dummy of the same length to the bottom of the pump housing casing. The minimum diameter of the pipe or dummy shall be 1 inch less than the inside diameter of the pump housing casing. If a dummy is used, it shall consist of a rigid spindle with three cylindrical rings, each ring having a height of at least 12 inches. The rings shall be true cylinders and shall be located at each end and in the centre of the dummy. The central shaft of the dummy shall be rigid so that it will maintain the alignment of the axis of the cylindrical rings. The pump housing casing shall be sufficiently straight so the pipe or dummy can be passed freely throughout the entire length of the pump housing casing. Plumbs, pipes and dummies used in these tests shall be approved by the Engineer-in-Charge.

Any tube-well failing to meet the specified requirements for straightness, verticality and concentricity shall be abandoned, and the Contractor shall construct a new well at his own expense at an alternative site designated by the Engineer-in-Charge.

After completion of installation of the pump housing casing and approval of the installation by the Engineer-in-Charge, the Contractor shall paint the letter and number designation of the tube-well on that portion of the pump housing casing which projects above the ground surface. All paint, brushes, stencils and other materials required shall be furnished by the Contractor. The characters shall not be less than 6 inches shall be painted with lines I inch wide, and shall be positioned on the casing in accordance with the Engineer's instructions.

27.1.3.5 MEASUREMENT

The net length of pipes as laid or fixed, shall be measured in the running metres correct to a cm. specials shall be excluded and enumerated and paid for separately. The portion of the pipe within the collar at the joints shall not be included in the length of pipe work.

27.1.4 GRAVEL SHROUDING

27.1.4.1 GENERAL

Gravel shrouding shall consist of all work required in connection with supply and placing of gravel shrouding in annular space between the walls of the drilled hole and the outside of the pump casing. The work shall include, but not limited to development of source, excavation, stock piling, grading, washing, storing, transporting and placing of' gravel shrouding as specified herein or as directed by the Engineer-in-Charge.

27.1.4.2 GRAVEL SOURCE

The Contractor may obtain gravel from any source or location subject to the approval of the Engineer-in-Charge provided that the gravel meets the requirements of the specifications. The Department will not be responsible for the amount of work involved or the amount of materials wastage in order to obtain the required amount of gravel of proper gradation.

27.1.4.3 SPECIFICATIONS

The gravel shrouding shall be clean, washed, water worn, hard, well rounded of siliceous material, without platty particles, free from gypsum and shale, and under no circumstances shall contain > 5% calcareous material. The gravel supplied shall be subject to inspection and screening in the field to ensure proper gradation suitable to the formation. The gravel shall be reasonably graded and shall conform to the following requirements or as specified by the Engineer-in-Charge.

U.S. Standard Screen Number	Percentage Passing
1 cm (3/8 inches)	100
No. 4	75 – 100
No. 8	35 – 65

No. 14	05 – 30
No. 16	00 – 15
No. 35	00 – 00

27.1.4.4 PLACING OF GRAVEL

Gravel shall be placed at constant rate using tremie pipe, hoppers or other similar devices to provide a continuous and uniform gravel flow so as to minimize segregation of particle sizes. When tremie pipe or hoppers are used, gravel shall be introduced in the annular space between the pump housing and the edge of the hole at two points located 180 degree apart. The tremie pipe, when used, shall be of suitable size and lowered to the bottom of the well on two opposite sides of the bore hole and calculated quantity of gravel .shall be poured in the pipe through a funnel and the pipe shall be raised by 6 ft. (1.80 meters) interval. In all cases water shall be circulated steadily during gravel placement by inserting the drilling rod into pump housing and operating the circulation pump on the drilling rig. The water level in the annular space outside the pump housing shall be maintained at or above natural surface level by return flow from the cutting bit. Temporary casing, if used, shall be carefully withdrawn in 6 ft. to 10 ft. (1.5 m to 3.0 m) interval during placement of gravel shrouding and the gravel shall be introduced so that each stage of the hole above bottom of the casing is completely filled before the casing is withdrawn to the next stage. The process of placement of gravel shrouding and withdrawing the temporary casing shall be continued to the ground level or upto level approved by the Engineer-in-Charge. As guidance the process of shall be continued until the bottom of temporary casing is at least 10 ft. above top of the topmost screen. Above this point temporary casing shall be removed or left at the option of the Contractor provided that no payment shall be made to the Contactor for temporary casing left in place except when it is of new material and is an acceptable substitute for an appropriate length of pump housing casing.

27.1.4.5 MEASUREMENT

Gravel Shrouding Shall be measured in cubic meter correct upto 2 decimal place.

27.1.5 GROUTING OF PUMP HOUSING CASING

27.1.5.1 GENERAL

Grouting of pump housing casing shall cover providing all equipment, labour and doing all work required to seal the annular space between the pump housing casing and the bore hole face by the introduction of grout as specified herein and on the drawings according to procedures approved by the Engineer-in-Charge.

27.1.5.2 MATERIAL

The grouting operation shall be done with 1:2 cement sand mortar. Cement and sand shall conform to the requirements of Section 5 – Plain & Reinforced Concrete.

27.1.5.3 PLACEMENT OF GROUTING MATERIAL

The grout may be placed by either the tremie method or by being pumped into place provided that both the method and the type of grout is approved by the Engineer-in-Charge prior to the start of the operation.

If the tremie method is selected and approved, the grout material shall be placed by tremie pouring, (after water or other drilling fluid has been circulated in the annular space of tremie pipe sufficient to clear obstructions). The tremie method shall be used where there is a minimum annular space of 3 inches (75mm) only between the outer surface of the pump housing pipe and the inside surface of either the external casing or the bore hole. The minimum size of tremie pipe utilized shall be 2 inches (50mm) inside diameter. Where concrete grout is used the minimum size tremie pipe used shall be 3 inches (75mm) inside diameter. When making a tremie pour, the tremie pipe shall be lowered to the bottom of the zone being grouted and raised slowly as the grout material is introduced. The tremie pipe shall be kept full continuously from start to finish of the grouting procedure, with the discharge end of the tremie pipe continuously submerged in the grout until the zone to be grouted is completely filled. The minimum curing time before construction may be resumed is 72 hours.

If the method of grout placement selected and approved is by pumping, the grout shall be injected (after water or other drilling fluid has been circulated in the pumping pipe sufficient to clear obstruction) in the annular space between the inner casing and either the outer casing or the bore hole. The annular space must be minimum of 1 ½ inches (37mm) for sand and cement or neat cement grout, and not less than three times the size of the largest coarse aggregate used. The grout pipe shall extend from the surface to. the. bottom of the zone to be grouted. The grout pipe shall have a minimum inside diameter of 1 inch (25mm) for sand cement or neat cement grout, It shall have a minimum diameter of 1 ½ inches (37mm) for concrete grout.

Grout shall be placed, from bottom to top, in one continuous operation. The grout pipe may be slowly raised as the grout is placed but the discharge end of the grout pipe must be submerged in the emplaced grout at all times until grouting is completed. The grout pipe shall be maintained full, to the surface at all times until the completion of the grouting of the entire specified zone. In the event of interruption in the grouting operation, the bottom of the pipe should be raised above the grout level and should not be re-submerged until all air and water have been displaced from the grout pipe and the pipe flushed with clear water. Curing time before construction may be resumed shall be minimum of 72 hours.

27.1.6 DEVELOPMENT AND TESTING

27.1.6.1 GENERAL

Development and testing shall consist of all work including power supply required in connection with the development of the tube-well to produce the design capacity of sand free water with a minimum drawdown, and the testing of the tube-well to determine the effectiveness of the development operations as specified herein. Development and testing shall include, but not be limited to surging, back washing and pumping the tube-well at higher than rated capacity, testing the tube-well for specific capacity, sand content and degree of development, and disinfection and sealing of the tube-well.

The Contractor shall be required to sound the well to determine wheather excess sand has accumulated at the bottom of the well at the following stages of the work;

a) On completion of the casing and screen installation
b) Before the starting of the development and
c) After completion of development and testing

If it is found at any stage mentioned above that the well contains more than 3 ft. of sand or other material in the bail plug, the Contractor shall clear the well down to a level approximately 3 ft. above the bottom plate of the bail plug. Water obtained in development and testing shall be disposed of by the Contractor in an approved manner.

27.1.6.2 DEVELOPMENT

The development procedure and methods used for development of the tube-well shall be established by the Contractor subject to approval by the Engineer-in-Charge and the development operations shall be witnessed by the Engineer-in-Charge from their initiation to their completion. The Contractor shall maintain a complete record of the development operation and shall make regular periodic measurements of discharge rates, sand content and water level measurements.

The procedures used shall include backwashing and pumping at 1.5 times the rated capacity and may include surging or similar procedures determined by the Contractor. The Contractor shall notify the Engineer-in-Charge following the completion of the 6 hours pumping, period that the tube-well is ready for testing. In wells where bentonite or other formation stabilizing agents are used, the Contractor shall undertake a programme of cleaning the well with phosphates or other dispersing agents in a manner and with chemical dosages as approved by the Engineer-in-Charge prior to starting normal development work.

27.1.6.3 TESTING

The contractor shall test each tube-well under the direction of the Engineer-in-Charge as described herein. Upon completion of the development operations the tube-well shall be permitted to recover for a minimum period of one hour. During this recovery period, the tube-well shall be sounded. If the comparison of the depth by sounding and the length of the casing string indicates that there is more than 6.00 feet of material in the tube-well, it shall be cleaned to within 2.0 feet of the bottom of the casing by bailing.

At the end of the first five minutes of pumping, the sand content of the water shall be determined by using a 40 inches Imhoff cone or other device approved by the Engineer-in-Charge. The sand content of the water at this time shall be less than 100 mg/litre. A second sand content determination shall be made 10 minutes after the start of pumping. The sand content at this time shall be less than 30 mg/l. If the sand content tolerances are exceeded at this time, or at any subsequent time upto the time of final acceptance of the installation, sand content determinations, water level, and discharge measurements during the remainder or the one hour sand test period shall be made as directed by the Engineer-in-Charge.

When the sand test has been satisfactorily completed, the tube-well shall be further developed for 4 hours by surging and backwashing with the test pump at five to ten minute intervals. Following the development period, the tube-well shall again be pumped for a period of one hour during which time the sand test shall be repeated. The specific capacity of the tube-well shall be determined from the water level measurements and flow rates obtained, during the pumping periods. If the specific capacity obtained from the second pump test is found to be more than 10 percent greater than that obtained in the first pump test, the development shall be continued as directed by the Engineer-in-Charge.

Upon satisfactory completion of the above one hour pumping period the tube-well shall be permitted to recover for a period of one hour. Upon the completion of this recovery period, a four hour multiple step pump test shall be performed by pumping the tube-well for one hour at each of approximately four equal increments.

27.1.6.4 SUMMARY

The following is a short summary of the development and testing procedure:

Development	
Development time by air lift Development tool or/and Development by pumping	2 hours (minimum)
Testing	
Recovery	1 hours (minimum)
Pumping Period(Sand Test)	1 hour
Development	3 hours
Pumping period(Retest)	1 hour
Recovery	2hour (minimum)
Step pumping	4 hours (one hour each of the rated capacities 35%, 70%, 105%, & 140%)
Pumping period (Constant discharge test)	2 hours

27.1.6.5 EQUIPMENT

The Contractor shall furnish all necessary equipment for testing the tube-well, including a water lubricated or oil lubricated test pump, a valve for fine adjustment of the discharge, an electric measuring device to determine the drawdown during each stage of the test and Imhoff cones to measure sand content. If oil lubricated test pumps are used, the contractor shall exercise all reasonable precautions to keep the leakage of lubricating oil into the tube-well at a minimum and shall promptly remove all oil which collects on the water surface in the tube-well by the addition of detergents or other suitable chemicals proposed by Contractor and approved by the Engineer-in-Charge and pumping the emulsified oil from the tube-well. In the event the Contractor fails to keep the leakage of oil into the tube-well within acceptable limits or to promptly remove oil accumulations from the tube-well, the Engineer-in-Charge will order the use of oil lubricated test pumps discontinued and the Contractor shall use water lubricated pumps for testing of the tube-wells. The actual depth of setting for the test pump will be determined by the Engineer-in-Charge after the tube-well has been developed. Piping, gauges, orifices, meters, wire boxes or other measuring devices shall be furnished, installed and removed by the Contractor and will remain his property. All measuring devices and testing equipment shall be subject to approval by the Engineer-in-Charge.

27.1.6.6 MEASUREMENT AND DATA

The Contractor shall take drawdown and discharge measurements and other pertinent data during each test at intervals as specified by the Engineer-in-Charge. All such data shall be recorded on forms approved by the Engineer-in-Charge, and the original of such forms shall be delivered to the Engineer-in-Charge at the completion of the development and testing operations.

27.1.6.7 DISINFECTION

After development and testing of the tube-well has been satisfactorily completed, and when approved by the Engineer-in-Charge, the Contractor shall disinfect the tube-well by dispersing chlorine solution throughout the entire depth of the well to obtain a minimum chlorine content of 50 mg/I. The procedure and equipment used to introduce and disperse the chlorine in the tube-well shall be subject to approval by the Engineer-in-Charge.

27.1.6.8 SEALING

Upon completion of the tube-well the Contractor shall seal the tube-well with a ¼ inch thick steel plate cap welded to the pump housing at few points using Arc welding, or by some other method approved by the Engineer-in-Charge. Compliance with this requirement will not relieve the Contractor of his responsibility for the safeguarding of any part of the tube-well completed until the Certificate of Acceptance is issued for the entire tube-well installation.

27.2 TUBE-WELL PUMPING FACILITIES

27.2.1 SCOPE

The work shall consist of furnishing, installing and commissioning deep well turbine pumps involving all mechanical and electrical works and construction of pump houses in accordance with these specifications and in reasonably close conformity with drawings and specifications and as established by the Engineer-in-Charge.

27.2.2 MATERIALS AND CONSTRUCTION REQUIREMENTS

Materials and construction requirements shall conform to those for Civil, Mechanical and Electrical Works.

Depending upon the strata, it is likely that the design of tube-well will require certain changes in the deep-well turbine pumps. Under such a deviation from the provisional design shown on the Drawings, capacity of motor (below or excess of the specified) shall form the 'basis for measurement and payment of such a deviation.

The installation, testing and commissioning of turbine pumps shall be strictly in accordance with the instructions of the manufacturer of such machinery.

27.2.3 CIVIL WORKS

Building for the pump house, fences and gates shall be constructed in accordance with the relevant specifications and Drawings or as directed by the Engineer-in-Charge.

27.2.4 MECHANICAL WORKS

(a) **General**

The work shall consist of providing, installing & commissioning pumps. motors and accessories, furnishing all plant, labour, equipment, appliances and materials, and in performing all operations in connection with mechanical works in strict accordance with the specifications and the applicable drawings and subject to the terms and conditions of the contract. Equipment damaged by the Contractor during the course of installation shall be repaired or replaced by the Contractor at his own expense.

(b) **Approval of Materials and Equipment**

As soon as practicable and within 30 days after receipt of notice to proceed and before any material or equipment is purchased, the Contractor shall submit, for approval by the Engineer-in-Charge a complete schedule, in triplicate, with the names and addresses of the manufacturers and their catalogue cuts, diagrams, drawings, and such other descriptive data as may be required by the Engineer-in-Charge. No consideration will be given to partial lists submitted from time to time. Approval of materials and equipment under this provision shall not be construed as authorizing any deviations from the specifications unless the attention of the Engineer-in-Charge has been directed to the specific deviations.

(c) **Material and Equipment**

Materials and equipment shall conform to the respective specifications and other requirements specified hereinafter and shall be new and unused.

27.2.5 WATER PUMPS

Pumps shall be of the open line shaft water lubricated vertical turbine type for installation and operation in tube-wells and shall be suitable for use with vertical, hollow-shaft, squirrel cage induction type motors. All pumps shall consist of pump bowl assembly, column pipe, line shaft and surface discharge head assembly, including water pre-lubrication system as required and all other parts and appurtenances to provide a complete operating pump in accordance with these specifications.

(a) Design

The material, design, fabrication and assembly of equipment shall be in strict accordance with American Water Works Association Standard A 101-61 Entitled" American Standard for Vertical Turbine Pump", or latest revision and the following requirements:

(i) **General**

Water Pumps shall be vertical shaft centrifugal pumps with rotating impellers and discharge from the. pumping elements coaxial with the shaft. The pumping element shall be suspended by the conductor system which encloses a system of vertical shafting used to transmit power to the impellers, the prime mover being external to the flow stream. The basic pump shall consist of the following three elements:

Pump Bowl Assembly

The pump bowl assembly shall be either a single or multistage, centrifugal vertical pump with discharge coaxial with the shaft.

Column and Shaft Assembly

The column and shaft assembly shall consist of the column pipe which suspends the pumps bowl assembly from the head assembly and serves. as conductor for the fluid from the pump bowl assembly to the discharge head. Contained within the column pipe shall be the line shaft which shall transmit the power from the driver to the pump shaft. The line shaft shall be supported throughout its length by means of bearings which are lubricated with water.

Head Assembly

The head assembly shall consist of the base (from which the column and shaft-assembly and the bowl assembly shall be suspended) the discharge head which directs the fluid into the desired piping system and the driver.

(ii) **The Driver Coupling**

The driver coupling is the mechanism, which transmits the power to the top shaft. It shall contain means for impeller adjustment and provide a bearing to carry the thrust load.

(iii) **Discharge Head**

A cast iron flange shall be integrally cast on the discharge head. The discharge flange shall have a companion flange suitable for connection to the discharge pipe.

(iv) **Motor Mounting Flange**

The motor mounting flanges of pumps shall match the NEMA flanged base plates of motors and base plates of right angle gears.

(b) Manufacture

The pumps shall be those manufactured by M/s KSB or equivalent of the types as specified. The pumps shall be manufactured to meet the characteristics specified on the drawings or as directed by the Engineer-in-Charge.

(i) **Pump Element**

The impellers shall be the enclosed skirt seal type constructed of bronze meeting the requirements of ASTM Standard B 145-61 titled "Leaded Red Brass and Leaded Semi-Red Brass Sand Casting". Impellers shall be accurately fitted, smoothly finished, and dynamically balanced at the normal pump speeds. The bowls shall be constructed of close-grained cast iron. The inside of each bowl shall be hand finished to mirror-like smoothness. Three or four stage pumps as approved by the Engineer-in-Charge shall be supplied by the Contractor. Each suction bowl shall be fitted with a grease-packed bronze bearing and suction case plug. A suction case and collar shall be provided to protect the bearings. Each pump bowl shall have a fluted rubber bearings above each impeller and shall be designed for the future installation of bronze or cast iron wear rings.

Each discharge bowl shall be equipped with a bronze bearing. The pump and line shaft shall be of stainless steel conforming to ASTM Standard A 276-60 entitled Hot-Rolled and Cold-Finished Corrosion Resisting Steel Bars", type 416, and shall be of suitable size to transmit the loads and to maintain correct alignment without distortion or vibration. The pump shaft shall be turned, ground and polished and shall be threaded for connection to the line shaft.

(ii) **Column Pipe and Line Shaft**

The column pipe shall be furnished in interchangeable sections having a normal length of 10 feet. Wall thickness shall be minimum 0.234 inches. . The ends of each column pipe section shall be faced parallel and perpendicular to the axis of the pipe. The threads shall be machined so that adjoining sections of column pipe will butt together to ensure proper alignment on assembly. The line shaft shall be ground carbon steel shafting in accordance with ASTM Standard A 108-61T entitled "Cold Finished Carbon Steel Bars and Shafting" Grade 1020 or 1045 and shall be furnished in interchangeable sections having a nominal length of 10 feet. The ends of the shaft sections shall be faced parallel and perpendicular to the axis of the shaft. Adjoining sections of the line shaft shall be connected by means of threaded, sleeve-type couplings of the same material as shall be supported by fluted, oil resistant, rubber bearings designed to be lubricated by water. The bearings shall be mounted in bronze bearing retainers which shall be threaded into the column couplings and butted against the adjoining section of column pipe. The rubber bearing shall be replaceable within the bronze bearing retainers and shall be spaced at intervals of not more than 10 feet along the line shaft.

(iii) **Surface Discharge Head**

Each surface discharge head shall be of the above ground type and shall be a suitable base for supporting the specified electric motor and the pump column. The discharge head shall be of cast iron conforming to ASTM Standard A 48-62 titled "Standard Specification for Grey Iron Casting" Class 30 A or an approved equal quality of casting. Each surface discharge head shall be furnished with an integral ASA 125 pound flange conforming to ASA B16-1-1948 "Cast Iron Pipe Flanges and Flanged Fittings, Class 125". The discharge heads shall include half couplings connecting to discharge pressure and suction pressure to accommodate gear cooling water lines as required by the gear drive unit.

(iv) **Pre-lubrication System**

The contractor shall furnish a manually operated water pre-lubrication system complete with all valves piping and storage tank for the turbine pump. The piping for pre-lubrication system shall be complete with necessary valves, lines and fittings to permit filling of the pre-lubrication tank from the pump discharge and to permit the water to be manually released prior to starting pump. The pre-lubrication tank shall be an enclosed tank of sufficient size to adequately lubricate the line shaft bearing before pump start-up and shall be equipped with an opening in the top through which it may be filled from the pump discharge or from an outside source.

(c) **Quality Control Tests**

The manufacturer shall perform all the quality control tests as specified hereafter and all test results and anticipated field performance curves shall be submitted in triplicate, to the Engineer-in-Charge.

(i) **Standard Running Test**

The pump bowl assembly shall be operated from zero capacity to the maximum capacity shown on the performance curve submitted with the manufacturer's bid. Readings shall be taken at a minimum of 5 capacity points, including one point within $\pm$ 2% of design capacity specified. The pump shall be operated at a speed within $\pm$ 5% of the design speed.

(ii) **Capacity Measurement Test**

The capacity of the pump shall be measured by means of a standard venturi tube, nozzle orifice plate or pilot tube traverse.

(iii) **Head Measurement Test**

For head measurement in excess of 36 ft. calibrated bourdon or other gauges with equivalent accuracy and reliability shall be used. All gauges shall be calibrated before and after each series of tests.

(iv) **Test for Velocity**

The average velocity in the pump column used to determine the velocity head shall be calculated from dimensions obtained by actual measurement of the pipe and shaft or enclosing tube diameter and the velocity head shall be obtained from actual measurement of the inside diameter of the discharge pipe at the point where the pressure tap is located.

(v) **Horsepower Input Test**

The power input to the pump shall be determined with vertical dynamometer or a calibrated electric motor. Calibrated laboratory type electric motors and transformers shall be used to measure the power input to all motors.

(vi) **Measurement of Speed**

The rotating speed of the pump shall be obtained by a hand counter, electronic computer or a counting slip.

(vii) **Hydrostatic Test**

A standard hydrostatic test on the pump bowl assembly shall be made at 1 ½ times the shutoff head developed by the pump bowl assembly or at twice the rated head, whichever is greater.

27.2.6 MOTORS

a) Pump Motors

The pump motors shall be vertical hollow shaft fan coated totally enclosed weather protected squirrel cage, induction type and shall have 4 poles with approximate speed of 1460 rpm on 400 volts, 3 phase. 50 cycle. The motor horse power for each site shall be indicated in the Bill of Quantities. When operating continuously at full rated load, the temperature rise shall not exceed 40 degree centigrade above an ambient temperature of 50 degree centigrade. The motor shall have a service factor of 1.15 times the rated horsepower and horsepower loadings shall not exceed the name plate at any point on the pump performance curve. The motors shall conform to NEMA Standard MG 1, titled "Motors and Generators" for a class B design and shall have low starting current and normal starting torque. The locked rotor input shall not exceed 5.6 KVA per horsepower. The winding shall have Class B insulation and shall be suitable for operation under conditions of high humidity and at an ambient temperature of 55 degree centigrade. Each motor shall be equipped with three thermal devices embedded and symmetrically spaced in the stator winding. These devices shall operate on temperature rise to de-energize the control circuit of the motor thus disconnecting it from the power source. The thermal devices shall be so located in the winding and so constructed that they will prevent motor damage due to overheating resulting from overload, lack of ventilation, single phasing, stalling, high ambient temperature or Voltage imbalance. The pump motors shall be designed for mounting on the surface discharge, head and for direct connection to the line shaft. A thrust bearing of adequate capacity to carry the weight of all rotating parts, plus the hydraulic thrust shall be provided on each motor. The motors shall be provided with a completed oil or grease lubrication for each bearing. Each motor shall be provided with a non-reverse ratchet to prevent reverse rotation of the pump.

(b) Motor Control

The motor controls for each motor shall consist of motor starter and control switches with all necessary components for a complete installation. Each motor control shall be suitable for controlling and protecting 400 volts. 3 phase 50 c/s electric motor. Motor controls shall be furnished in complete accordance with the applicable provisions of NEMA Standard 1 CI, entitled “Industrial Controls". shall have a minimum insulation level for 600-volt class equipment, and shall be designed to provide short circuit protection in all phases and overload protection in all three phases. The thermal overload relay reset device shall be mounted to be opera table without the necessity of opening the casing. Each motor control shall be furnished complete as a unit with all component parts and accessories completely wired to conform to NEMA Class-II construction, Class-B wiring. The conductor shall be 600 volt. heat resistant, thermoplastic insulated wire suitable for 75' operating temperature. A weather proof enclosure NEMA Type-III with a lockable outer door, shall be provided.

27.2.7 PIPING

Piping for mechanical equipment shall be accomplished as indicated and shall conform to the relevant specification in the following Section 27.3 covering “PIPES, PIPE LAYING AND APPURTENANCE”.

27.2.8 INSTALLATION

Installation shall include all bolts, nuts, washers, shims, fittings, grout and other materials required for proper installation of the equipment which are not supplied as part of the equipment. Equipment damage during the course of installation shall be repaired or replaced by the Contractor at his own expense.

a) Pumps and Motors

The Contractor shall carefully clean, assemble, align and install the pumps in accordance with the manufacturer's recommendations. Care shall be taken that all connections are clean and free from burrs and foreign material so as to ensure tight fit and proper alignment. Connections between adjoining sections of column pipe and line shaft shall be correctly assembled and tightened to maintain accurate alignment. A suitable thread lubricant shall be used on all threaded connection to facilitate disassembly for maintenance. The pumps and motors shall be installed in tube-well in accordance with the manufacturer's instructions. The surface discharge heads shall be accurately set on the concrete pump platforms shown on the drawings and shall be aligned with pump housing casing. The surface discharge heads shall be rigidly connected to the reflux (check) valve and the dresser-type couplings. All the fittings shall be properly installed as shown on the drawings. In order to ensure the accurate and proper alignment of the pump, anchor bolts shall set only after the pump has been set and aligned. Anchor bolt holes may be formed in the concrete platform as the concrete is placed or may be drilled in the concrete after the concrete has set thoroughly. The anchor bolts shall be minimum 5/8 inch diameter and minimum 12 inches long with nut and lock washer, and shall be set in the anchor bolts holes with sufficient extension to permit the fun threads of the nuts to be engaged by the anchor bolt. The anchor bolts shall then be set in cement grout. Where holes are drilled after the concrete has set thoroughly, expansion bolts or lead expansion anchors may be installed at the option of the contractor in lieu of grouting anchor bolts. Non-shrink grout shall be placed under the entire surface of the discharge head to provide proper support for the pump. Non-shrink grout shall conform to the applicable requirements set forth in the Specifications for concrete.

27.2.9 ELECTRICAL WORKS

The work shall consist of furnishing all plant, labour, equipment, appliances, and materials and in performing all operations in connection with the electrical work in strict accordance with the applicable specifications, Section 30 – Electrical Works and the drawings, and subject to the terms and conditions of the Contract Agreement.

27.2.10 CHLORINATION EQUIPMENT

(a) Chlorinator

Chlorinator shall be of vacuum solution feed, manually set cylinder mounted type. Chlorinator shall be capable of meeting requirements of water flows ranging from 1cusecs to 2 cusecs and delivering upto 1 lb/hr. of chlorine gas in solution to give a maximum dosing rate of 2 ppm. The chlorinator shall be supplied complete with all standard accessories and complete in all respects to ensure satisfactory operation.

(b) Chlorinator Accessories

The chlorinator should include among its accessories an injector. a water booster pump with electric controls, a chlorine gas inlet connected via pressure regulating valve, a linear feed rate indicator, a feed rate adjuster, a pressure relief valve, a drain relief valve, and chlorine pressure gauge.

(c) Booster Pump

The Contractor shall supply alongwith each chlorinator a water pump for booster water pressure to meet, requirement of the chlorinator. The pumps shall have adequate pumping capacity and to ensure proper mixing of chlorine and water in the injection assembly of chlorinator. The pumps shall be electrically driven by single phase motor capable of operation on 220 V, 50 hz. with $\pm$ 10% fluctuation in voltage. The pumps shall be supplied complete with suction and delivery isolating valves. check valves, pressure gauge and appropriate starters.

(d) Empty Gas Cylinders

The Contractor shall supply with each chlorinator two 150 lb. empty chlorine cylinder designed and fabricated in accordance with AWWA or A.S.T.M. Specifications or equivalent. The welded seams shall be fully stress relieved after fabrication. A corrosion Allowance of 1/16 inch shall be provided for the design thickness of the cylinders. Material of construction shall be according to ASTM A-515 Grade 60 or ASTM A -285 Grade C or equivalent.

Cylinder shall be provided with matching outlets corresponding to chlorinator offered under this Contract. Each cylinder shall also have a protection cap provided along-with the cylinder.

27.2.11 GUARANTEE

Equipment furnished shall be guaranteed for a period of one year from date of acceptance hereof against defective materials, design, and workmanship or as stated in the Contract. Upon receipt of notice from the Engineer of failure of any part of the guaranteed equipment during the guarantee period, new replacement of part or parts of same trade mark as provided originally shall be furnished promptly by the Contractor at no additional cost to the Department.

a) Operation and maintenance Manual

The Contractor shall furnish 6 copies of an illustrated operation and maintenance manual with each piece of equipment furnished under this section.

b) Spares and Tools

The Contractor shall furnish common spares such as O-rings, bushing, bearing, other similar items and special tools for each piece of equipment furnished under this section for its efficient service for over 3 years period.

27.3 WATER SUPPLY

27.3.1 MATERIALS

27.3.1.1 PIPES

Material of the water supply pipes shall conform to the respective specifications and other requirements specified hereinafter. The pipes shall be new and unused unless otherwise specifically specified or directed by the Engineer-in-Charge. The standard length of pipes of each material as specified shall be used.

a) Polyethylene pipes and Fittings

Polyethylene pipes for supply to underground and overhead tanks complying ISO 4427:1996 & DIN 8074,8075.

Providing, fixing, jointing and testing Polypropylene Random (PPR) pipes of approved make pressure pipe for cold and hot water as per DIN 8077-8078,PN-20 for pipes and DIN 16962,PN-25 for fittings (polyfusion welded joints) inside building including fittings and specials (sockets, tees, elbows, bends, crosses, reducers, adaptor, plugs and union etc.) supported on walls or suspended from roof slab or run in chases including pipe hangers, supports, cutting and making good the chases and holes, complete in all respects.

b) Cast Iron Pipes and Fittings

Cast iron pipes and fittings shall comply with ISO 13-1978 (E) or B.S. 78 for spigot and socket vertically cast pipes, B.S.1211 for spigot and socket spun iron pipes and B.S. 2035 for flanged pipes. (Not to be used in new construction).

c) Asbestos Cement pipes, Fittings and Specials

These shall conform to International Organization for Standardization Recommendation R160 "Asbestos Cement Pressure Pipe and joints" or British Standard Specification 486 "Asbestos Cement Pressure Pipe" or to Pakistan standard specification No. PS. 428 : 1984 of the class capable of withstanding a 400 ft. head test pressure. Short lengths of pipe machined overall shall be used at fittings for tying in the fittings and specials for asbestos cement pipes shall be cast-iron conforming to British Standard Specification 78: PART 2 Fittings: "Cast Iron Spigot and Socket Fittings", Class AV, except that the fittings and specials shall have the shapes, dimensions and tolerance required to fit the asbestos-cement pipes.

Rubber ring shall conform to Pakistan Standard Specification No. PS. 1915: 1987.

(Not to be used in new construction).

d) Galvanized Iron Pipes and Fittings

The galvanized iron pipes shall conform to B.S. 1387 Specifications for "Steel Tubes and Tubular suitable for screwing to B.S. 21 pipe threads" and shall be of medium grade. All screwed pipes and sockets shall conform B.S. 1740. A complete and uniform adherent coating of zinc white will be provided for galvanized iron pipes and fittings.

e) M.S Pipe

All mild steel pipes shall conform to ASTM designation A53, Schedule 40 "Standard Specification for Welded and Stainless Steel Pipes". All pipes shall be internally cement mortars lined and externally bituminous coated. M.S. short pieces shall be flanged at both ends. The flanges shall conform to B.S. 4504, part 3 (PN 16). M.S. pipe pieces shall be externally protected by applying two coats of red oxides (of approved quality) and bituminous coating (grade 10/20) at the rate of 0.4 lb/Sq.ft.

f) Un-plasticized Polyvinyl Chloride Pipe and Fittings

Un-plasticized polyvinyl chloride (uPVC) pipe and fittings if approved by the Engineer-in-Charge shall confirm to BS 3505. The pipes shall be class B. The pipes and fittings shall not be stored directly exposed to sunlight handled or laid in conditions where ambient temperatures may cause distortion or damage. In extreme conditions, pipes and fittings may have to be stored under water.

g) Joints for Un-plasticized Chloride Pipe

Joints for un-plasticized polyvinyl chloride pipe shall be the Z type consisting of a socket with rubber gasket, or approved equal, and assembled in accordance with the pipe manufacture's recommendations.

h) Ductile Iron Pipes and Fittings

Ductile iron pipes shall be made from a suitable spheroid graphite iron centrifugally cast in lined or unlined metal moulds in conformity with the ISO Standard 2531 Class K9 or its equivalent. The pipes shall have spigot and socket ends employing elastomer gaskets for making push-on joint. Pipes with mechanical joints shall be used wherever rigidity is required and shall have flanges with appropriate nuts and bolts and the gasket. Fittings and specials shall be of ductile iron made to match the type and size of pipes. Except tees, all standard fittings shall conform to ISO Standard K12 whereas tees shall conform to K14.

i) Measurement for all types of Pipes

The lengths shall be measured in running metre correct to a cm for the finished work, which shall include pipe and fittings such as bends, tees, elbows reducers, crosses, plugs, sockets, nipples and nuts. All pipes and fittings shall be classified according to their diameters, method of jointing and fixing substance quality and finish. In case of fittings of an equal bore the pipe shall be described as including all cuttings and wastage. In case of fittings of unequal bore the largest bore shall be measured.

27.3.1.2 SLUICE (GATE) VALVE

Valves shall be wedge gate valves conforming to British Standard Specification 5163. Ends of valves shall be suitable for the type of pipe to which the valves will be connected.

MEAUREMENT

As mentioned in Section23

27.3.1.3 CHECK VALVES

Check valve shall comply with the requirements of BS 5153 latest revision for pressure rating of 16 bar. The valve shall be of swing type and shall be of quick acting single door type.

MEAUREMENT

As mentioned in Section23

27.3.1.4 FIRE HYDRANTS

The metal of the fire hydrant shall conform to B.S. 750 and shall be of screw down streamline pattern. The body shall be best quality, closed grain, grey cast iron with spindle of manganese bronze having tensile strength of not less than 11.0 tons per square inch (1.63 kg/mm^2) machined from solid rolled bars, the seating valves and other parts shall be of best quality gun metal with Brinell Hardness No. 80. The direction of closing shall be by clockwise rotation and outlet shall have screwed joint for accommodation 2-1/2" dia hose connection. Inlet flanges of hydrant shall be suitable for jointing with flanges of hydrant bends and tees. All fire hydrants shall be coated with three coats of solution from an approved manufacturer to give a uniform protective coating on cast iron.

MEAUREMENT

As mentioned in Section23

27.3.1.5 SURFACE BOXES

The surface boxes shall be manufactured as per drawings. Cover and frame shall be of cast iron.

27.3.1.6 FERRULES

Brass ferrules of the sizes required shall be provided with M.S straps and cast iron saddles as approved by the Engineer-in-Charge.

27.3.1.7 APPROVAL OF MATERIALS

As soon as practicable but within 30 days after receipt of notice to proceed and before any materials or equipment are purchased, the Contractor shall submit for approval by the Engineer-in-Charge a complete schedule, in triplicate, of materials and equipment to be incorporated in the work, together with the names and addresses of the manufacturers and their catalogue cuts, diagrams, drawings, and such other descriptive data as may be required by the Engineer-in-Charge. No consideration will be given to partial lists submitted from time to time. Approval of materials and equipment under deviations from the specifications shall not be granted unless the attention of the Engineer-in-Charge has been directed to the specific deviations. Laboratory results and certifications, specified or otherwise required, shall be submitted prior to delivery of the material and equipment to site.

27.3.2 INSTALLATION

27.3.2.1 HANDLING

Pipe and accessories shall be handled in such a manner as to ensure their delivery to the trench in sound, un-damaged condition. If any pipe or fitting is damaged, the repair or replacement shall be made by the Contractor at his expenses in a satisfactory manner. No other pipe or material of any kind shall be placed inside of a pipe or fittings. Pipe shall be carried into position and not dragged. The interior of pipe and accessories shall be thoroughly cleaned of foreign matter before being lowered into the trench and shall be kept clean during laying operations by plugging or other approved method. Before installation, the pipe shall be inspected for defects. Material found to be defective before or after laying shall be replaced with sound material at the cost of the Contractor. Rubber gaskets that are not to be installed immediately shall be stored in a cool dark place and protected against the direct rays of the sun.

27.3.2.2 CUTTING OF PIPE

This shall be done in a neat and workman-like manner without damage to the pipe. Unless otherwise authorized by the Engineer-in-Charge or recommended by the manufacturer, cutting shall be done with a mechanical cutter of approved type. Wheel cutters shall be used wherever practicable.

27.3.2.3 LOCATION

Where the location of the water pipe is not clearly defined by dimensions on the Drawings, the water pipe shall be located as directed by the Engineer-in-Charge.

27.3.2.4 EXCAVATION IN TRENCHES AND BACKFILLING

The trenches shall be set out to suit alignment of the pipe lines. The trenches shall be carefully trimmed at sides and bottom of that pipe lines when laid shall rest on the firm bed throughout the length. Shallow joint holes shall be left for the joint, where necessary. Where pipe line is to be laid in plains the depth of cover, i.e., the normal distance from ground level to the top of the pipe be kept at about 800 mm and shall not be less than 750 mm except due to special reasons where the Engineer-in-Charge directs in writing to the contrary.

27.3.2.5 PLACING AND LAYING

Pipe and accessories shall be carefully lowered into the trench by means of derrick ropes, belt slings, or other suitable equipment. Under no circumstances shall any of the water line materials be dropped or dumped into the trench. Care shall be taken to avoid abrasion of the pipe coating. Poles used as levers shall be of wood and shall have broad flat faces to prevent damage to the pipe. Except where necessary in making connections with other lines or authorized by the Engineer-in-Charge pipe shall be laid with the bells facing in the direction of laying. The full length of each section of pipe shall rest solidly upon the pipe bed, with recesses excavated to accommodate bell coupling and joints. Pipe that has the grade or the joint disturbed after laying shall be taken out and re-laid. Pipe shall not be laid in water. The water shall be kept out of the trench until the materials in the joints have hardened or until caulking or joining is completed. When work is not in progress, open ends of pipe, fittings, and valves shall be securely closed so that no trench water, earth, or other substances will enter the pipes or fittings. Where any part of a coating or lining is damaged, the repair shall be made by the Contractor at his expense in a satisfactory manner as approved by the Engineer-in-Charge. Pipes shall be installed in accordance with recommendations of the pipe manufacturer. Pipe ends left for future connections shall be valved, plugged or capped, and anchored, as shown on drawings or as directed, where connections shall be made by using specials and fittings to suit the actual conditions.

27.3.2.6 JOINTING

a) General

The joints shall be in accordance with the recommendations of the manufacturer or as approved by the Engineer-in-Charge.

Connections between different types of pipes and accessories shall be made with transition fittings where recommended by the pipe manufacturer.

b) Cast Iron/ Ductile Iron Pipes and Fittings

The jointing could be any of the following:

Rubber Gasket Joints

Rubber gasket joints may be used for socket and spigot pipes, where called for Rubber gasket joints shall be made using specified rubber gaskets, conforming to PS-428: 1984 and ISO 160-1980 made to fit the applicable socket and spigot pipes. An approved rubber ring lubricant (but not grease), shall be used for joining the pipes. Care shall be taken to avoid contamination of the gasket and lubricated surface, with earth or other undesirable material during installation.

Lead Caulked Joints

The socket joints of the pipes and special castings shall be made with lead and white spun yarn. The joints shall be made by forcing the spigot end of one pipe into the socket end of the preceding one. A gasket of spun yarn being then driven and caulked into the joint keeping the pipes concentric. The gasket shall either be driven in complete rings, or better still a spiral coil of yarn shall be inserted. In the former case, care shall be taken that the joints of the successive rings do not coincide. Each ring shall be packed with a thin steel "yarning" tool and then lightly hand caulked to ensure that the yarn is solidly packed. Short pieces of yarn forming less than a complete ring shall not be used. The yarn shall be caulked to such a depth as to leave clear the following depths measured from the faces of the sockets for the lead joints.

Pipe dia. (cm)	Finished Depth of Lead Joints (mm)
5 to 12.5	40
15, 18	45
20, 23	48
25, 30	50

A jointing ring shall be placed round the barrel and against the face of socket. Molten lead shall be poured in to fill the remainder of the socket. Before making any joint, care shall be taken to remove all thick bituminous material or coal tar from the spigot end and from the inside of the socket. Both shall be thoroughly cleaned and dried before the joint is made after the lead has solidified in the joint, the jointing ring shall be removed and the lead shall be caulked right round the joint to make up for the shrinkage of the molten metal on cooling. The joint shall be set back by caulking, not less than 4 mm inside the face of pipe socket.

Lead Wood Caulked Joints

This type of lead caulking shall be done where it shall be inconvenient or dangerous to use molten lead for joints for example, in cases such as inverted joints or in wet trenches. The spun yarn shall first be inserted and caulked into the socket as described under jointing with molten lead. Lead wool or lead yarn shall then be introduced in the joint in strings not less than 6 mm thick and the caulking repeated with each turn of lead wool. The whole of the lead wool shall be compressed Into a dense mass. The joint shall then be finally finished flush with face of the socket. The lead wool brought to site shall be properly protected and packed with wax paper or polythene sheet, to prevent oxidation.

Flanged Joints

These shall be made using 3 mm rubber insertion jointing discs accurately cut. The bolts of the joints are to be tightened up systematically and uniformly in such a manner that the tension in all the bolts shall be similar and there shall be no tendency to distortion. No bolt shall be stressed beyond its elastic limit.

c) G.I / M.S Pipes and Fittings

Screwed Joints

All screwed joints, both internal and external, shall be examined before jointing, to ensure that the threads are perfect for the full depths of the joints. The jointing shall be such that the ends of pipes or Specials remain equidistant from the middle of the socket and space between them in the centre of the socket is not more than 6 mm. All burrs from the ends of the threaded joints shall be removed.

To make the joints water tight thin strands of best quality country cotton yarn smeared over carefully with genuine Red lead shall be used. A paste of genuine red and white lead mix shall be lightly smeared over the threads to act as a lubricant and to make up for imperfections in the threads when the pipes are screwed up. No red and white lead paste or cotton yarn shall project outside the ends of the joints

Flanged Joints

In the case of pipe lines laid in open country whether in trenches or on the surface, flanged joints shall be provided at intervals of not more than 500 feet. The flanges shall be screwed on to the pipes in the same manner and using the same jointing composition as already described for screwed joints so as to be water tight. All flanges shall be screwed home and the end of the pipe projecting in front of the flange faces shall be neatly cut off, filed and made perfectly smooth and not to project ahead of the faces of the flanges so as not to interfere with the accuracy of the joints. Each flanged joint shall be made by inserting an accurately cut disc of tough multiple rubber insertion about 3 mm thick of approved quality between the flanges. The bolt holes in the rubber insertion as well as in the flanges shall be, drilled to template. The bolts shall be pulled up gradually and evenly so as to ensure a perfect joint. They shall, however, not be over-strained.

d) Asbestos Cement Pipes

Comete Couplings

Comete couplings manufactured in asbestos cement and provided with two jointing rings, one at each end shall be used. The rings shall be supplied by the pipe manufacturer. They shall be lip seal type conforming to P.S-1438, latest version, "Rubber sealing rings for joints in asbestos cement water piping". The joints shall not only withstand internal test pressures but also provide adequate safeguards against seepage of ground water into pipe lines.

Flanged Joints

Gaskets for flanged joints shall conform to the requirements of Standard Specifications for "Sheet Buffer Packing" (ASTM Designation: D 1300-59). Grade No.1, black colour, and thickness of 8 mm.

e) PVC Pipes

The joints in the pipe line shall be "Z" type rubber ringed joints. For jointing with specials like valves, special stub flanges and steel flanges drilled to shape and size of flange on the special fitting will be used. For jointing with CI or asbestos cement pipes special, socketed pieces or spigotted pieces or pieces with stub joints on one end and socket or spigot on the other end shall be used.

Pipes should be jointed outside on the side of trench and then lowered into prepared trench with necessary bedding already in place. Heavy fittings will be jointed in the trench. For achieving reliable and satisfactory installation, factory made fittings must be used and due consideration be given to thermal effect on PVC .and to supporting heavy fittings like valves, independently so that these do not bend or damage the pipe. On hot days the pipe should be allowed to cool off in the trench before being fixed to valves etc., so as to avoid stresses on shrinkage. Hot air in the body of pipe be released through air valves or through taps connected to saddled tappings. Use of 'Z' type joint reduces the risk of shrinkage as it allows movement. Branching shall be done by special welding process, which shall be obtained from the manufacturer and should preferably be done by his crew or by specially trained workers.

Only special jointing solution and other items like rubber rings supplied by the manufacturer shall be used. The solution should be applied uniformly, evenly and thinly. A thick layer will not improve but may weaken the joint. Only tapping saddles made from gun metal and supplied by the manufacturer of pipes will be used for making house connections. End connections with screwed

GI pipes will be made with special socked and screwed connecting pieces obtained from the pipe manufacturer.

27.3.2.7 DEFLECTION

Maximum allowable deflections from a straight line or grade, as required by vertical curves, horizontal curves, or offsets will be 2" for Asbestos Cement Pipe unless otherwise recommended by the manufacturer. If the alignment requires deflections in excess of the specified limitations special bends or a sufficient number of shorter lengths of pipe shall be furnished to provide angular deflections within the limit set-forth, as approved.

27.3.3 MASONRY CHAMBERS FOR SLUICE VALVES,

Valves Fire Hydrants etc.

Masonry chambers shall be constructed according to the drawings or as instructed by the Engineer-in-Charge. The concrete and masonry work shall be according to the provision of the relevant Sections.

27.3.4 SETTING OF FIRE HYDRANTS, VALVES AND SURFACE BOXES

Fire hydrants shall be located and installed, as shown on drawings. Hydrants shall be set plumb and in accordance with the manufacturer's instructions.

Valves and surface boxes shall be installed as shown or directed, and shall be set plumb. Surface shall be centered on the stems or operators. Concrete, concrete pipe, brick, brick ballast used in chambers shall conform to the relevant clause of the Specification. Where feasible, valves or operators shall be located outside the area of roads and streets. Earth fill shall be carefully tamped around each valve box to the satisfaction of Engineer-in-Charge on all sides of the box, or to the undisturbed trench face if less than 4 ft.

Hydrants and valves shall have the interiors cleaned of all foreign matter before installation. Surface boxes shall be lighted and the hydrant or valve shall be inspected in open and closed positions to ensure that all parts are in working condition.

27.3.5 FERRULE CONNECTIONS

Service connections to water mains shall be made either by drilling and tapping the main after the pressure has been shut off, or by use of special tapping apparatus whereby the main can be drilled and tapped and the ferrule introduced while the main is still under pressure. The later method shall be used for trunk mains or in other cases where it would be inconvenient to shut off the water while the connection is being made. In order to make a service connection to an asbestos cement water main, a malleable iron saddle piece with a flat boss shall be first bolted round the main with a rubber washer between the main and the boss. The boss and the pipe shall then be drilled and tapped together, giving a continuous thread through the boss and the wall of the main.

27.3.6 THRUST BLOCKS

Plugs, caps, tees, bends and fire hydrants shall be provided with concrete thrust blocks. Backing shall be placed between solid ground and the hydrant or fitting to be anchored. The area of bearing shall be as shown on the Drawing. The backing shall be so placed that fitting joints shall be accessible for repair. The concrete shall be 2000 psi plain cement concrete.

27.3.7 PIPE BEDDING

Fine sand as pipe bedding material shall be used for A.C. pipe and C.I. fittings. The sand shall be free from clay, site, salts, organic impurities and debris. Approval of pipe bedding materials shall be obtained from the Engineer-in-Charge prior to placing.

27.3.8 PAVEMENT RESTORATION

The Contractor shall restore paved surface which have been cut, as part of the work under the excavation items and at no extra cost to the owner/employer.

27.3.9 FLUSHING

The Contractor shall provide facilities for flushing the line. Water for flushing the line shall be arranged by the Contractor. Flushing of line shall be done section by section. For each valved section of pipeline the Contractor shall make a temporary hose connection between the water pipeline and the pipeline under test. Water shall be pumped into the section flushed. Other arrangements for storing and pumping of water shall be subject to the approval of Engineer-in-Charge. Due precautions shall be taken by the Contractor for the disposal of water. The pipeline shall be flushed by keeping all the branching pipes open. Flushing shall be continued until clean water starts flowing through the other end. Section by section, the entire pipeline shall be flushed at a minimum flushing velocity of 2.5 ft./sec.

27.3.10 LEAKAGE TEST

Flushing of the pipeline shall be followed by a leakage test. The Contractor shall provide facilities for performing the leakage test. Water and pumping facilities shall be provided by the Contractor. Before the testing of pipeline the Contractor shall ensure that concrete backing blocks have been provided where necessary. The test shall be performed only after all concrete work in contact with pipe to be tested has set for a minimum of 24 hours. All joints shall be left exposed. Leakage test shall be performed by keeping the end of the pipeline closed by proper plugs blocked to resist 150 per cent of the working pressure. While filling the line all valves and openings shall be kept open and water shall be filled in slowly. When the pipeline is completely filled with water and all air expelled, water shall be pumped into the pipeline to a minimum pressure of 150 percent of actual working pressure and the test pressure shall be maintained for at least 1 hour. Each and every joint shall be inspected for leaks and for all visible leakage and displacement leakage test shall be performed by the Contractor, for the newly laid pipeline. A measured quantity of water shall be pumped into the pipeline. No piping installation will be accepted until the leakage is equal or less than the number of imperial gallons per hour as determined by the formula:

$$L = 0.00054\ ND / P$$

Where

L = Leakage in Imperial Gallons

N = Number of joints

D = Nominal diameter of pipe in inches

P = Average test pressure (psi) during test

In the event of the pipeline failing the leakage test, the Contractor shall locate and repair the defective pipe, fitting or joint at his expenses. For dewatering the line for repairs the Contractor shall follow the instructions given by the Engineer-in-Charge for disposal of water. After repairs of the line, the Contractor shall retest the line. The line will not be accepted until it passes the leakage test.

27.3.11 RETESTING AFTER BACKFILL

After the pipe trench has been backfilled, the entire length shall be subjected to a leakage test as a whole unit. The Contractor shall repair the line if it fails to pass the leakage test requirements specified hereinbefore. The test shall be repeated and repairs affected until the pipeline passes the leakage test.

27.3.12 PIPELINE DISINFECTION

27.3.12.1 GENERAL

The Contractor shall furnish all equipment, labour and material for the proper disinfection of the pipeline. Disinfection shall be accomplished by chlorination after the lines have been tested for leakage but before they have been connected to the main system. Disinfections of the pipelines shall be done in the presence of the Engineer-in-Charge’s representative with equipment approved by him.

27.3.12.2 CHLORINATION

A chlorine and water mixture shall be supplied by means of a solution feed chlorination device. The chlorine solution shall be applied at one end of the pipeline through a trap, in such a manner that as the pipeline is filled with water, the dosage applied to the water entering the pipe shall be at least (25 ppm) or enough to meet the requirements given hereinafter.

Chlorinated water shall be retained in the pipeline for a period of at least 24 hours. After the chlorine treated water has been retained for the required time, the chlorine residual at the pipe extremities and at such other representative points shall be at least 10 parts per million. This procedure shall be repeated until the required residual chlorine concentration is obtained.

During the process of chlorination the pipeline, all valves or other appurtenances shall be operated while the pipeline is filled with the heavily chlorinated water.

27.3.12.3 BY ADDING CHLORINATED LINE

Chlorinated line is dissolved in water tank and is lead into mains along with water for sufficient to ensure complete freedom from pollution. In general the following amount of chlorinated line for each 3.5 meter length of main will be sufficient.

Diameter of main (mm)	100	150	200	250	300
Chlorinated line in (mm)	10	20	40	60	85
Chlorinated line in table Spoonful	0.5	1	2	3	4

27.3.12.4 BY ADDING BLEACHING POWDER

After the main have passed the pressure test, they shall be thoroughly scoured out; and further to ensure that the pipe system is free from injurious matter, it shall be filled with solution of bleaching powder (calcium hypocholorite) or of permanganate of potash and allowed to remain there for 24 hours. After the period, the system shall again be scoured out and filled with the water of supply main.

27.3.13 FINAL FLUSHING

Following complete disinfection of the pipeline, all treated water shall be thoroughly flushed from the pipeline at its extremities. Treated water and water used for flushing the pipelines shall be disposed of in a manner instructed by the Engineer-in-Charge. Fresh treated water shall be filled in the line and water tested from presence of coliform, the test result should indicate negative coliform presence. If the test indicates any positive coliform, the entire process of disinfection shall be repeated or improved upon until coli form free samples are obtained.

27.3.14 SAMPLING AND TESTING

Disinfection of the pipeline and appurtenances shall be the responsibility of the Contractor. The first set of samples will be collected for analysis by the Engineer-in-Charge. Should the samples reveal presence of coliform the Contractor shall again disinfect the pipeline and appurtenances at his own cost for sampling and testing for subsequent retests until coliform free samples are obtained.

27.3.15 CLEAN - UP

Upon completion of the installation of the water supply lines, distribution system and appurtenances, all debris and surplus materials resulting from the work will be removed and disposed off in a manner satisfactory to the Engineer-in-Charge.

27.3.16 INDICATION PLATES

The indication plates shall be installed in accordance with the drawings and as directed by the Engineer-in-Charge.

27.3.17 WASHOUTS

The design and locations of washouts shall be illustrated on the Drawings to be approved by the Engineer-in-Charge. Exact positioning shall be determined with regard to topography and to the approval of the Engineer-in-Charge. At least 10 ft. of the washout pipe-work, inclusive of the isolating valve, measured from the centre line of the pipeline, shall be laid at the same time as the pipeline and suitably capped to prevent ingress of foreign material. The minimum gradient for the washout pipe-work shall be 1 in 100.

27.4 POLYETHYLENE (PE) PIPES AND PIPE FITTINGS

27.4.1 SCOPE

The work under this section of the specifications includes furnishing all plant, labour, equipment, appliances, materials and in performing all operations required in connection with providing and laying of polyethylene Pipes and Pipe fittings, in accordance with the Contract or as directed by the Engineer and the manufacturer's recommendations.

27.4.2 MATERIALS

27.4.2.1 GENERAL

Materials shall conform to the latest referenced specifications and/or other provisions specified herein. Materials shall be new and unused. In cases where manufacturer are specified, materials shall be of the same manufacturers. In all other cases, the Contractor shall submit the names of the manufacturer from whom he intends to buy. Other information such as diagrams, drawings and descriptive data shall be supplied as desired by the Engineer. Approval of materials under this provision shall not be construed as authorising any deviations from specifications.

27.4.2.2 MANUFACTURING

The material from which the pipe is produced shall consist substantially of polyethylene, to which may be added only those additives that are needed to facilitate the manufacture of the polymer, and production of sound, durable pipe of good surface finish, mechanical strength. None of these additives shall be used separately or together in quantities sufficient to constitute a toxic hazard, or to impair the fabrication of welding properties of the pipe, or to impair its chemical and physical properties.

27.4.2.3 PIPE

Pipes shall conform to International Standards Organisation (ISO) recommendations, I.S.O-4427: and shall be of specified class (SDR 11) capable of withstanding the specified working pressure and test pressure, suitable for jointing with solvent welded joints for small dia. pipes. Fittings shall be conform to ISO BS5114

27.4.2.4 QUALITY

The pipe shall not have any deter mental effect on composition of the water flowing through them. The quantities of any toxic substances extracted from the internal wall, of the pipes shall not exceed the values specified in ISO 4427:1966(E)

27.4.2.5 FITTINGS

Compatable fittings and specials for use with polyethylene Pressure Pipes shall be of the appropriate class and shall conform to International Standard/National standard. Fittings and specials shall have the required shapes, and dimensions of turned ends to fit the polyethlene pressure pipes.

27.4.3 HANDLING AND STORAGE

27.4.3.1 GENERAL

The Contractor shall be responsible for proper handling, as per manufacturers recommendations, of pipes and pipe fittings etc. All the material shall be stacked in accordance with the manufacturer's recommendations at approved places as directed by the Engineer.

27.4.3.2 TRANSPORT

Transportation of pipes shall be done in such a way that they are secure and that no more than an absolute minimum of movement can take place on the vehicle during transit. The same care is needed if pipes are to be transferred from one vehicle to another, how short the final journey may be.

27.4.3.3 OFF-LOADING

Cranes shall be used for off-loadifllg. Whole sequence of operations shall be carried out smoothly and without snatch. Rope or nylon slings, lifting beams with flattened hooks or scissor-dog shall be used. Hooks and dogs shall be well paded to prevent the pipe being damaged and shall be fitted with locking device. Steadying ropes are essential.

27.4.3.4 STORAGE

Pipes, and fittings damaged during handling, transporting or lowering shall be rejected and replaced at the contractor's expense. storage hall be under shade so that all polyethylene pipes &fittings are not exposed to sunlight and extreme heat.

27.4.3.5 STRINGING AND INSPECTION

Stringing, consists of placing pipes on the ground in line ready for laying. Care is again needed to prevent damage during this operation.
The turned ends of all pipes shall be inspected to ensure that they are free from any local irregularities which could affect the water tightness of the joint. All pipe shall also be visually inspected for evidence of impact damage. When such damage is detected, a thorough examination of internal surface in region of the pipe ends shall be made for sign of hair cracks. Damaged pipes, joints, and fittings shall be rejected and replaced at the expense of the Contractor.

27.4.4 JOINTING

Jointing hall be made by butt fusion/socket fusion using plain/socket ended polyethylene fittings except for joining of valves and appurtenances.

27.4.5 LEAKAGE TEST

It shall be in accordance with the specification setforth under 27.3.10

27.4.6 MEASUREMENT

The lengths shall be measured in running metre correct to a cm for the finished work, which shall include pipe and fittings such as bends, tees, elbows reducers, crosses, plugs, sockets, nipples and nuts. All pipes and fittings shall be classified according to their diameters, method of jointing and fixing substance quality and finish. In case of fittings of an equal bore the pipe shall be described as including all cuttings and wastage. In case of fittings of unequal bore the largest bore shall be measured.

27.5 MEASUREMENT AND PAYMENT

27.5.1 COMPOSITE RATE

The measurement and payment for the items of the work of Tube-well & Water Supply hereof shall be made corresponding to the applicable CSR item as provided in Contract Agreement and shall constitute full compensation, for procurements, transportations, performance in all respect and completion of work as specified including the site clearance as approved by the Engineer-in-Charge.

27.5.2 LABOUR RATE

The measurement and payment for the items of the work of Tube-well & Water Supply hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurements transportations, performance in all respect and completion of work as specified including site clearance, as approved by the Engineer-in-Charge except the cost of materials to be provided by Department at designated location as defined in the Contract Agreement.

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IRON STEEL AND ALUMINUM WORKS

28.1 IRON AND STEEL WORKS

28.1.1 SCOPE

This Section covers general requirements of Iron steel, steel work fabrication, methods including precautions for erection of steel structures, painting and other general requirements incidental to steel work, for complete job as shown on the design drawings or as directed by the Engineer-in-Charge.

The applicable requirements of this section as determined by the Engineer- in-Charge shall apply to all Iron and structural steel works. The work covered by this section, consists of supply of all material, labour, plant, equipment and appliances including welding, bolts, nuts, washers, anchor bolts, embedded parts etc., fabrication, erection and painting in accordance with the specifications and as per drawings and as directed by the Engineer-in- Charge.

28.1.2 CODES AND STANDARDS

The work shall conform to the requirements of the following Codes and Standards, unless otherwise specified.

ASTM A-36-81	Structural steel specifications
ASTM A-307-80	Specifications for carbon steel bolts.
BS 729-71	Hot dip galvanized coating on iron and steel articles.
AWS D-12	Recommended Practice for welding steel

28.1.3 SUBMITTALS

Prior to execution of work and sufficiently in advance, the Contractor shall submit the following to the Engineer-in-Charge for approval:

a) Shop Drawings

Shop Drawings, which shall show full construction details, quantities and locations, with metal gauges, reinforcing, cut-outs, holdfasts & attachment to adjacent construction and materials.

b) Samples

Representative samples of a typical metal window and ventilator, hardware, accessories and any other product required.

For metal doors and shutters, cross-sections of typical welded jointed or assembled frame, in specified thickness showing reinforcing, welding and prime paint coat.

c) Methodology

Methodology for fabrication, installation, erection and fixing.

28.1.4 QUALITY ASSURANCE

a) Type and Form of Product

All metal doors, windows, ventilators and shutters shall be the product of reputable manufacturer and. shall be of the type indicated on the Drawings and shall conform to the requirements specified herein.

b) Metal Doors and Shutters

All metal door and shutter frames shall be made of good quality cold rolled steel; exterior frames and doors shall be galvanized steel.

Frames shall be fabricated form locally available hot flush hollow pressed sections, 'Z' section angle, tee and channel or pipe sections as specified in the drawings. Materials shall conform to ASTM-A-36.

All frames shall be secured to the structure with strong wrought iron holdfasts. Holdfast shall be 50 mm wide and 6 mm thick and shall be secured to frames. Attachment shall be concealed.

Shutters shall be double skin made of frames of any of the sections noted above with faceplate of at least 18 S.W.G. or as shown in the drawings.

The internal surfaces of frames and shutter including frame shall be painted with one coat of epoxy primer or as specified.

External surfaces in contact with or embedded in concrete shall not be painted, greased or oiled. However, such surfaces shall be given a cement wash after sandblast cleaning. All other external surfaces shall be given two coats of primer and two coats of epoxy enamel paint or as specified.

Accessories such as hinges, steel standard track, roller and guides, standard bracket, anchors, bolts, locks handles, latches, L--drops, stoppers, hydraulic door closure shall be heavy duty and shall conform to the requirements shown on the drawings or as directed by the Engineer -in-Charge.

c) Metal Window and Ventilators

- Window frame and ventilator sections shall be of mild steel.
- Hinges shall be subject to the approval of the Engineer-in-Charge.
- All operating hardware shall be of bronze lacquered iron as specified.

d) Structural Steel

All structural steel shall conform to the requirements of ASTM A-36 or equivalent.

e) Welding

All welding shall be executed and inspected in accordance with the provisions of the applicable code of the American Welding Society.

f) Bolts

All bolts, including anchor bolts shall conform to the requirements of ASTM A-307 or equivalent.

28.1.5 DOORS AND WINDOWS

28.1.5.1 DELIVERY AND STORAGE

a) Doors shall be packed individually in a manner which will ensure complete protection of all door surfaces and shall be stored in upright position, under cover, in a manner so as to prevent rust and damage.
b) Frames shall be supplied with removable angle spreaders securely fastened to the bottom of each joint. The spreaders shall not be removed until frames are secured in place.
c) Windows shall be delivered in a manner that prevents damages to the units and shall be stored off the ground, under cover, in a manner so as to prevent rust or damage.

28.1.5.2 PRODUCTS – GENERAL REQUIREMENTS

a) All contours and arises in metal door shall be true and sharp as can be produced in the thickness of metal required.

b) Construction joint of steelwork welded to full depth and width, or equivalent splice plates shall be welded on unexposed faces of frames. Exposed surfaces of welded joints shall be dressed and ground smooth to produce invisible connections.

c) Reinforcement and stiffeners shall be welded to the inside of the frame surfaces.

d) Window frames and ventilators shall conform to the sections shown on the detailed Drawings and all corners shall be electrically flash welded and finished smooth.

e) Weather baffles shall be integrally rolled and shall provide contact on all the four sides of the operating ventilators.

f) Weep holes and drips shall be provided for drainage in accordance with Drawings or instructions of Engineer-in-Charge.

g) All windows shall be designed for exterior glazing to accommodate glass thickness specified.

h) Ventilators shall show in or out, as indicated on the Drawings and shall be mounted over heavy steel pivots with brass pins.

i) Push bars for out swinging windows shall be a notched device for fixed settings and designed to lock shutters in open/closed position.

j) In-swinging windows shall be provided with a casement for fastener, designed and arranged to close with wedging erection to draw each leaf firmly into contact with window fixed rail.

k) Windows shall be provided with all necessary clips and anchors required for securing the windows to the structure.

28.1.5.3 FABRICATION OF DOORS AND WINDOWS

a) Shape

The steel sections shall be thoroughly straightened in the shape by methods that will not injure it before being laid off or worked in any way.

b) Cutting and Forming

All members shall be so cut and formed that they can be accurately assembled without being unduly cracked strained or forced into position.

c) Jointing

The jointing of different parts of the members of mild steel shall be carried out by welding process in conformity with the requirements of American Welding Society for such joints. Welding points shall be made quite smooth by filing them and making smooth.

d) Galvanizing

If required all exterior doors frames, anchors reinforcing and related items shall be fabricated from hot dipped galvanized steel, conforming to BS-729, Part-1. After fabrication all welds shall be touched up with liquid zinc.

Window frames and ventilators shall be hot dipped galvanized after fabrication conforming to BS-729 Part-1 as specified.

28.1.5.4 FABRICATION OF ROLLING SHUTTERS

a) Shutters

The shutter shall be fabricated using standard galvanized corrugated segments of the required length according to size of the shutter and of 22 gauge thickness. These segments shall be inter-linked properly to allow rotation for smooth rolling up and down. In order to reduce noise during operation, 2 inch (50 mm) wide wire reinforced canvas belt shall be riveted (using aluminum rivets) to both shutter ends. The aluminum rollers shall be installed at top.

b) Guide

The guides for the shutter shall be fabricated from mild steel plates and shall be embedded to wall or columns by providing necessary anchors.

c) Main Rollers

The main rollers, mounted on the supporting pipe, on which the shutter has to roll up, shall be of mild steel with deep groove ball bearings and provision for greasing.

d) Supporting Shaft

The supporting shaft shall be of standard mild steel pipe, strong enough to support the load of the shutter with minimum deflection. This shaft shall have adequate supports at the ends fabricated from mild steel plates. Each shutter shall have separate bracket supports. However, due to space limitation for mounting, the same may be made common for adjacent shutter.

e) Coil Spring

On each end, between the bracket support and the roller coil, a spring shall be provided. The spring shall be of spring steel one end of which shall be fixed to the pipe and the other to the roller. These springs shall be suitable to balance the weight of the shutter to allow smooth operation.

f) Cover

The cover shall be fabricated from 22 gauge galvanized steel sheet of uniform shape and size without deformations.

28.1.5.5 INSTALLATION

a) Doors, Windows and Ventilators

The Contractor shall be responsible for proper protection and installation of all items furnished. Should the prime coat be damaged, or rust scale appears, he shall at his own expense and at the Engineer-in-Charge's direction, have all exposed surfaces cleaned to bare bright and re-primed with an approved priming coat before finish painting.

All items shall be installed plumb and square and shall be solidly anchored in a good workman-like manner in accordance with the approved Shop Drawings. The Contractor shall be responsible for the protection of installed items from damages by other trades. All items shall be left in operating neat and clean condition free from dirt, finger marks, etc. The Contractor shall be responsible for final cleaning before final acceptance.

b) Wire Gauze

Unless otherwise specified or directed by the Engineer-in-Charge, the wire gauze to be fixed with doors, windows and ventilators shall be 22 gauges having 12x12 mesh and shall be from an approved manufacturer.

c) Shutters

The installation of all components of the shutter shall be done true to line and level and in perfect plumb. It should be ensured that the shutter should roll up automatically after initial manual lifting upto a desired height. The shutter closing should also be easy smooth and unobstructed. The operation shall be performable by a single person.

28.1.5.6 PRIMARY COAT AND FINISHING

a) The non-galvanized doors, windows and ventilators shall be painted with primary coat of red oxide and good quality double boiled linseed oil or any approved anti-corrosion paint after proper grinding. Afterwards two coats of synthetic enamel paint of approved make and shade shall be given.

b) Two coats of red primer and one coat of synthetic enamel paint shall be applied on all components of shutters except galvanized shutter, after fabrication and before installation. One coat of synthetic enamel paint shall be applied to all exposed surfaces after installation. Before applying paint all surfaces shall be cleaned from rust, burrs, scale, dust or grease.

c) The finished work shall be strong and rigid; neat in appearance and free from defects. Plain surfaces shall be smooth and free from warp or buckle. Molded members shall be clean, straight and true. Fastenings shall be concealed where practicable.

d) The painting as specified shall be carried out in accordance with the applicable provisions of Section 17, Painting and Varnishing.

28.1.5.7 MEASUREMENT

a) Shutters

The width and height of shutters shall be measured to the nearest cm. The area shall be calculated in square metre correct to two places of decimal.The rate shall include the cost of materials and labour involved in all the operation described above. Nothing extra shall be paid for cement concrete block or wooden blocks nor anything deducted for these from the measurement of the masonry wall.

b) Rolling Shutter

Clear width and clear height of the opening for rolling shutter shall be measured correct to a mm. The clear distance between the two jambs of the opening shall be clear width and the clear distance between the sill and the soffit (bottom of lintel) of the opening shall be the clear height. The area shall be calculated in square metres correct to two places of decimal. The rate shall include the cost of materials and labour involved in all the operations described above including cost of top cover and spring except ball bearing and mechanical device of chain and crank operation, which shall be paid for separately.

c) T-Iron Doors, Windows and Ventilators Frame

T- iron door windows and ventilator frames shall be measured in running metre, along the centre line of the frame correct to a 1mm and weight calculated on the basis of standard tables. No deduction or extra payment shall be made for making holes and making arrangement for fixing fittings including packing wherever necessary. No deduction will be made for not providing tie bars in case of windows and ventilators.

d) Pressed Steel Door Frames

The length shall be measured in running metre correct to a cm along the centre line of the frames.

e) Items of work for which unit of measurement is Kg in CSR

Doors

The weight of finished section shutters of different sizes, inclusive of all fixed /welded fittings i.e. hinges pivots lugs, brackets striking plates etc, shall be worked out before fixing of shutters (exclusive of weight of glass panes, glazing clips, putty etc.). Sectional weight of steel members only shall be measured without weight of glass panes etc. Any loose fittings such as casement stays/fasteners etc. shall be enumerated and paid for separately.

Unit of measurement shall be Kg and Weight of cleats, brackets, packing pieces bolts nuts, washers distance pieces separators diapharam gussests (taking overall square dimensions) fish plates, etc. shall be added to the weight of respective items unless otherwise specified. No deduction shall be made for skew cuts.

28.1.6 GLAZING

28.1.6.1 APPLICABLE STANDARDS

Latest editions of the following British Standards are relevant to these specifications wherever applicable.

BSI	**British Standards Institution**
952	Glass for glazing
5051	Security glazing Part I & II
CP.152	Glazing

28.1.6.2 GENERAL

a) Each type of glass shall have the manufacturer's label on each pane, and the labels shall remain on the glass until final cleaning.

b) Glazing sealant shall be as recommended by the manufacturer for the particular application.

c) Spacer shims (distance pieces) shall be plasticized polyvinyl chloride (PVC). Thickness shall be equal to space shown on drawings between glass and rebates, bead or cleat. Depth shall give not less than 6mm cover of glazing sealant.
d) Contractor shall submit samples for each type of glass, minimum 100mm x 100mm in size with protective edges. Samples of glazing sealant minimum 0.1 liter of specified types shall be submitted. Samples of minimum of three glass blocks shall also be submitted.
e) Contractor shall submit 300 mm long sample of each type of glazing gasket.
f) Contractor shall also submit printed materials manufacturer's installation instructions for specified glazing glass block gaskets, compounds sealants and accessories including description of required equipment and procedures and precautions to be observed.

28.1.6.3 DELIVERY STORAGE AND HANDLING

a) Contractor shall deliver materials in manufacturer's original, unopened containers clearly labeled with manufacturer's name and address, material, brand, type, class and rating as applicable.

b) Contractor shall store the materials in original unopened containers with labels intact/protected from ground contact and from elements which may damage glass.

c) Contractor shall handle the materials in a manner to prevent breakage of glass and damage to surfaces.

28.1.6.4 MATERIALS

a) General

Glass shall be free from all blemishes, bubbles, distortions and other flaws of any kind and shall be properly cut to fit the rebates so as to have a uniform clearance of 1.6 mm round the panes between the edges of glass and the rebates. All glass shall be best quality from reputable manufacturer as approved by the Engineer-in-Charge.

Unless otherwise indicated glass shall be of the following weight per square metre for various sizes mentioned below:

i) Not exceeding 300 x 350 mm - 4.3 Kg/M.
ii) Exceeding 300 x 350 mm but not exceeding 600x600 mm - 8.0 kg/M.
iii) Exceeding 600 x 600 mm but not exceeding 750x750 mm - 9.0 kg/M.
iv) Exceeding 750 x 750 mm but not exceeding 900x900 mm - 9.8 kg/M.
v) Plate glass 6 mm thick shall be used where size of glass exceeds 900mm either in breadth or in length or in both.

b) Sheet Glass

Sheet glass shall be of thickness and size shown on the Drawings. Each glass shall be bedded with a thin layer of good quality putty as approved by the Engineer-in-Charge and should be fixed with glazing bead securely screwed and finished off neatly.

c) Obscure Glass

Obscure glass shall not be less than 5 mm thick with one side smooth and polished whereas the other side with pattern to be selected by the Engineer-in-Charge, if specified, sheet glass shall be made obscure by grinding off the polish from one side.

d) Plate Glass

Plate glass shall be first quality polished transparent glass, conforming to the applicable requirements of BS 952. Unless otherwise indicated, plate glass shall be 6 mm thick with two surfaces ground smooth and polished so as to give clear undistorted vision and reflection.

f) Wire Reinforced Glass

Wire reinforced glass shall be 6.35 mm thick polished plate reinforced with Georgian wire conforming to the applicable requirements of BS 952.

g) Tinted Glass

The imported tinted glass for doors, windows and ventilators shall be of specified thickness and tint and shall be from a manufacturer as approved by the Engineer-in-Charge. The tinted glass shall comply with the applicable specifications of B.S. 952.

h) Solar Control Film/Glass

The approved Solar Control film shall be applied on all sun-facing glasses of doors and windows as indicated on the Drawings. It shall consist of aluminum vapour coated polyester film with water activated adhesive thereon. Color shall be soft grey. The film shall be optically clear from the inside. Total thickness shall be 0.025 mm to 0.033 mm.

h) Glass Blocks

The glass block shall be of specified size and shall be from a Manufacturer approved by the Engineer-in-Charge.

i) Putty

Putty for wood frames shall be of the best linseed oil conforming to the requirements of BS-544 and for metal frames best metallic putty. Wherever required the putty shall be colored to match with woodwork. The rebates, if not painted, shall be well primed with boiled linseed oil to prevent the wood drawing the oil from the putty.

j) Unbreakable Glazing (Poly Carbonate Sheet)

Unbreakable glazing material shall be LEXAN MR-4000 sheet as manufactured by GE Structural Product or approved equivalent and shall be provided as glazing where shown on the Drawings. It shall have the property of high impact resistance, weather resistance, clarity, 'and durability. It should be attractive and light weight.

28.1.6.5 BEADS AND SHIMS

Glazing beads shall be of deodar wood.

Spacer shims (distance pieces) shall be of plasticized polyvinyl chloride (PVC). Thickness shall be equal to space shown on the Drawings between glass and rebate, bead or cleat. Depth shall give not less than 6 mm cover of putty.

28.1.6.6 GLAZING SEALANTS AND COMPOUNDS

Contractor shall provide material colored to match frame in which glass is installed and only compounds known to be fully compatible with surfaces which they will contact as follows.

1) Two component polysulfide glazing for sealant.
2) One component acrylic glazing for sealant.
3) Acrylic-latex glazing sealant consisting of modified latex rubber and acrylic emulsion, non-hardening, non-staining and non-bleeding.
4) Cleaners, Primers & sealer as recommended by the sealant manufacturer.

28.1.6.7 ACCESSORIES

a) Glazing Sealant

It shall be tape or ribbon of polymerized butyl or mixture of butyl and polyisol butylene compounded with inert fillers and pigments, solvent based, 95 percent solids thread or fabric reinforced, paintable, non-staining.

b) Setting Blocks

It shall be chloroprene (Neoprene) 70 to 90 durometer hardness, compatible with sealant used, channel shaped and of the necessary height for proper perimeter clearance.

c) Channels, Gaskets, and spacer's

It shall be chloroprene (Neoprene), 40 to 50 durometer hardness compatible with sealant used.

28.1.6.8 INSTALLATION OF GLAZING

a) Preparation

All rebates and grooves shall be clean, dry and unobstructed at the time of glazing. The beads shall match the surrounds. Manufacturer's recommendations for the putty, metal surrounds and primer shall be followed.

b) General

All glazing shall be wind and watertight on completion. Edge clearance shall be equal all around each pane, and not less than 3 mm. No void or space shall be left at the back of bedding compound. Surplus bedding compound to top and side edges shall be stripped at an angle to avoid collection of water. Sand blasted glass shall be protected from oil attack by treating edges before fixing, and cleaning surfaces after fixing, as recommended by glass manufacturer.

c) Glass

Glass shall be secured with spring clips or cleats as provided or recommended by the manufacturer. Back-putty shall be of regular thickness, not less than 1.5 mm short of sight line. Surface shall be brushed lightly to seal putty to glass.

d) Fixing

For bead fixing, setting blocks shall be located as required in BS 6262. Spacer shims (distance pieces) shall be used in all external bead fixing and located opposite each other on each side of glass not more than 600mm apart around the perimeter.

e) Control Film

All run-facing glasses shall be washed properly with potable water to render them free from any greasy matter. Solar control film shall be applied on cleaned glass by authorized servicemen for this work as approved by the Engineer-in-Charge. The film shall be applied on the glass before it is fixed at its appropriate place. The film shall be applied with approved adhesive in such a way that no air bubble is left between the glass and film and optical clarity is not affected.

f) Depth of Rebate

The minimum rebate depths will depend upon the area of the pane and block and exposure conditions as under:

For small panes upto 0.372 square metre in area inside buildings or for external panes not exceeding 0.093 square metre, the depth should not be less than 6.3 mm. For linseed oil or metal putty the depth should not be less than 7.9 mm for wood or metal and 9.5 mm for stone brick or similar material. For non-setting compounds, the depths should not be less than 9.5 mm.

The depth of rebate shall be increased for larger panes or for panel which butt together, and for exposed conditions. The increase in rebate shall be as shown on the Drawings or as directed by the Engineer-in-Charge.

28.1.6.9 INSTALLATION OF GLASS BLOCKS

The method and equipment used for transporting the glass blocks and neat white cement paste shall be such as that will not damage the glass block nor delay the mixed paste of white cement. Glass blocks shall be laid as shown in the drawings or as directed by the Engineer-in-Charge. Both Horizontal and vertical joints shall be approximately not more than 1/16” in thickness and. completely filled with white cement paste. Each glass block shall be bedded firmly by tapping with the rubber hammer. All Horizontal and vertical joints shall be parallel to each other. All glass block shall be erected true to line plumb and level. Excess mortar at the outer edges shall be removed with cloth. After completion of days’ work, the glass block wall shall be thoroughly cleaned with water and/or damp cloth as directed by the Engineer-in-Charge.

28.1.6.10 CARE AGAINST DAMAGE

While glazing operation is in progress great care shall be taken to avoid breakage or damage to the glass and adjoining glazing. The Contractor shall make good at his own cost, all glass broken by his workmen while cleaning or carrying out other operations. On the completion of the glazing work, all glass that has been set by the Contractor shall, if it becomes loose, within the maintenance period, be re-fixed at Contractor's expense.

No glazing shall be considered complete until and unless paint and other stains have been removed from the surface of the glass ad checked by the Engineer for water tightness.

28.1.6.11 PROTECTION AND CLEANING OF GLAZING

a) Remove all smears labels and excess glazing sealent. Leave clean inside and outside free from scratches. The Contractor shall be responsible for the protection of installed glass. Before final acceptance, damaged or broken glass shall be removed and replaced with new glass at no additional expense to the Employer.

b) All glass surfaces shall be washed clean both inside and outside within two weeks prior to final acceptance by the Employer

28.1.6.12 MEASUREMENT

The width and height of glass shall be measured to the nearest cm. The area shall be calculated in square metre correct to two places of decimal

28.1.7 MISCELLANEOUS STEEL WORK

28.1.7.1 GENERAL

The work covered shall include furnishing; fabricating, installing and painting

Miscellaneous Steel Work including the following:

- Steel stairs
- Steel Joists, Protection angles and channels
- Steel Grating
- Steel Hand Rail
- Steel Gates
- Embedded plate, anchor bolts and other miscellaneous items

Drawings, material, fabrication, surface preparation shall conform to the applicable requirements of relevant clauses of these specifications. Any proposed deviation due to field conditions and availability of local material shall be submitted to the Engineer-in-Charge for approval a week prior to the start of the work.

a) Steel Stairs

i) General

Structural steel stairs complete with grating treads or checkered plate treads, landings, supporting structures, handrail supports etc. shall be furnished and installed in accordance with working drawings.

ii) Material

Except otherwise indicated in the working drawings, materials shall conform to the requirements of ASTM A36 (specifications for structural steel).

iii) Installation

The stairs shall be installed in a first class workman like manner. Connections to adjacent concrete structures shall be made with anchor bolts or shall be welded to embedded part at site as shown on the drawings. .

b) Steel Joists, Protection Angles and Channels

Steel protection angles joists and channels as shown on drawings and specified shall be erected true to line and level. Steel angles and channels shall be grouted and fixed in position by using anchors as shown on the drawings or as directed by the Engineer-in-Charge.

c) Steel Grating

Steel grating shall conform to the requirement as shown on drawings. All panels shall be banded on the all edges as specified.

d) Steel Hand Rail

Steel Hand Rail shall be fabricated in accordance with the drawing or as directed by the Engineer-in-Charge and shall conform to the applicable requirement of ASTM A53 for the type and class of pipe indicated.

28.1.8 FENCING

28.1.8.1 GENERAL

This work shall consist of constructing post and barbed wire fence or chain link fence in accordance with the details and at the locations shown on the Drawings or as directed by the Engineer-in-Charge.

28.1.8.2 MATERIALS

a) Barbed Wire

Barbed wire shall conform to the requirements of ASTM A-121 Class-1. The barbed wire shall consist of two (2) strands of twelve and a half (12½) gauge wire, twisted with two (2) points, fourteen (14) gauge barbs spaced ten (10) cm apart.

b) Chain Link Fabric

Chain link fabric shall be fabricated from ten (10) gauge galvanized wire conforming to AASHTO M-181 and shall be of the type shown in the Drawings. Before ordering the chain link fabric the Contractor shall submit a sample of the material to the Engineer-in-Charge for his approval.

c) Concrete Posts

Concrete posts shall be made from 1:2:4 (4000 psi – 6”x12” cylinder strength) concrete in accordance with Section 5 – Plain & Reinforced Concrete. The posts shall be cast to the length shown on the detailed drawings and shall have a smooth surface finish.

d) Steel Posts

Steel posts shall be of the section length as specified or as shown on the Drawings. The posts shall be of copper bearing steel and shall confom to the requirements of AASHTO M-183 for the grade specified.

e) Wooden Ballies

The wooden ballies shall be of shisham or kail wood as specified and approved by the Engineer-in-Charge.

f) Steel Reinforcement

Steel reinforcement for the concrete posts shall be deformed steel bars Grade-60 or Grade-40 as specified conforming to the provisions of Section 5 – Plain & Reinforced Concrete.

The Concrete shall comply with provisions of Section 5 – Plain & Reinforced Concrete.

g) Hardware

Nuts, bolts, washers and other associated hardware shall be galvanized after fabrication as specified in ASTM 153.

28.1.8.3 CONSTRUCTION REQUIREMENTS

a) Erection of Posts

The posts shall be erected vertically in position, inside the formwork of the foundation block prior to the placing of the concrete and shall be adequately supported by bracing to prevent movement of the post during the setting process of the concrete. The posts shall be erected to the height and location shown on the Drawings or as directed by the Engineer-in-Charge.

b) Installation of Chain Link Fabric

The chain link fabric shall be set to line and elevation and pulled tight between each post before spot welding or other method of fixing is carried out.

Where splicing of the fabric is necessary or at joints the lapping of the chain link fabric shall be a minimum of ten (10) cm and shall occur only at the concrete post. No horizontal splicing will be permitted. The, fabric shall be fixed to the concrete post as shown on the Drawings.

28.2 ALUMINIUM WORKS

28.2.1 APPLICABLE STANDARDS

Latest editions of following ISO and British Standards are relevant to these Specifications wherever applicable.

ISO (International Organization for Standardization)

6612	Windows & Doors	-	Wind resistance tests
6613	Windows & Door	-	Air permeability test

BSI (British Standard Institution)

1227	Hinges
4873	Aluminum alloy windows

28.2.2 SUBMITTALS

a) General

The Contractor shall in general comply with the provisions of Clause 28.1.3 and 28.1.4.

b) Manufacturer’s Certificate

The Contractor shall on request get certificate signed by the manufacturer stating that each lot has been sampled tested and inspected and has met the requirements in accordance with these specifications and the same shall be furnished to the Engineer-in-Charge.

c) Guarantee

The manufacturer shall furnish his standard written guarantee against leakage of rain water excessive infiltration of dust air and all defects in materials, workmanship covering all the work under this section.

Such guarantee shall be in addition to and not in lieu of all other liabilities which manufacturers and the Contractor may have by law or other provision of the Contract Agreement.

28.2.3 INSPECTION & TESTING

a) Contractor shall arrange tests and analysis if directed by the Engineer- in-Charge of scaled models of each Door, window ventilator type at the maker's works or any laboratory specified by the Engineer-in-Charge for the material supplied by him to be tested in the presence of the Engineer-in-Charge/Inspector to whom test certificates, proof sheets etc. shall be furnished. The models shall be submitted to the Engineer-in-Charge for approval prior to testing. Nevertheless neither the fact that the materials have been tested in the presence of the inspector nor that the Engineer-in-Charge may have been furnished with test certificates in lieu of sending an inspector to the works shall affect the liberty of the Engineer-in-Charge to reject after delivery of materials found not in accordance with these specifications.

b) After approval of shop drawings and tests etc. the Contractor shall submit at his own cost one mock-up sample of each type of aluminum works complete with glazing, all components assembly method and required fittings and accessories prior to the actual fabrication of the bulk. The samples shall be returned to the Contractor for incorporation in the works after installation of at least 80% of the works.

28.2.4 PRODUCT DELIVERY AND STORAGE

a) The Contractor shall deliver doors windows ventilator and louvers in a manner preventing damage to units. The contractor shall store materials off the ground under cover in a manner preventing deterioration or damage.

b) All embedded parts and anchor bolts shall be delivered to the site carefully and keeping the fabricated shape and configuration. All these parts shall be suitably marked for identification.

28.2.5 MATERIAL

a) All the sections used for Doors, windows, ventilators & fly screens shall be of best quality aluminum products such as equal and unequal angles, channels, tubes, corrugated strips mouldings etc; in accordance with international standards conforming to ASTM B-308 & B-221.

b) Frames
The frames of aluminum doors, windows, ventilator, louvers and fly proof shutters shall be formed from rolled, strip or extruded aluminum and be at least 2mm thick deluxe section. Fastenings bolts and screws shall be made from hardened aluminum.

c) Fasteners shall be stainless steel of a type selected to prevent galvanic action with the components fastened.

d) Gaskets shall be vinyl glazing channel gasket according to commercial standard CS-230-60.

e) Hardware as required shall be manufacturer's standard hardware of aluminum, stainless steel or other corrosion resistant materials and shall blend in design with the frame finishes.

f) Joint sealant shall be approved elastomeric.

g) Fittings and fixtures shall be as per approved samples.

28.2.6 FINISHED COATING

a) General
The finished coating shall be as stated on the Drawings and applied strictly in accordance with the manufacturer's instructions.
The color of the coating shall be selected from available ranges if not stated in the drawing and or bill of quantities. The Contractor shall offer samples for approval prior to the final selection and the manufacture of these elements.

b) Anodized coating
The aluminum anodizing shall comply with BS 3987 and be integral color hard coat anodizing 550 kp/mm^2 hardness, minimum 25 microns thick.
The color of anodizing shall be as described on the drawings. Samples of color including limits of color variation shall be submitted to the Engineer-in-Charge for his approval before work commences.
The Engineer-in-Charge reserves the right to reject the products of any supplier who cannot guarantee a reasonable limit of color variation, the acceptable limit of variation being at the Engineer-in-Charge's discretion.

c) Polyester Powder coating
All aluminum sections that are to receive a polyester powder coating shall be given a caustic etch followed by an anodic oxide treatment to obtain an architectural class 1 anodic coating. Anodization should be not less than 25 micron thickness.

All aluminum works shall be finished in colored electrostatic polyester powder coating as per DIN standard 53151, 53153, 53156 or equal and approved to Ral color subject to the Engineer-in-Charge’s approval.

d) Coating Thickness
As and when instructed by the Engineer-in-Charge, the Contractor shall provide certificates from independent laboratories that the minimum thickness as specified has been applied to the aluminum sections. Failure to provide such information shall result in the complete installation being rejected and replaced at the Contractor's expense.

e) Dissimilar Materials
All aluminum surfaces that are to be in contact with cured concrete, mortar, steel and other metals shall have the contact surfaces protected wherever they may entrap moisture or corrosive elements.

Metals that are to be in contact with mortar or concrete shall be protected with a two coat bituminous coating. Prime paint shall be applied to steel parts of anchors, anchor inserts, reinforcement, supports, and all parts after field welding or blotting with zinc chromate. Minimum dry film thickness shall be of 1 mil for zinc chromate.

28.2.7 FABRICATION

a) General

All nuts, bolts, washers and screws used for assembly and fixing shall be of adequate strength for their purpose within the design and shall be stainless steel grade 18/8.

All sealants used in the assembly of, and in the fixing of cladding and window framing, shall be non-setting to allow thermal movement without detriment to those joint sealants used for peripheral caulking and shall be one part silicone sealant and shall conform to BS 4245. All spliced joints between mullions will be sealed with an approved silicone product, compatible with other sealants and packing used. All ironmongery which is to have the same finish as the frames and shall be approved by the Engineer-in-Charge.

At all opening of windows and doors and where there are louvered screens and doors, a fly screen shall be provided to the approval of the Engineer-in-Charge, constructed following the principles & specifications as described elsewhere in this specification.

Glazing sections shall be set in special heat resisting PVC and of channel type. Separate glazing sections on each side of the glass will not be permitted.The following table indicates the basic requirements for window construction. The weights of framing make no allowance for beads, glazing bars, opening light framing, coupling mullions or transoms.

Classification	Min. weight of basic frame kg/m run	Max. superficial area of window in Sq. M.	Max. Dimension either way mm	Remarks
Light	0.60	1	1500	
Light	1.00	3	2000	
Medium	1.50	5	2500	
Medium	2.00	9	3000	
Heavy	2.50	12	3500	
Heavy	3.00	12	3500	With door

b) Sliding Windows and doors

Weather-stripping - high density acrilan wool weather pile shall be used. There should be double brushes at every contact between shutter and frame sections for complete insulation. These should be present consistently throughout the unit between the inside and the outside and no portions without it are permitted.

The rollers for sliding shutters for both windows as well as doors shall be of the adjustable type. The adjusting screws must be accessible in the assembled state of the shutters and a vertical adjustment of 7 mm should be possible.

All sections for sliding windows and doors should be hollow section and the cross section dimensions of the sections should not be less than 60x40mm.

The outer frame must be suitable for accommodating sliding fly screens as required.

The handle-latch set should have all visible surfaces finished as the aluminum sections. The handle must have a proper grip. A small projecting flange or recess in the shutter sections cannot be accepted to serve as handles. The latching mechanism should not be surface mounted but should be concealed within tile sections. Sash rails of vertical sliding windows are to be of tubular box sections with corner joints of outer frames and sashes interlocked, and the balance mechanism is to be an approved proprietary product.

c) Side hung windows, doors and ventilators

All windows and doors should be weather-stripped with heat resistant PVC sections. The weather protection should be achieved by a positive compressive action against the PVC section and should not depend on external contact with the PVC section. At every contact between two profiles two weather-stripping section should be provided to complete weather protection.

The bottom sections for hinged doors must be capable of being adjusted vertically if necessary. The gap between the bottom section and the floor should be covered with a pair of special splay-type PVC sections.

The shutter sections for both windows as well as doors shall be hollow section type and shall be overall size 57 x 45 mm and door sections shall be overall size 81 x 45 mm (including flanges).

The shutters of the windows and doors should be assembled with concealed corners of high rigidity. Hinges should be concealed within the sections.

Hinges shall be anodized aluminum with stainless steel pins and nylon washers. Handles shall be anodized aluminum finished to match the aluminum sections and mounted with self-lubricating nylon washers.

A mortice cylinder rim automatic deadlock of high quality with double pin tumbler Is to be used.

Windows shall have anodized aluminum handles, color as framing and a latching mechanism securing the shutter to the frame both at the top and bottom.

Fitting where required:

d) Single action door closer concealed in the head bar of the outer frame and mounted on an adjacent pivot at the threshold and deadlock fitted.

e) The left hand leaf of double doors with flush bolts at head and sill with deadlock fitted to the right hand leaf.

f) Escape doors to have panic bolt assembly with vertical elements concealed in the stile and door closer as in (a).

g) Fly screens

Fly screens shall be fitted to all opening leaves of windows or sliding doors, consisting of a separate metal sub-frame in with aluminum mesh fly wire. The fly screens shall be adequately secured with suitable dips, set screws or turn buckles and shall be removable for maintenance purposes. Fly screen doors shall consist of similar section to metal casement doors and shall be fitted with removable panels of fly wire.

The aluminum frame .to the fly screen shall be finished to match the framing of the window or sliding door with color and type of mesh to Engineer-in-Charge 's approval.

h) Glazing

The glass shall conform to specification laid down under Section 28.1.6; 'Glazing' and shall be free from all blemishes, bubbles, distortions and other flaws .of any kind and shall be properly cut to size as shown on drawings, so as to fit the grooves in window members. All the glass shall be best quality of approved manufacture or equivalent standard as approved by the Engineer-in-Charge.

28.2.8 ERECTION AND WORKMANSHIP

28.2.8.1 ERECTION

a) Raw plugs and anchoring bolts shall be embedded into the concrete or masonry for holding the doors, windows, ventilators and louvers in their correct position.

b) Care shall be taken to install the doors and windows, ventilators and louvers in line and plumb, solidly anchored in a good workman-like manner in accordance with the Drawings. Should any scale or scratch appear on the surface of doors, windows, ventilators and louvers the Contractor shall at .his own expense and at the Engineer-in-Charge's direction have all exposed surface cleaned to bare bright metal and made good as required.

All joints between structure and the metal shall be fully caulked and painted. All works shall be installed in strict accordance with the manufacturer’s instructions.

28.2.8.2 WORKMANSHIP

The Contractor shall be responsible for the protection and installation of all items furnished. All items shall be installed plumb and square and shall be solidly anchored in a good workmanship like manner in accordance with the manufacturer's instructions and as specified herein. All items shall be left in operating, neat and clean condition, free from dirt, finger marks, cement mortar stains etc. The Contractor shall be responsible for final cleaning before the final acceptance.

The glass panes shall firmly be secured in the rebates with the rubber gasket. Beads and grooves shall be ensured to be clean, dry and unconstructive at the time of glazing. The complete unit shall be airtight and watertight on completion.

No door and window shall be considered complete until the finger prints and other stains and marks have been removed from the surface of glass and aluminum.

Temporary protection shall be achieved by applying water soluble protective coating capable of withstanding the action of mortar.

Protective coating shall be applied in the manufacturer's plant to the exposed surface of all components after removing all fabrication compounds, mixture and dirt accumulations.

28.2.8.3 FINISHING

All exposed surfaces shall be carefully polished and all alloy defects, die marks scratches, strokes or other surface blemishes shall be buffed to a clear surface and given an anodic oxides treatment. The structural shape of aluminium members shall be of uniform quality, color and temper; clean, round, commercially straight and free from injurious defects

28.2.9 PROTECTION AND CLEANING

- Temporary protection shall be achieved by applying water soluble protective coating capable of withstanding the action of mortar.
- Apply coating in the manufacture(s plant to the exposed surfaces of all components.
- Before application of coating, remove all fabrication compounds, moisture and dirt accumulations.

28.2.10 DEFECTIVE WORK

In the event of non-conformance to specifications and drawings the aluminum work shall be rejected by the Engineer-in-Charge and the Contractor shall remove and - replace the rejected works by new work of same specifications.

28.2.11 MEASUREMENT

The height and breadth shall be measured correct to a cm. The height of the Window and Doors shall be measured as the length and breadth from outside to outside of the end . The area shall be calculated in square metres, correct to two places of decimal.

28.3 MEASUREMENT AND PAYMENT

28.3.1 COMPOSITE RATE

The measurement and payment for the items of the work of Iron, Steel and Aluminum Works hereof shall be made corresponding to the applicable CSR item as provided in Contract Agreement and shall constitute full compensation, for procurements, transportations, performance in all respect and completion of work as specified including the site clearance as approved by the Engineer-in-Charge.

28.3.2 LABOUR RATE

The measurement and payment for the items of the work of Iron, Steel and Aluminum Works hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurements transportations, performance in all respect and completion of work as specified including site clearance, as approved by the Engineer-in-Charge except the cost of materials to be provided by Department at designated location as defined in the Contract Agreement.

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29. HORTICULTURE

29.1 GENERAL REQUIREMENTS

29.1.1 SCOPE

Work covered under this section consists of furnishing all labour, equipment and material necessary to perform all operations required for landscaping inclusive but not limited to finished grading, supplying and spreading of soil and manures, turfing, planting/seeding/grass for lawns including supply and installation of tree guards, decorative stones, maintenance period, landscape, warranty, appliances and services necessary for and incidental to completing all the turfing operations and the associated works in a workmanship like manner, according to the provisions of the Contract.

29.1.2 QUALITY ASSURANCE

The work must be undertaken by an experienced contractor specialising in turfing work and other specified activities. Work shall be performed and supervised at all times by qualified personnel.

All materials shall be shipped with certificates of inspection as required by the Engineer-in-Charge. Manufacturer's certified analysis for standard packaged products shall be provided.

29.1.3 SUBMITTALS

The Contractor shall submit catalogue data and literature of manufacturers and suppliers.

The Contractor shall submit manufacturer's certified analysis of all standard products, including soil, fertilisers, peat, seed, inorganic and organic mulches.

The Contractor shall submit a Performance Schedule for plantation of grass and carrying out other works within fourteen (14) days of the start of the Contract. This schedule shall identify the source of procurement of grass for plantation.

The Contractor shall submit a weekly work schedule for approval before work is started. The schedule shall identify tasks to be completed on a weekly basis and the anticipated schedule for completing the tasks. The Contractor will then modify and submit the schedule on a weekly basis identifying tasks completed, tasks to be completed, problems encountered and recommendations.

If ordered a soils report is to be submitted by the Contractor for all soils to be used for preparation of ground. The Contractor shall arrange for an approved independent analyst to prepare a physical and chemical analysis of the soil and irrigation water to be used. The analyst shall also provide recommendations on soil amendment, fertiliser application and the like. The report shall be submitted to the Engineer-in-Charge for approval before soil is placed. In the case of imported soil, the report shall be submitted at least 10 days prior to delivery. The report shall identify the source(s) from which imported soils are to be furnished. At a minimum, the soil shall be analysed for:

a) Total salts (electro-conductivity of soil solution)
b) Soil pH
c) Exchangeable sodium, calcium, magnesium and potassium
d) Available phosphates
e) Organic matter as a percentage
f) Available zinc, manganese, iron and boron
g) Total sulphates

The soil analysis shall also include fertilisers and other amendment requirements and quantities which when incorporated with the soil will provide the required nutrient levels for vigorous plant growth.

Additional soil samples shall be taken at the rate of one in every 20 loads or as directed by the Engineer-in-Charge and analysed. The results will be compared with the original sample to ensure consistency and compatibility of supply.

If specified, an operation and maintenance manual is to be provided by the Contractor. Instructions shall be furnished for year round care of plantation to be followed by the Owner. As a minimum, the manual will include the following:

1 Irrigation details: including water application rates and maintenance procedures
2 Fertilisation: including fertiliser descriptions, application rates and application schedule
3 Salinity control: including leaching methods and leaching program monitoring.
4 Pesticide/fungicide/herbicide applications: including safety application rates, procedures, and schedules.
5 Turf grass management: including mowing procedures, a verification, topdressing, vertical mowing for thatch removal, rolling, over-seeding and springing.
6 General maintenance: including pruning, stakes and ties, replacement and clean-up, protective fencing and grading.
7 Equipment inventory: including maintenance procedures and manufacturer's maintenance manual.
8 Landscape maintenance personnel requirements and job descriptions.

29.1.4 JOB CONDITIONS

The Contractor shall proceed with and complete grass planting operations as rapidly as possible as portions of the Site become available.

No planting shall be carried out during periods of heavy rain, sandstorms, heavy winds, or during intense daytime heat.

When special conditions warrant a variance to the planting time and conditions, a proposed planting schedule shall be submitted to the Engineer-in-Charge for review and approval. In such cases, the planting will be installed at no additional cost and all conditions and obligations such as maintenance and warranty remain the same.

29.2 SOIL

Soil shall be sweet sand or washed marine sand free of admixtures of subsoil, foreign matter, toxic substances, weeds and any material or substance that may be harmful to plant growth. The Contractor shall furnish agricultural soil from approved sites.

Material shall be stored in piles less than 1 metre high. Piles shall be protected from undue compaction and maintained free of contamination and construction debris.

The soil shall comply with the following chemical criteria:

a) pH value: not less than 6.5 nor more than 8.5
b) Electro-conductivity: less than 4 mm mhos/cm saturated extract at 25 oC
c) Free carbonates: less than 0.5 % air dried.
d) Chlorides: less than 200 ppm in saturated extract.
e) Sulphates: less than 200 ppm in saturated extract.
f) Exchangeable sodium: less than 15 % in neutral normal ammonium acetate.
g) Boron: less than 1.5 ppm, hot water soluble.

The soil shall comply with the grading criteria in Table 29.4(a).

Table 29.4(a)

Sieve Size (mm)	% by Pass
5.000	100
2.380	65 to 100
1.180	45 to 100
0.600	35 to 80
0.300	5 to 48

Sieve Size (mm)	% by Pass
0.150	0 to 15
0.075	0 to 3

29.2.1 SOIL CONDITIONERS & FERTILIZER

Peat shall be used where specified. Peat shall be a natural product of sphagnum moss peat/peat humus derived from a fresh water site. Peat shall be shredded and granulated to pass through a 12 mm mesh screen and conditioned in storage piles for at least 6 months after excavation. The peat shall be free from sticks, stones, roots, and other objectionable matter. It shall have a pH value of not less than 4 and nor more than 7.5. The minimum organic content shall be 85% on a dry weight basis. Peat shall be delivered in undamaged commercial bales in air dry condition.

Manure shall be the decomposed animal manure of fully fermented pre-dried cow or chicken manure with minimum nitrogen, phosphoric acid and potassium percentage of 2-2-2 and a pH value of 6.0 to 7.5. Sludge waste product may be used as a substitute subject to approval of the Engineer-in-Charge. Manure and sludge shall be free of stones, sticks and non-bio-degradable material.

Fertilizer shall consist of an approved compound containing not less than

- 10% Nitrogen
- 15% Phosphoric Acid
- 10% Potash
- or similar approved compound

29.2.2 PLANTING SOIL INGREDIENTS

The planting soil in gradients shall consist of approved soil, peat, manure and other soil conditioners as specified. The ingredients shall be placed in sequence as specified to meet the requirements of grass to be planted.

29.3 GRASS PLANTATION (LAWNS)

29.3.1 SITE PREPARATION FOR PLANTING AREAS

i. General Requirements

The Contractor shall examine areas to receive grass plantation with requirements and conditions affecting performance of work in this Section. The Contractor shall not proceed with plant operations until unsatisfactory conditions are discussed with the Engineer-in-Charge and corrected.

The Contractor shall determine the location of above grade and underground utilities and perform work in a manner which will avoid damage to them. Damage to underground utilities shall be repaired at the Contractor's expense.

When conditions detrimental to the growth of grass are encountered, such as rubble, adverse drainage or obstructions, the Contractor shall notify the Engineer-in-Charge prior to planting. The area shall be cleared of stones, pebbles, stubbles, grass roots and other injurious matters and clods shall be broken.

The following pre-planting steps shall be required for building a lawn.

a) Careful grading makes good drainage so that lawn won't puddle and develop spots that are water logged and soft, or hard and dry.
b) Incorporating organic matter and other soil amendments which are needed for proper growth and easy maintenance.
c) Blending of top soil with native soil is done to make a transitional layer between top soil and native soil as it avoids trapping roots in a shallow top soil basin in which they would be dependent on frequent feeding and very frequent watering.

The Engineer-in-Charge shall verify that sub-grades are as specified.

ii. Sub-Surface Grading

All perennial weeds shall be treated with an approved herbicide and the period of time recommended by the manufacturer shall be allowed to elapse prior to commencing grading operations.

Grading operations shall occur when the sub-soil is reasonably dry and workable.

Areas to be graded shall be graded to smooth flowing contours with all minor hollows and ridges removed. Rock projections and boulders shall be removed and disposed of at a location agreed with the Engineer-in-Charge.

Non-cohesive, light subsoil shall be loosened with a 3-tine ripper to a depth of 300 mm at 600 mm centres. Stiff clay and other cohesive subsoil shall be loosened with a single tine ripper to a depth of 450 mm at 1 m centres.

A minimum of 150 mm of approved soil in accordance with 29.2 shall be spread uniformly over the loosened area and incorporated into the sub-grade soil to obtain a uniform and well pulverised soil mix.

The area shall be compacted to a minimum of 90 % of maximum dry density as determined in accordance with Test 13 of BS 1377.

iii. Finished Grading

Grades shall be brought to the finished ground levels agreed with the Engineer-in-Charge to a tolerance of ± 25 mm. Finished ground levels shall be 30 mm below adjoining paving or kerbs after compaction and settlement. Grading shall be carried out in such a manner that even gradients are formed between the spot levels with a pleasant contour. No depressions shall remain which could collect standing water.

Soil shall be placed in lifts not greater than 150 mm in thickness.

The filled area shall be compacted to a minimum of 90% of maximum density as determined in accordance with Test 13 of BS 1377. The manure shall be spread uniformly for the specified thickness.

iv. Scalping Old Lawns

The old lawn contains noxious weed grasses as Bermuda grass and old sod shall be stripped off with flat back spade before building a new lawn. The existing sod shall not be dug into soil as clumps of buried sod.

v. Making the lawn bed smooth

A lawn bed shall be as smooth and flat as possible. However it should have slight pitch, even in flattened garden. Figure on fall of 6 to 12 inches in 100 feet so that water can run off once the root has reached its saturation point.

29.3.2 SEEDING A PREPARED LAWN BED

Divide the amount of seed necessary for the area into four equal portions, so that there are four approaches over the seed bed. Divide the seed bed half by running a string down the middle. Broadcast one quarter portion down each half, spreading it evenly and uniformly within each marked area. Then run the string across the middle of the lawn in the opposite directions and scatter the remaining two quarter portions on the two halves.

Broadcast the seed on the prepared lawn bed while the air is quite. It shall be done with hand or mechanical seeder.

After the seed is broadcast, rake it in lightly to ensure a thorough contact of seed with seed-bed soil. Very lightly brush up the seeded surface with a wire rake using light circular motion so that the seed is dispersed evenly. In case there are concentrated patches, swirl them out lightly into the surrounding area to make an even covering. At this stage, do the cross raking and mulching in flat soled shoes, tennis shoes, or barefooted.

In case of hot dry weather or drying winds, in the 30 days after sowing, apply a thin, moisture holding mulch, over the seed. After seeding and cross raking, put on a 1/8 to 1/16 inch layer of peat moss of screened sawdust that has been aged at last one year. Don't toss it upward so that it falls in piles.

Whatever the covering, roll it smooth with a light roller (empty) after you have applied it. If a peat moss covering is lumpy, chop up the lumps with the back side of a wire rake before rolling.

For initial watering, use adequate length of hose to get all the way around the lawn without dragging across it and a hand sprinkler that throws out a through but gentle spray. An hour a day for 20 to 30 days of watering shall be needed when days are warm and windy, waters 2 to 3 times a day to keep the surface continuously wet and keep the top dark with moisture until all the grasses are up.

If seeds and mulch happens to wash off on to an adjoining paved area, don't attempt to blast them back into place with the spray as it may washout more seeds along the sides of the seedbed.

After the first week, the little seeding will have gained enough stature to take a bending. It is possible at that time, to pull the weeds that come up with the seeds, lay a plank out across the seedbed and walk along it to pull the weeds.

Mow the lawn first time, when the grass is about 2 inches high or when the blades of grass take on a noticeable curvature. Bent grasses that are to be cut at 1 inch height should never be allowed to grow much higher than 1 inch. It is important that the mower be sharp at all times.

29.3.3 SEEDING ON A SLOPE

Lawns can be planted successfully on the ground that slopes upto 15%. If the slope is steeper, a ground cover or a system of terraces would be more satisfactory.

Prepare the seedbed as described in specifications 29.2.2.with following special care;

When racking the seed bed, rake across the slope, when rolling the seed bed, roll it up and down. Burlap or specially manufactured anti-erosion net spread over a newly seeded slope will keep moisture in the ground and prevent seed from washing away. If burlap is of a tight weave, remove it as soon as the grass begun to come up. Anti-erosion net or loose weave burlap can be left in place to vet. Sprinkler system can be used if the slope can be covered with burlap and holes are cut for the sprinklers head. Otherwise water the seedbed by hand, standing at the bottom of the top. Don't use sprinklers for at least two weeks and then run them slowly to avoid puddling or washout.

If erosion is likely to be a problem, install a drain scraper across the top of the slope to carry water off to one side.

Sodding with desired permanent grasses is a good solution where an immediate erosion hazard exists.

29.3.4 SODDING A PREPARED LAWN BED

i. Shipping and Delivery

Prior to shipping the grass to be planted shall be inspected, dug, and made ready for shipping in accordance with standard practices and procedures. The Engineer-in-Charge shall be notified of the delivery schedule in advance so the grass may be inspected upon arrival at the Site.

All unacceptable grass shall be removed from the Site immediately. The Engineer-in-Charge may request inspection at the source prior to delivery of grass to the Site. The Engineer-in-Charge reserves the right to reject any delivery that does not meet the quality requirements.

ii. Storage

Grass shall be installed as soon as possible after delivery to the Site. Grass shall be protected from exposure to wind and direct sunlight prior to installation. Grass not installed on the day of arrival shall be stored in shaded areas, protected from the wind and maintained and watered to good horticultural standards until planted. Care shall be taken to ensure that the grass does not dry out.

Seed and fertilisers shall be kept in dry storage away from contaminants in areas as designated or approved by the Engineer-in-Charge.

Soil, compost, fertilisers and other amendments shall be delivered to the Site and stored separately in approved locations and in a manner to avoid contamination and wetting until soil mixing operations commence.

iii. Procedure

Unroll the sod on prepared soil, lay the strips parallel with the strips staggered as in the brick layer running bond patterns. Press each successively laid strip snugly up against the one next to it.

After the sod strips are all laid in this fashion, roll the sod with roller half filled with water to smooth out rough spots and bond the sod with soil.

Now water a little more carefully than usual for a few days till the grass is set.

29.3.5 SPRINGING OR PLANTING GRASS ROOTS

i. Grass Materials

Grass sprigs shall be provided as healthy living stems stolons or rhizomes with attached roots including two to three nodes. They shall be 5 to 15 mm long without adhering soil. The limitation of time between harvesting and planting of sprigs shall be 24 hours. Sprigs shall be obtained from heavy and dense turf, free from weeds. Sprigs that have been exposed to heat and excessive drying will be rejected. Sprigs shall be planted at 150 mm apart in both directions.

Grass seed shall be the latest season's crop and shall be delivered in original sealed packages bearing the producer's guaranteed analysis for percentage of mixtures, purity, weed seed content, and inert material. Seed that has become wet, mouldy, or otherwise damaged will not be acceptable.

On-site seeding shall be done in the presence of the Engineer. The seed mixture shall be sown at the rate of 35 g/m2. Grass seed mixtures shall be listed by schedule with information as follows:

a) botanical name
b) common name
c) proportion by weight
d) minimum percentage of pure seed
e) minimum percentage of germination
f) maximum percentage of weed seed

Turf shall be strongly rooted, not less than 2 years old, free of weeds and undesirable native grass. Only turf that is capable of vigorous growth and development when laid shall be used.

Turf shall be of a uniform size in width and length. Broken pads or pads with uneven ends will not be acceptable.

ii. Grass Sowing

(i) The soil shall be suitably moistened and then the operation of planting grass shall be commenced. The grass shall be dibbled at 10 cm, 7.5 cm, 5 cm apart in any direction or other spacing as specified to a depth of 15 cm. Dead grass and weeded shall not be planted. The Contractor shall be responsible for watering and maintenance of levels and the lawn for 30 days or till the grass forms a thick lawn free from weeded and fit for mowing whichever is later.

Generally planting in other direction at 15 cm, 10 cm, spacing is done in the case of large open spaces, at 7.5 cm spacing in residential lawn and at 5cm spacing for Tennis Court and sports ground lawn.

(ii) During the maintenance period, any irregularities arising in ground levels due to watering or due to trampling by labour, or due to cattle straying thereon, shall be constantly made up to the proper levels with earth as available or brought from outside as necessary Constant watch shall be maintained to ensure that dead patches are replanted and weeds are removed.

29.4 IRRIGATION WATER

29.4.1 SALT CONTENTS

Irrigation water shall be provided by the Contractor from a source approved by the Engineer-in-Charge as being suitable for irrigation. Water shall be free from substances harmful to plant life. Water sources shall not exceed the following parameters:

a) pH : 6 to 7
b) total dissolved solids : less than 1000 ppm

29.4.2 CAPACITY

Each soil type has its own water holding capacity. The larger the sol particles, the less will be its water holding capacity.

Here is the capacity of 100 square feet of soil, 1 feet deep

i) In Sand - 60 Gal. = 1" deep irrigation

ii) In Loam - 60 Gal. = 1-1/2" deep irrigation

iii) In Clay - 160 Gal. = 2-1/2" deep irrigation

Obviously the lighter soil must be watered more frequently than the heavy soil in order to keep moisture in it. In good deep soil grass roots will go down to from 24 to 30 inches, depending upon the type of grass, its age (a lawn root system goes deepest during the first year or two), and how the soil is watered. The root depth is however limited if the top soil is under laid with a layer of soil that is impervious to water.

29.4.3 RATES OF WATER LOSS

The average water loss in mild summer areas is about 1 inch of water each week. In the hot localities, especially when a dry wind is blowing, the weekly loss increases to 2 inches and more in a week.

29.4.4 HOW DEEP DOES THE WATER GO

In dry soil one inch of water will penetrate as follows:

i) In Sand - 12"

ii) In Loam - 6"

iii) In Clay - 4" to - 5"

Water does not move down through soil until each soil particle has its film of water. After each particle has its quota, the additional water is free to move on the external particle. How deep one inch of water will penetrate depends on the moisture in the soil when water is applied.

For example an open field with a clay soil that was completely dried out by the time of a rain, had to receive 10 inches of rain before it becomes wet to a depth of 3 feet. But an added inch of water would penetrate 3 feet and more if the first were saturated.

29.4.5 INTERVALS FOR WATERING OF LAWN

Alternate wetting and partial drying out of soil, encourage healthier plant growth and deeper rooting in hot summer areas.

Normally the soils would need more than 1" deep irrigation every week depending upon the penetration, aeration and the wilting coefficient of soil. Deep watering once a week shall be preferable which is however practicable only in canal irrigated area. In other areas light irrigation is resorted every 2nd or 3rd day or daily sprinkling.

29.5 LAWN MAINTENANCE DURING PLANT ESTABLISHMENT PERIOD

The Contractor shall be responsible for maintenance of lawn as specified. Maintenance shall consist of watering, fertilising, weeding, mowing, trimming and other operations as required to establish a smooth acceptable lawn free of eroded or bare areas. If required, the Contractor shall apply maintenance fertiliser after the second mowing. Any additional fertiliser shall be added when grass is dry. After application of the fertiliser, the area shall be watered well

The Contractor shall maintain lawns for not less than the period stated below and longer as required to establish an acceptable lawn.

Seeded lawn areas shall be maintained through three (3) maintenance cuttings but not less than sixty (60) days after substantial completion.

Sprigged and turfed lawn areas shall be maintained through two (2) maintenance cuttings but not less than thirty (30) days after substantial completion.

29.6 FINAL ACCEPTANCE

Prior to the completion of the plant establishment period, a preliminary inspection shall be undertaken by the Engineer-in-Charge. The time for this inspection shall be established in writing.

The plant establishment and warranty period will end with this inspection provided the grass is growing in healthy condition. The Contractor shall repair any damages and defective turf shall be replaced. Replaced plants will be of the same size and species as originally specified.

A final inspection, if required, shall be undertaken by the Engineer-in-Charge to determine that the deficiencies noted in the preliminary inspection have been corrected. The time for this inspection shall be established in writing.

29.7 DECORATIVE BOULDERS

The stone boulders for placement in lawns shall be of size and shape as specified. The stones shall be of quartzite from river gravel limestone, sandstone from quarry as approved by the Engineer-in-Charge. Stones shall be hard sound durable and free from weathering and defects and patches of loose or soft materials that may adversely affect strength and appearance.

The stones shall be placed in lawn as specified. The procurement shall be on the basis of sample stones presented by Contractor and approved by the Engineer-in-Charge.

29.8 TREE GUARDS

29.8.1 GENERAL

Tree guard shall be as specified and approved by the Engineer-in-Charge.

29.8.2 BITUMEN DRUMS GUARDS

Bitumen Drum shall be free of damage or any weathering. The drums shall be perforated as specified and painted with alternate lines of black/white enamel paint of an approved brand.

29.8.3 RCC GUARDS

RCC guards shall be of specified sizes and shape and produced complying with the requirements of Section 5 – Plain and Reinforced Concrete. The guards shall be given three inside and outside white washing coats complying with the provisions of Clause 15.3 – White Washing of Section Finishing. The guards shall be cast to the length shown on drawings and shall have a smooth surface.

29.8.4 SOLID BLOCK MASONRY GUARDS

Solid Block Masonry Blocky Guards for trees shall be of Block Masonry for the size and shape as specified with perforations as shown. The Block masonry shall comply with the provisions of Section – 9 Block Masonry. In general the perforations shall be 33% of the surface area of guards. The foundation shall be of 1:2:4 Plain Concrete as shown in Drawings complying with the requirements of Section 5 – Plain & Reinforced Concrete.

29.8.5 BRICK MASONRY GUARDS

The Brick Masonry Guards for trees shall be of size and shape as shown on Drawings complying with provisions of Section 11 – Brickwork. The white washing shall comply with applicable provisions of Section 15 – Finishes.

29.8.6 STEEL FRAME TREE GUARD

Steel frame Tree Guard shall be of size and shape as specified made of ASTMA-36 steel sections. The members shall be framed by welding according to AWS Code as specified using AWS

7016/7018 electrodes. The tree guards shall be given two coats of enamel paint over a primer as specified in accordance with applicable provisions of Section 15 – Finishes.

29.8.7 G.I. BARBED WIRE

GI barbed wire where specified shall be fixed as shown on Drawings. The work shall comply with applicable provisions of Sub-Section 28.1.7 under - Iron Steel & Aluminium Works.

29.9 MEASUREMENT AND PAYMENT

29.9.1 COMPOSITE RATE

The measurement and payment for the items of the work of horticulture hereof shall be made corresponding to the applicable CSR item as provided in Contract Agreement and shall constitute full compensation, for procurements, transportations, performance in all respect and completion of work as specified including the site clearance as approved by the Engineer-in-Charge.

29.9.2 LABOUR RATE

The measurement and payment for the items of the work of horticulture hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurements transportations, performance in all respect and completion of work as specified including site clearance, as approved by the Engineer-in-Charge except the cost of materials to be provided by Department at designated location as defined in the Contract Agreement.

ANNEXURE - A

DEFINITION OF SOILS

Soils can be considered a three-phase system of solids, liquids, and gases. The solid phase consists of mineral and organic particles separated by a network of pores, some filled with gases-air with its carbon dioxide and oxygen being most important-and others filled with water. The proportions of each phase vary with the type of soil and are further modified by time, environment, and human, plant, and animal activities.

GENESIS OF SOILS

The lithosphere, the solidified crust of the earth, currently is exposed over aquarter of the surface of the earth, with the remaining three quarters covered by water or ice. Oxygen, silicon, aluminum, calcium, sodium, potassium, and magnesium are the most abundant elements in the crust, accounting for about 90 percent of the lithosphere, although over 80 elements combined into 2000 compounds are present, The rocky crust, the parent rock for soil formation, is slowly fragmented into smaller pieces and into individual minerals by the action of wind, water, ice, and temperature changes. These fragments are altered by mechanical and chemical processes, mixed with organic materials, and changed by biological processes to form the extremely variable substance we can call soil. Rates of soil formation from rock vary not only with the nature of the parent rock, but also with time. Many soils are, on a geological scale, very young and are still being developed. Depending on climatic conditions, the nature of the parent rocks, and a host of biotic factors.soil formation may be measured in eons, in centuries, or in decades. The establishment of a new home ·garden can be an example of soil formation within a few years.

The type of parent rock is of major importance in the type of soils developed in a particular location. Sedimentary rocks produce soils that tend to be neutral or slightly alkaline, while soils formed above igneous granites are usually more acidic.

PHYSICAL PROPERTIES

Texture

Many of the horticultural characteristics of soils depend upon the relative size of the mineral particles, termed texture; Texture is determined by the proportions of sand, silt, and clay that make up the soil. Sand is composed of compounds of silicon, primarily silicon oxides or quartz, Sand particles are comparatively large with a low surface-to-volume ratio (Table A.1).Because particles may be large and irregularly shaped, there can be a large volume of space between the grains. Water enters easily, but passes out just as easily, so sand has little water-holding capacity. The large space between particles also means that sand has low cohesiveness. Sand tends to hold low amounts of plant nutrients.

Silt is chemically heterogeneous, composed of particles of whatever the parent rock was. Being smaller in particle size than sand, water-holding capacity is higher because the space between the individual particles is smaller. Silts have moderate to high level s of nutrients with low to moderate cohesiveness.

Clay particles are very small, with a high surface-to-volume ratio. Water- holding capacity is high, space between the particles may be almost nonexistent, and there is great cohesiveness of the particles. Many clays are composed of aluminum compounds, although other minerals are involved. Clays may be rich in nutrients. The minerals bound to clay may not always be available to plants because they may be tightly bound by electrostatic charges to the surface of the particles. Clays are separated into two major groups, those that swell when wet (and shrink when dry) and those that rarely swell. Swelling clays are usually composed of finer particles that play important roles in nutrient retention and soil cohesiveness.

Table A-1

Size Classification of Mineral Soil Particles According to the U.S. Department of Agriculture systems

Particle Name	Diameter (mm)	Particles per gram	Surface Area (cm2/g)
Boulder	Over 250		
Cobble	250-60		
Pebble	60-4		
Gravel	4-2		
Fine Gravel	2-1	100	10
Coarse Sand	1.0-0.5	700	25
Medium Sand	0.50 -0.25	6,000	50
Fine Sand	0.25 –0.1	50,000	100
Very Fine Sand	0.1 – 0.05	700,000	200
Silt	0.05 – 0.002	6,000,000	500
Clay	Less than 0.002	90,000,000,000	8,000,000

Fewsoils are composed of only one particle type, but are mixtures at all three plus organic matter. Several methods are available for determining the ratios among particle groups and when the proportions are plotted on a textural triangle (Figure A-1), mineral soils can be classified in horticultural terms. Textural analyses refer to the soils in the upper meter (39 in.) of the soil, that region in which most plant roots grow.

Horticultural soils can also be classified simply by their feel. A handful of soil is mixed with water to the consistency of putty and squeezed into a ribbon between thumb and fingers. The ribbon that forms is related primarily to the clay content of the soil. If clay makes up more than 45 to 50 percent of the soil.the ribbon will be long and flexible due to the high cohesiveness of clay. Failure to form a ribbon indicates a soil with a high proportion of silt, and a gritty feel suggests that the sand content is high. Ribbons that start to form but then beak are indicative of silty loams.

The formal designation of soil textures indicates the coarseness or fineness of soils, but not whether they are, in common terminology, heavy or light. These terms refer more to the ease of working or tilling soils than to texture, although heavy soils are almost always high in clay (when they aren't excessively stony).

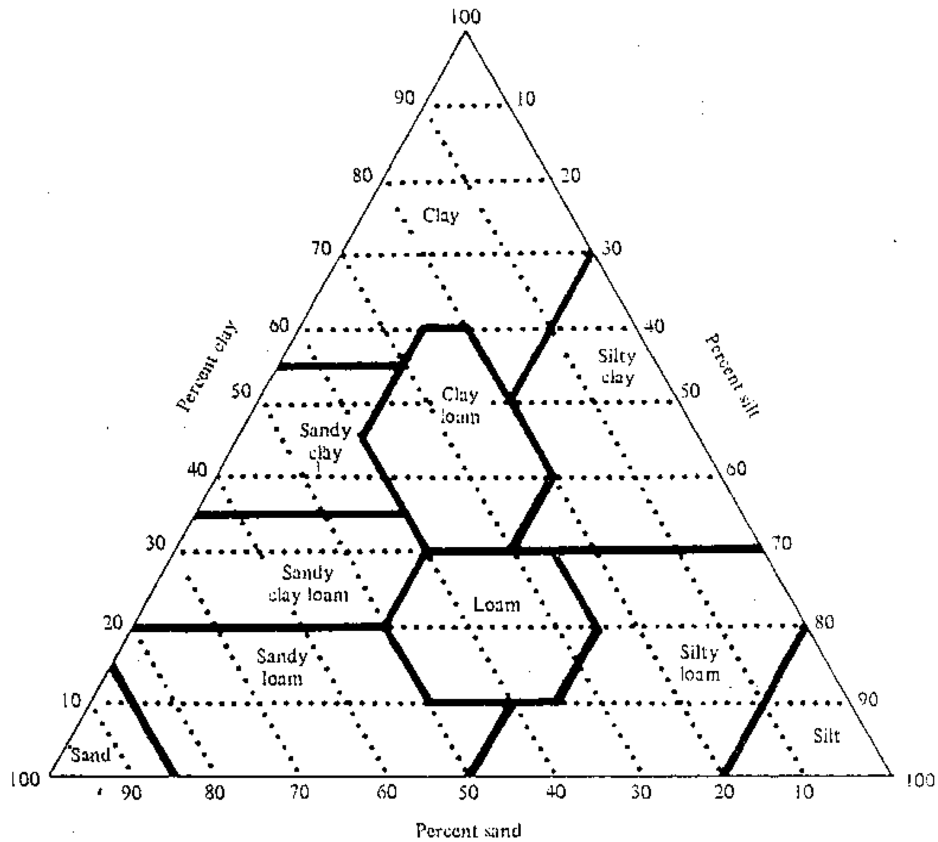

Fig A-1 Soil Texture Triangle

Pore space is usually determined by measuring the bulk density of the soil. Commonly expressed as the weight of oven-dry soil divided by the volume of oven-dry soil, or grams per cubic centimeter (g/cm3), soils with low bulk densities have large pore space volumes. A good horticultural soil will have a bulk density of 1.0 to 1.5 g/cm3 and a pore spacefraction of 0.4 to 0.6 (i.e., close to one-half of the total soil volume is pore space). The bulk density of heavy clay soils ranges from 1.0 to 3.0 g/cm3 and tillable silty loams range from 1.6 to 1.9 g/cm3.

WATER RELATIONS

From a plant's point of view, the soil in which it grows provides anchorage for its roots, a supply of air, and is the source of water and nutrients. The role of nutrients and of water in plant development is discussed later, but it is useful here to examine some of the water relations of soils. Water can exist in soils in all three physical phases, solid (ice), liquid, and vapor. Ice plays an important role in fragmenting rocks during soil genesis, and liquid and gaseous water are both involved in water retention, water movement through soil, and water uptake by plants. It should be remembered that soil water always contains dissolved minerals and gases. This soil solution is taken up by plants and is the source of minerals required by plants.

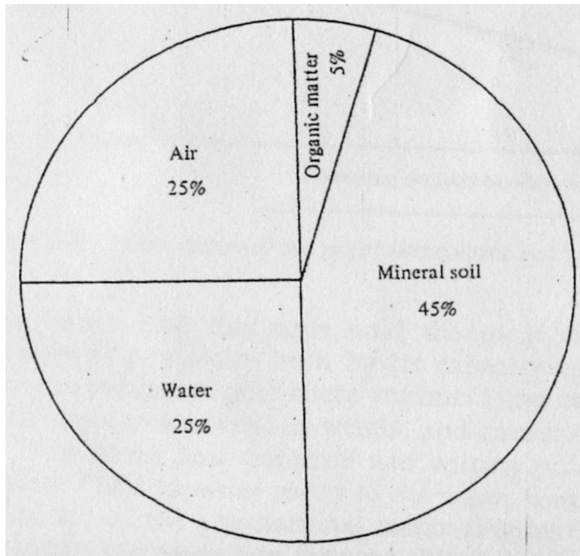

Fig A-2 Proportion of Soil Constituents

CHEMICAL PROPERTIES

Water, H20 or HOH, dissociates into two electrically charged particles or ions, one hydrogen ion (H+) and one hydro1tide ion (OH-). In pure water the number' of ions is very small relative to the number of un-dissociated molecules. One water molecule in over 500 million is dissociated; 1.0 mole of pure water (18 g) contains only 0.000001 moles of each ion, a number conveniently expressed as an exponential, 1 x 10-7.

Because of the difficulty of dealing with extremely small numbers, the concentration or activity of the hydrogen ions is given on a pH scale defined as:

$$pH = -\log [W]$$

For pure water, the pH can be calculated as follows:

$$pH = \log (1/0.0000001) = \log 10{,}000{,}000 = 7$$

Since a log scale is used, a full unit change in pH is a 10-fold change in the concentration of a hydrogen ion (Table A-2).

Water in soils is not pure, but contains many Inorganic and organic chemicals that supply hydrogen or hydroxide ions which contribute to the total concentration of these ions in solution. The addition of hydrochloric acid (H+Cl-), for example, supplies additional hydrogen ions; the pH of the solution decreases as the concentration of H+ increases. When an alkali such as sodium hydroxide (Na+OH-) is added, some ofthe OH- combines with H- present in the solution to form water, and the pH increases as the number of H+ ions decreases. Soils at pH 7 are neutral in reaction (having an equal number of H+ and OH- ions) soils with pH values below 7 are acidic and those with pH values above are alkaline. In plant science, soils with H values from ph 6.5 to 7.5 are considered neutral.Acid soil range from ph6.5 to 4.0 and alkaline soils from 7.5 to 8.5. Soils with values below 3.5 or above 8.5 very rarely show good productivity.

The pH reaction of soils depends on many factors. Soils in areas of high rainfall tend to be more acidic than those of dry areas because alkaline components-sodium. potassium, calcium, and magnesium-are relatively easily leached. Soils witha high aluminum content or those formed from granitic parent rock are acidic, while those formed from limestone with a high calcium component are alkaline.

Table A-2

Hydrogen Ion Concentration and pH

H+ (moles/l)	pH	Soil Reaction	Substance With given pH	Soil types
10	0		Battery acid	
10-1	1			
10-2	2		Vinegar	
10-3	3	Acid toxicity	Lemon juice	Acidic peats
10-4	4	Very acidic	Orange juice	
10-5	5	Strongly acidic	Boric acid	Rainy region
10-6	6	Mildly acidic	Milk	Agriculture Horticulture
10-7	7	Neutral	Pure water	
10-8	8	Mildly alkaline	Sea water	
10-9	9	Strongly alkaline	Laundry soap	Arid region
10-10	10	Alkali toxicity	Laundry bleach	
10-11	11			
10-12	12		Ammonia	
10-13	13		Lye solution	
10-14				

Table A-3

Horticulture Soils Grouped Ph

Group	pH range	Type	Optimum for Representative plants
Medacid	4.0-5.5	Very low calcium_ Swamplands	Orchids, beets, heath family, swamp and mountain plants
Subacid	5.5-6.0	Low calcium___ Abandoned fields, uplands	Cereal grains, maples, woodland flowers
Minacid	6.0-7.0	Moderate calcium__ Garden loams, meadowlands	Most vegetables and ornamentals, lawn grass
Circumneutral	6.5-8.0	High calcium__ semitropical	Most fruits and nuts trees, food and forage legumes, asparagus

SALINITY AND SODICITY

Independent of the chemical nature of the compounds involved, soils that- contain high concentrations of salts present problems to the grower. By definition, soils in which more than 15 percent of the total cation exchange sites are occupied by sodium ions are considered to be sodic (sometimes called alkali soils), and those in which the sites are occupied by other cations in sufficiently high concentrations to impair plant growth are considered to be saline. Saline soils may result from the accumulation of almost any ionic substance, although those in which the excess salts are from sodium, potassium, or lithium usually have the additional problem of disruption of soil structure by de-flocculation of soil colloids and loss of adequate pore space. Occasionally, soils are found which are both saline and sodic.

Saline and sodic soils are found primarily in arid or semiarid regions where rainfall is limited and where extensive leaching does not occur. Even in regions with adequate precipitation, poor drainage conditions can lead to the accumulation of salts. Lands irrigated with water containing salts may, over a period of years, become saline or sodic. Soils near marine waters may become sodic as the fresh water is removed, allowing the infiltration of sea water.

LIFE IN THE SOIL

So far we have considered only the inorganic characteristics of soils, although we have mentioned how the presence of organic matter affects some of these characteristics. Many plants can grow satisfactorily under experimental conditions or in hydroponic culture in the complete absence of organic substance, but few plants do well in soils lacking organic matter. Microorganisms, plants, and animals all play roles in determining soil characteristics and productivity. For our purposes, we can separate organic soil constituents into two groups, those that are alive and those that are dead.

The numbers of living organisms in soil are staggering. In a gram of a good horticultural soil, there may be over 2 billion bacteria, 400,000 fungi, 50,000 algae, and 30,000 invertebrates, plus roots and other plant parts (Table A-4). There are also uncountable numbers of virus particles. Soil organisms are not uniformly distributed since soils are themselves not homogeneous. They are concentrated in films on the surface of soil particles and congregate on fragments of decaying biotic debris. The species and numbers of soil organisms vary with the season and with environmental conditions; fewer are found during droughts and in the winter than in periods of optimum moisture and temperature. Changes in plant cover also affect the organisms in the soil. Conversion of a forest to an agricultural pasture results in alterations in the flora and fauna of the soils. Modifications of soils by fertilization, tilling, liming, and irrigation also alter the composition of the biota.

Table A-4

Kinds & Amounts of Organisms & Organic Matter Typical Of a Horticultural Loam Soil in the North Temperature Zone

ORGANISMS	Dry weight	
	PERCENT	Kg/ha
Bacteria	0.1-0.2	2,000-3,000
Fungi	0.1-0.2	2,000-3,000
Algae	0.0001-0.0005	5-10
Invertebrates	0.001-0.005	10-50
Vertebrates	0.0001-0.0005	1-5
Plants root	0.5-5.0	5,000-50,000
Organic matter	4.0-8.0	75,000-150,000

Table A-5

Carbon to Nitrogen Ratio of Common Mulching Materials

	PERCENT CARBON(C)	PERCENT NITROGEN(N)	C:N ratio
Green cover crops			
Alfalfa	40	2.0	20:1
Clovers	40	3.0	13:1
Grasses	40	1.0	40:1
buckwheat	38	2.0	19:1
Mulches			
Peat moss	48	0.8	58:1
Fresh grass clippings	40	2.0	20:1
Dry leaves	40	1.0	40:1
Mixed mature compost	15	1.0	15:1
Straw	40	0.5	80:1
Sawdust	200	0.5	400:1
Rotted manures	30	1.5	20:1

ACIDIFICATION AND ALKALIZATION

Tolerance of plants to pH is fairly wide, ranging from about pH 4 (fairly acidic) to pH 8 (moderately alkaline). Many cultivated plants have a much narrower range. It is necessary to modify soil pH to ensure nutrient availability, reduction of metal toxicities, growth of desirable microorganisms, and conditions for in- creased crop productivity. The pH optimum for horticultural plants is species- dependent, but most will thrive at pH values between 5.5 and 7.0 and alteration of pH of soils within this range may not be necessary. Some alteration may be desirable to obtain the optimum for a specific crop, and alteration will be necessary for acid-loving plants since their optimum values range from 4.0 to 5.5. Decisions on modifying soil pH should always be made on the basis of a soil analysis.

Acidification of soils can be done by several methods. Organic materials that provide hydrogenions, such as conifer needles, bark mulches. Sawdust mulches, cottonseed meal, oak leaves, and peat (sphagnum moss) are frequently used. Their acidifying potential is high and long lasting, but they are slow acting since they must break down before releasing hydrogen ions. Much quicker, but not as long lasting, are a variety of inorganic chemicals (Table A-8). Among the least expensive is elemental sulfur, also called flowers of sulfur. Its use in poorly;' drained or heavy soils is questionable since the sulfur may be converted by microorganisms into toxic compounds. Ammonium sulfate [$(NH4)2SO4$], ammonium nitrate ($NH4No3$), and ferrous sulfate ($FeSO4$) are used for small areas, and urea or liquid ammonia are used for agricultural lands. It is difficult to predict the effects of these chemicals and the amounts to be applied since soil depth organic matter content, cation exchange capacity, and other factors are involved soil tests are vital.

Many crop plants do best at pH values near neutrality. Soils that are subjected to leaching of basic cations or that have been cropped for many years may require upward adjustment of pH.

With few exceptions, lime is the substance of choice to reduce acidity. It is inexpensive, readily available, easy to handle, and very effective. Lime is a generic term covering ground limestone or calcium carbonate (CaCO3)), slaked lime or calcium oxide (CaO), hydrated lime or calcium hydroxide [Ca(OH)2], and dolomitic. Limestone, which is a mixture of calcium carbonate and magnesium carbonate (MgCO3). Other liming substances include marl, ground oyster shells, hardwood ash, basic slag, and egg shells. All of these act. similarly by increasing the base saturation level of the soil and converting the exchangeable hydrogen ions into water. In order to determine the amount to he applied, a soil test is conducted. The liming substances have different neutralization capacities based on weight, but similar capacities based on the calcium content (Tables A-6 and A-7).

Limestone has a more immediate effect if it is finely ground, although this increases the chance of its being blown away during and after spreading. A compromise grind of 90% capable of passing a 20 mm screen and 25 % passing a 0.15 mm screen is usually used. Coarser grind are also available and less expensive. Lime does not move horizontally in soils to any extent and its vertical movement is limited even when it has dissolved in soil water.

Table A-5

Some Characteristic of Common Soil Acidifying Materials

	Sulfur S	**Ferrous sulfate $FeSO_47H_2O$**	**Aluminum sulfate $Al_2(SO_4)_3$**	**Ammonium nitrate NH_4NO_3**
Solubility	Low	Moderate	High	High
Effect on pH	Slow	Moderate	High	High
Corrosivity	None	None	None	None
Effective time	long	Moderate	Moderate	Moderate

Table A-6

Filed Estimation of Calcium Carbonate ($CaCO_3$) Content of Soil

Percent CaCO3	**Sound**	**Effervescence**
0.1	None	None
0.5	Faint	None
1.0	Faint-Low	None
2.0	Distinct	Visible bubbles
3.0	Quite Distinct	Small bubbles
5.0	Very Distinct	Moderate bubbling
8.0	Very Distinct	Vigorous bubbling

Table A-7

AMOUNT OF ACIDFING SULPHUR OR ALKALINIZING LIMESTONENEEDED TO ALTER SOIL pH

To change upper 20cm		**Sandy loam**		**Silty loam**		**Clay loam**	
From pH	**To pH**	**Lime[2]**	**Sulfur**	**Lime[2]**	**sulfur**	**Lime[2]**	**Sulfur**
4.0	5.6	250	----	400	----	500	----
5.0	6.5	170	----	280	----	325	----
6.0	6.5	70	----	110	----	120	----
7.0	6.5	----	5	----	8	----	15
8.0	6.5	----	60	----	75	----	100

MULCHES AND COMPOSTS

The optimum %age of organic matter in a productive soil varies somewhat with climate, soil type and the nature of the crop, but generally it is about 5 to 15 %. As soils are tilled as microorganism gradually utilized the humus and other organic matter, and as leaching or erosion occurs, the amount of the organic fraction decreases. Among the many consequences of this are

1. Decreased soil porosity
2. Disruption of soil aggregates and loss of granularity
3. Decreased water-holding capacity
4. Decreased aeration
5. Increased erosion potential
6. Increased water evaporation
7. Decreased water buffering
8. Increased leaching nutrients
9. Alteration in favorable microorganism population
10. Increased temperature variations

These changes are more rapid in soils of tropical areas where temperature and rainfall are high but occur fairly rapidly even in temperature zones. For good productivity organic matter should be replaced.

Table A-8

Approximate Composition of Common Mulching Materials

	Nutrients(as present of dry weight)			
	Nitrogen	**Phosphorus**	**Potassium**	**Present dry weight**
Cow manure	1.5	0.4	0.8	20-30
Horse manure	2.0	0.3	2.0	20-30
Sheep manure	4.0	0.6	3.0	25-40
Poultry manure	4.0	2.0	2.0	30-40
Bone meal	0.1	10.0	0	100
Dried blood	13.0	1.0	1.0	100
Hay and straw	2.0	0.3	2.0	90
Cottonseed meal	6.0	1.0	2.0	100
Peanut hulls	2.0	0.1	0.7	100
Dried kelp	0.6	0	1.0	100
Wood ash	0.0	2.0	6.0	100
Hardwood sawdust	0.2	0.1	0.2	100
Softwood sawdust	0.1	0.1	0.1	100

Table A-9

CHEMICAL COMPOSITION OF PLANT –DERIVED SOIL ORGANIC MATTER COMPARED WITH THE PLANT TISSUE

Compounds	**Present dry weight**	
	Soil organic matter	**Living plant tissue**
Cellulose	30-60	2-8
Hemicelluloses	15-30	0-2
Lignins	15-30	30-50
Proteins	2-12	1-5
Fats and waxes	1-5	1-4

SOIL MIXES FOR HOMES AND GREENHOUSES

Few house or greenhouse plants do well in soil dug out of the garden. Garden soils are usually too heavy and have variable composition. To standardize and control the substrate, potting mixes have been developed, Some containing soils and some soilless. A variety of all purpose and specialty mixes are commercially available, but for general use and volume production they are not cost efficient, and some contain sewage sludges contaminated 'with household and industrialwaste.

Potting mixes also called growing mixtures or soil mixes have advantages over top soil. They can be reproduced and are stable have excellent porosity, water holding capacity, cation exchange capacity and pest free. Because they are light in weight, large plants may topple or pulled from the pot, but the advantages outweigh the disadvantages.

Most potting mixes contain both plant-derived and inorganic materials with high water-holding capacity, resistance to compaction and high cation exchanges (Table A-10). Milled peat moss, leaf mold, shredded bark, humus, well-rotted manure, and wood chips are used. Inorganic constituents, such as sharp builder's sand, vermiculite, perlite, scoria (ground lava rock), and ground granite, improve drainage and increase pore volume. Small amounts of other substances are added to regulate pH and supply trace elements or nutrients

Table A-10

POTTING MIXING FOR HOUSE PLANTS , GREENHOSE, AND GARDEN TRANSPLANT USE

Ingredient	Cornell peat-lite	University of California C	John innes	Humus mix	Succulent and cacti mix	Epiphyte mix#1	Epiphyte mix#2	General house plant mix	Perennial container mix	Cornell seed starting mix	John innes seed compost	Rooting cutting mix#1	Root cutting mix#2	Coniferous bonsai mix
Major ingredient														
Sphagnum peat(shredded)	2	1	3	1	1	1	1	1	1	1	1	1	1	1
Sharp sand (0.5-1-0mm)		1	2	1	1			1	1		1	1	1	1
Bark (shredded)									1					
Leaf mould or humus				1	1	1	1	1/2	1					
Sandy loam soil			7				1	2			2	1		1
Vermiculite	1			1		1							1	
Perlite	1													
Additives														
Dolomitic lime(ground)	20	300	250			75	150	100	50	50	100			
20 present superphosphate	50	50	50				50		75	25	100			25
Chelated iron	5	5					5		5	5				5
Fritted trace elememt	1								1					

ANNEXURE-B

LAWNS

Contrary to expectations, lawn installation and maintenance are among the more expensive and time-consuming horticultural activities, The individual grass plants are not only subject to many pests and diseases, but also are deliberately crowded 'and in intense competition for space, light, water, and nutrients. Nevertheless there is great personal desire and community pressure for a beautiful lawn to reduce dust and mud, to soften and enhance the landscape, and to sit and play on.

Table B-1

Grass Seed Mixtures

Situation	Hardiness zone	Composition
Sunny area	3-7	75% improved bluegrasses+25% improved red fescues
Shady area	3-7	75% improved red fescues+25% improved bluegrasses
Play area	4-8	80% improved tall fescues+20% perennial rye
Quick cover	3-9	75% annual rye+25% redtop
Rough lawn	3-8	33 1/3%ladino clover + 33 1/3% bluegrasses + 33 1/3 % tall fescues
Heavy traffic	4-8	60%fescues+ 20% bluegrasses +20% perennial rye
Overseeding	7-9	100% redtop

Establishing a good lawn demands quality seed, appropriate to the particular soil and climatic conditions. Many grass species have been selected and bred for particular characteristics (Table18-1). Within these, named cultivars have been developed that are generally superior to the unimproved species. The amed cultivars have the disadvantage of being almost isogenic (genetically uniform) To increase the lawn's survival under adverse conditions, most lawn grasses are sold as mixtures of two or more species. These mixtures are usually' keyed to hardiness zones, to environmental conditions in various lawn climatic regions, arid to the expected use of the lawn. In southern climates (Hardiness Zones 8 to 10) many lawns are established with a single species of grass, frequently as blends of several cultivars. Lawn grass seed should be labeled with the species and cultivars included, the germination percentage, the percentage weed seed (less than 1 percent is best), the percent of inert materials (less than 5 percent) and the percent of crop seed (less than 0.3 percent). Certified seed labels indicate that the plants were inspected in the field and were found to be true to type

SOWING

Sowing seed into a well prepared seed bed can be done by hand or with mechanical grass seeding machine. Since the seed is small, hand seeding, is made easier if the seed is thoroughly mixed with a carrier such as sand or topsoil. To ensure uniform distribution of seed, half the seed is sown in one direction and the other half at right angles to the first lot. After planting, the seed may be raked with a tooth rake to make sure that the seed is in direct contact with the ground. Rolling or treading the seeded area also ensures good contact. The seed should not be covered by more than 0.2 to 0.3 cm (1/8 in.) of soil for most cool-season grasses. Some varieties, such as the bluegrasses, germinate slowly, requiring over three weeks for full germination. Mulching the sown area conserves moisture, prevents the seed from being washed away by heavy rains, and prevents wide swings in temperature. A weed-free straw or hay cover is excellent when used at the rate of 100 kg/100 m2 (100Ib/100 ft2). On steep slopes or banks, cheesecloth, sacking, or one of the commercially available mulching cloths can be used. The grass blades will grow through the mulch which usually rots away within a few months.

If the seedbed was properly prepared and adequately fertilized, additional fertilizer may not be needed for the first months of lawn growth. If fall planting was done, a light fertilization in spring when the grass begins to grow may be helpful, particularly if the plants are pale green or yellowish. A phosphorus deficiency is recognized as dark green plants with red stems and reduced growth.

To avoid compaction of the soil, new lawns should not be walked on for the first month following appearance of the seedlings. Mowing can begin at this time with mower height set at 2 in. Chemical weed control is best deferred for another month or can be done the following spring.

SODDING

Sod is pre grown turf consisting of a weed-free mixture of grasses appropriate to the area. It should be purchased locally. Rectangles or strips of a mature turf 1 to 3 years old. are cut with special equipment-to a thickness of 2 to 3 cm (l in.), with little soil below the mat of roots. Laying sod is expensive, but it is an effective method on slopes subject to erosion or where a line, mature lawn is to be established in a short time. In many areas sodding provides an excellent turf, usually weed free, that is permanent with proper maintenance.

In Hardiness Zones 4 to 8 sodding is most successful when done in the fall, although spring sodding may be done if adequate moisture and care are provided. In Hardiness Zones 8 to 10, where warm-season grasses are used, summer sodding is best. It is important that the sad is laid as soon as possible after delivery; a delay of even a few days will injure the turf since the root systems are exposed.

Soil preparation is identical to that used for seedbeds except that the soil is graded 2 to 3 cm (1 in.) lower near walkways to adjust for the thickness of sad. The bed must be well prepared and leveled to allow firm and close contact between the sod; and the soil. Rectangles or strips are planted as tightly together as possible, much as flooring tiles are laid: To minimize trampling or compaction of the soil, a board is laid over the soil surface to be sodded. After the sod is installed, the area is top-dressed with a thin layer of good topsoil and topsoil worked into the cracks between the pieces of sodding. The new lawn is light tamped or rolled to ensure good soil-sod contact and is watered immediately. Should be watered frequently for the first growing season to prevent root damage and to encourage good root penetration. A light application of superphosphate will accelerate root penetration.

Some grasses, particularly the warm-season species and the bent grasses, also be established from plugs or plantings (Table B-2). Plug sodding utilize small rectangles or discs of sodded grasses with adhering soil. These are plant 15 to 30 cm (6 to 12 in.) apart in well-prepared bed.

MAINTENANCE

If a fine, thrifty, weed-free lawn is desired, its maintenance becomes a significant part of management and cultivation. Unfortunately, lawns are neither work-free nor trouble-free. Fertilization. Liming, watering or irrigation, mowing. and control of animal and plant pests are the basic constituents of lawn management.

FERTILIZING

If soil nutrients are brought to an adequate level during site preparation, additional fertilization will be unnecessary for the hulk of the first growing season. Indeed, over-fertilization is inadvisable since a young root system is less tolerant of high levels of inorganic salts than is the root system of an established lawn. Excessive nitrogen results in succulent, soft growth that is less disease and insect resistant.

Lawns should not be fertilized when the grass or the soil is wet. But it is good practice to water thoroughly after spreading fertilizer to wash any chemicals off the leaves, This prevents burning and ensures that the fertilizer reaches and enters the soil.

There is some confusion about the amount or rate of fertilizer application. While the phosphorus and potassium components in standard fertilizer formulations are necessary for grass development, lawn grass growth is primarily dependent upon the amount of nitrogen supplied, and it is the nitrogen component that is given primary consideration in determining fertilizer applications. For lawn applications, the amounts needed are usually given as pounds of nitrogen per thousand square feet or kilograms per hundred square meters, To provide 1 Ib N/ 1000 ft^2 (1kg N/100 m2) using a 10-10-10 fertilizer, 10 lb (4 kg) of fertilizer would be used.

Fertilizers may contain inorganic nitrogen as ammonium or nitrate ions, organically bound nitrogen, or a mixture of both, Inorganic nitrogen is immediately available to the plants, while organically bound forms release nitrogen slowly. When spring applications of fertilizer to cool-season lawns or summer applications to warm-season lawns are made, the combination formulations work well in spite of their high cost. For fall applications, where immediate uptake in cool weather is desired, only inorganic formulations are cost efficient.

'Fertilization schedules depend on the region and the grass type (figure18-3). Warm-season grasses put on most of their growth during the hot summer months and should be fertilized at the time of maximum growth. Bermuda grass, St.Augustine grass, zoysia, or Bahia grass benefit. from high fertilizer applications. Bermuda grass should receive 5 kg N/100 m2 (5 Ib N/1000 ft2), St.Augustine grass and the zoysias 2 kg N/1OO m2,and Bahia grass 3 kg N/100 m2.

LIMING

It should be obvious that correction of soil pH should be done only when it needs correcting as determined by a soil test. In general, established lawns on sandy soils require liming every two to three years, while those on clay soils need adjustment only every five to six years. The lime is usually supplied in a finely ground or granular form and can be spread at any time of the year, although late fall or very early spring are best. Amounts vary according to need, but are in the range of 10 to 30 kg/100 m2 (10 to 30 lb/1000 ft2).

WATERING

Watering or irrigation of lawns is, for most areas of North America, a necessity. An acre (0.4 ha)of lawn can transpire 2400 gallons (9600 liters) of water per day in midsummer. Considerable damage will occur if soils dry to their permanent wilting point (-15 bars) for any length of time. Many lawn grass roots grow to 30 cm (1 ft) or more into the subsoil and moisture levels at this depth should not fall below -8 bars during the period when the grasses arc actively growing. It requires 2 to 5 cm (I to 2 in.) of water to bring the upper 30 cm (12 in.) of a sandy or silty loam soil from near wilting point to field capacity. This amount of water will be transpired or lost by evaporation in a week under summer conditions. To replace this water, regular watering is required. In midsummer, when cool-season grasses stop growth and become summer- dormant, less, water is needed. if it is desirable to maintain growth during this time watering must be continued at somewhat higher rates than the 2 to 5 cm per week.

A light sprinkling of water several times a week is poor management practice. A good deal of this wafer is merely evaporated from leaf and soil surfaces and does-not enter the soil at all. The water that does enter the soil remains in the upper few centimeters and the grass roots become concentrated in this superficial horizon. The danger of massive root kill by even light droughts or a short period of hot weather is great. Watering should provide the amount needed to bring the upper 30 cm (12 in.) to field capacity and should be repeated when this layer is sti1l above the permanent wilting point-usually once a week or more frequently in very hot, dry weather with moderate to high winds.

MOWING

The fundamental rule on lawn mowing is to use only well-designed, well- maintained, and well-sharpened equipment. A dull blade, whether on it reel or a rotary mower, will shatter rather than cut grass blades cleanly and will increase the number of plants that die or become susceptible to infection. Although reel mowers involve more human effort, they preferable to rotary mowers because they cut cleaner and are less dangerous to use.

Cool-season grasses should not, except under special circumstances, be mowed closer than 5 cm (2 in.). Close mowing removes too much of the photosynthetic leaf blade tissue and depresses the growth of-root systems. It also exposes previously shaded stems to direct sunlight which may result in sun scald. Cool-season grasses should be mowed at frequent intervals during the growing period. It is a good general rule that lawns should be mowed when the grass length has exceeded the recommended height by no more than 1.0 to 1.5 cm (1/2 in.) where mowing shock is minimal. The warm-season grasses are generally cut shorter than the cool-season grasses, Bermuda grass is maintained at heights of 1.5 to 2.0 cm (5/8 in.) and the others at 2.0 to 2.5cm (3/4 to 1 in).

WEEDS

A bright green, well-trimmed, and weed-free lawn is not only an esthetic pleasure, but adds financial value to a property. Weed control is a necessary' cultural practice for most areas. Close to 50 species of weed plants invade lawns and require control if clean turf is to be maintained (Figure 18-4). Weed control starts with the turf itself. A healthy lawn, provided with adequate fertilizer, water, and lime and properly mowed, resists the invasion of the seeds of many lawn particularly if the turf is mowed to at least 3.5 to 5.0 cm (1.5 to 2.0 in.), a cutting height that is also best for lawn development.

Weedy species in lawns are separated into persistent (perennial) non persistent (annual) types and each type includes monocots and dicots. Two of the more troublesome weedy plants are the crabgrass and the nimble-wills. Both are monocots related to the lawn grasses. The crab-grasses are annuals, and nimble-will is a persistent perennial. The crab-grasses are vigorous C4. Photosynthetic plants and are particularly difficult to eliminate once they have become established. Other grass species that are problems for lawns are the creeping bent-grasses foxtails, Dallies-grass and quack grass.

Since the desired lawn grasses are usually as sensitive to herbicides as are the weedy species, special control measures are required in an established lawn. When lawns contain few weeds, hand removal is the least damaging method of control. Removal is best done after a rain or thorough irrigation since many weeds have relatively superficial root systems and it is easier to pluck out the entire plant when the soil is damp. Many weeds reproduce easily from rootstocks and failure to remove the entire plant results in spread of the weed. This is particularly true for dandelion (Taraxacum), cinquefoil (Potentilla canadensis) and the plantains (Plantago spp.).

Both pre-emergence and post emergence herbicides are used in any thorough weed control program. The pre-emergence herbicides inhibit weed seed germination and early seedling growth, but have virtually no effect beyond that stage. They are effective in treating established lawns to eliminate crab-grasses, goose- grass (Eleusine indica), and creeping bent-grass all of which are resistant to most other herbicides. They may also be effective against seedlings of broad-leaved weeds, although post emergence herbicides are usually used for these plants. Pre-emergence herbicides are available as granules that at spread in early spring. They should not be used on new lawns since they can kill lawn grass seedlings.

The post emergence herbicides include 2, 4-dichlorophenoxyacetic acid (2, 4-D) and its derivatives plus a variety of other chemicals that interfere with a number of physiological activities including photosynthesis, respiration, and synthesis of various compounds. Many are available as spreadable granules or as liquid formulations used as sprays. With few exceptions, spray formulations are most effective against young plants: as many weeds age. their tolerance to herbicides increases.

Herbicides are human and animal toxins. and as with all chemicals, package directions should be followed exactly. They can injure or kill desirable plantings and should not be used in very hot weather where they volatilize or in wind conditions where they may be carried to other plantings. Spot applications can be made by tipping a stick with a paint brush or a piece of plastic foam and touching individual weeds with the herbicide. Although formulations of fertilizer plus herbicides are available for dual treatment of lawns, they are more expensive than purchasing and applying each separately, and the timing for optimum effectiveness of each may be different.

PESTS AND DISEASES

Three insect types are responsible for most lawn problems. Those that suck sap include the chinchbugs, some aphids, and scale insects. Plants of Augustine grass in the south are particularly plagued by chinch bugs. The webworms, occasionally called tobacco crambids, are larvae of moths that damage by feeding on grass leaves and stems. Armyworms, the larval stage .S. another moth, are leaf feeders. By far the most serious pests are grubs, the larval hatchlings of the Japanese beetle, Mayor June beetles, and the billbugs. Beetle grub damage is evidenced by death of patches of grass in June through early August and by observations of white grubs directly beneath the sod. These insect feed on the roots of grass plants just below the sod level and can destroy a large lawn area within a week.

The sap sucking insects and leaf feeders are controlled with appropriate insecticide sprays, usually applied in midsummer in the south and a few earlier in more northerly climates. Grubs can be controlled by preventing through sound cultivation practices, trapping or killing adults, use of biological , control and soil treatments with appropriate pesticides.

Other animal pests rarely present major problems. Termites damage the roots of some grass species in the Ohio River basin, wireworms occasionally attack grass rhizomes near potato fields, ants are more of a nuisance. Land crabs dig holes in southern lawns and arc controlled with a rotenone solution poured into each burrow. Mole burrows are unsightly and can result in uprooted plants. Moles feed on grubs, so that grub control almost invariably. Resolves the mole problem. No one has successfully dealt with neighborhood dogs, cats, and squirrels.

A well-managed lawn is the best disease control. Among the worst management practices in terms of disease development is over-fertilization with high nitrogen formulations. Hot, wet summers are unavoidable, but they should alter the gardener that special care must be exercised if serious fungal diseases are to be avoided. Among the most common diseases of lawn grasses are the mildews, rusts, and smuts. Mildew infections look as if the grass had been dusted with a white powder and are controlled with fungicides. Rusts and smuts rarely kill thrifty, deep-rooted grass plants and can usually be controlled by fungicides; Smuts attack tender leaves forming black, powdery spore masses on curled leaves. In northern regions snow molds are a recurrent problem. The snow mold fungi attack overwintering leaves, and the results of their activity, dead circles or patches of grass, are seen when the snow melts. Unless the disease is far advanced, fungicidal treatments are effective.

REPAIR, RESTORATION AND RENOVATION

Even with reasonable maintenance. lawn repair, restoration or renovation becomes necessary. Soil compaction in traveled areas, the growth of shade trees, diseases, and neglect can individually or collectively create problems that must be corrected. These operations should be distinguished from routine maintenance.

Older lawns that show minor wear and tear can be repaired by relatively simple procedures. Chemical and hand removal of weeds is best done prior to mowing the lawn to 2.5 cm (1.0 in.). Clippings should not be added to a compose the heap, but collected and discarded. Fertilization to correct nutrient deficiencies, liming as indicated by soil tests, and accelerated maintenance techniques should be included. Repair work can be done at any time of year, but spring and fall are best.

Much has been written about the horrors of thatch buildup as a factor in lawn decline and waste of it is probably overstated. The stolon’s of lawn grasses such as the bents and Bermuda grass are horizontal stems that extend along the ground and become intertwined. As stolon’s die, they can form a thick layer of organic material that decomposes slowly, sheds water, causes soils to dry out, and harbors earwigs and other pests. True thatch is a fluffy, matted blanket of these stolon’s above the soil.

GROUND COVERS

In many situations grass lawns are neither practical nor desirable. Heavily shaded areas including those on the north sides of structures, under mature trees, and behind hedges and tall fences rarely receive enough light to allow a good lawn to develop; Areas immediately adjacent to woodlots also rarely form good lawn. Steep banks are difficult to mow, are frequently dry and infertile, and rarely can be successfully seeded because of runoff and erosion, All of these situations are being handled by planting ground cover plants. These should not be considered as second choices or compromise plantings, many ground covers are handsome and colorful additions to the landscape (Table B-3). Contrasting textures, foliage colors, and splashes of flower color add greatly to the total view of a garden.

Most effective ground covers are herbaceous perennials or small woody shrubs. They may trail along the ground or spread by rhizomes so that bare areas are quickly covered. Some ground covers are essentially care-free, requiring only minimal fertilizing and watering, while others need as much or more attention as lawn grasses. Because of the large number of possible ground covers, selection is based not only on prevailing environmental conditions, but also on considerations of hardiness, foliage and flower interest, and the landscaping plan.

Many low-growing perennial flowering plants can be used as ground covers, Baby's breath (Gypsophila repens) turfing daisy (Matricaria tchihatchewe), some saxifrages, lily of the valley (Convaltaria majolis), and others can fill in shaded areas .For southern areas (Hardiness Zones 9 to 10), gopher apple (Geobalanus spp.), peperomia, creeping charley (Pilea hummulariaefolia) inch plant (Zebrina pendula), and several species of veronica are excellent shade-tolerant ground covers. Although not usually considered as ground covers, there are herbs to suit most conditions and locations. Included among those that are often used as ground covers are catnip, tarragon, mint, pennyroyal, burnet, germander, lovage.

Table B-2

Seeding of Planting of Lawn Areas

Latin Name	Common Name	SEEDS		Plugs or Plant		Mowing Height (in)	Remarks
		Time	Rate (lb/1000ft^2)	Time	Rate (lb/1000ft^2)		
	Cool Season Grasses						
Agropyron crictatium	Crested Wheetgrass	F	1-2	----	---	2	Dry, cool areas
Agrostis canina	Velvet bentgrass	F	1-2	---	---	1	Humid, cool areas
A.gigantea	Redtop	F	1-2	---	---	1.5	Quick cover, short-lived.
A.stolonfera	Creeping bentgrass	F	1-2	F	1000	1	Humid, cool areas
A.tenuis	Colonial bentgrass	F/S	1-2	---	---	1	Humid, cool areas, finest lawns
Bouteloua grevilis	Blue gramagrass	S	1-2	---	---	1.5	Dry, cool areas drought resistant
Festuca rubre	Red fescue	F	3-5	---	---	2	Dry, cool areas shade resistant
F.ruba	Fescue improved	F	2-4	---	---	2	Water resistant, shade tolerant
F.ruba hetrophylla	Chewing Fescue	F	3-5	---	---	1.5	Cool areas, shade resistant

Lolium mulslorum	Annual ryegrass	F/S	4-6	---	---	2	Quick cover, short lived.
L.perenne	Perennial ryegrass	F/S	3-5	---	---	1.5	Used in mixtures with other grasses.
Poa pratense	Common blue grass	F	2-3	---	---	2	Drought resistant, rough use
P. pratense	Bluegrass improved	F	1-2	F	1000	2	Most common component in mixtures.
Trifolium repens	White Clover	F/S	2-4	---	---	1.5	Cool areas, nitrogen fixing legume.
T.r. forma lodigense	Ladino clover	F/S	2-4	---	---	---	Dry areas, rough lawns
	Warm season grasses						
Buchloe dactylsides	Buffalo grass	S	1-2	S	50	1.5	Drought resistant, rough use
Cynodon Dactylon	Bermuda grass	S	2-3	S/S	10	0.75	Southern areas, in acidic area
Emerochola optiroides	Centipede grass	S	2-3	S/S	10	1	Low maintenance invasive
Paspalum notaum	Bahia grass	S	2-3	---	---	1	Humid Warm areas, coarse textures
Stenotaphrum condatum	St. Augustine grass	---	---	S/S	30	1	Shade tolerant heat resistant
Zoysia Matrella	Japanese zoysia	S/S	1-2	S/S	30	1	Wear resistant, yellows in summer
Z.tenuifolia	Velvet Zoysia	S/S	1-2	S/S	30	1	Fine texture, yellows in summers

Table B-3

Some Ground Cover Plants

Latin name	Common name	Mature height(cm)	Light	Soil	Flowers	Hardiness zone
Acaena microphella	Sheepbur	0.5	FS	N	_	7
Achillea spp.	Yarrow	30	FS	N	_	3
Aegropodium spp.	Goutweed	35	FS	N	_	4
Ajuga repens	Bugleweed	20	FS	N	+	4
Akebia quinata	Akebia	Vine	Sh	N	_	5
Aloe spp.	Aloe	10	FS	N	+	9
Andromeda polifolia	Bog roesmary	30	FS	Wet	+	3
Arabis alpine	Rock ress	20	FS	N	+	4
Arctostaphylos spp,	Bearberry	30	FS	Wet	_	3
Arenaria verna	sandwort	8	FS	N	+	3
Armeria maritima	Thrift	30	FS	Wet	_	3
Cerastium spp.	Snow in summer	20	Sh	N	+	3
Chamaemelum nobile	Chamomile	15	FS	N	+	4
Convallaria majalis	Lily –of-the-valley	20	Sh	N	+	3
Cornus Canadensis	Bunchberry	18	FS	Wet	+	3
Coronilla varia	Crown vetch	60	FS	N	+	4
Dichondra micrantha	Dichondra	8	Sh	N	_	9
Duchesnea indica	Indian	5	Sh	Wet	_	6

	strawberry					
Erica carnae	Heath	25	FS	Acid	+	6
EUONYMUS FORTUNEI	Wintercreeper	15	FS	Wet	_	5
Fragaria chiloensis	Wild strawberry	12	FS		+	5
Galax urcreolate	Wandflower	15	Sh		+	4
Gaultheria procumbens	Wintergreen	1	Sh		+	4
Glechoma hederacea	Ground ivy	2	FS		_	4
Hadera helix	English ivy	Vine	Sh		_	6
Juniperis cvs	Creeping juniper	35	FS		–	4
Liriope spicata	Lilyturf	20	FS		+	7
Mitchella repens	Partrideberry	3	Sh		+	4
Mazus reptans	Mazus	3	Sh		+	4
Ophiopogon japonicas	Dwarf lilyturf	15	Sh		+	6
Pachysandra spp.	Pachysandra	30	Sh		_	5
Phlox subulata	Moss pink	15	FS		+	4
Phylanodiflora	Lippie	10	FS		_	6
Potentilla spp.	Cinquefoil	10	FS		+	5
Prunella vulgaris	Self-heal	5	FS		+	3
Sagina subulata	Pearlwort	10	FS		+	5
Sedum spp.	Stonecrop	10	FS		+	4
Teucrium chamaedrys	Germander	30	Sh		+	6
Thymus spp.	Thyme	4	FS		+	4
Veronica spp.	Speedwell	10	FS		+	4
Vinca minor	Periwinkle	15	Sh		+	5
Vtola spp.	violet	10	Sh		+	3

FS = full sun; Sh = partial shade; N = normal soil ; wet=can withstand wet soil; acid= requires pH

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30. ELECTRICAL WORKS

30.1 GENERAL

30.1.1 SCOPE

The work shall include furnishing of all labour, materials, equipments tools and plants as required and providing the internal electrification and other works as specified consisting of but not limited to conduits and pipes, wires and cables, wiring fixtures, lighting system, power distribution, fans, fittings, earthing system. The Contractor shall execute the works as shown on the Drawings specified herein and or as directed by the Engineer-in-Charge, and shall be responsible for proper functioning, testing, commissioning and satisfactory operation and performance during the maintenance period.

30.1.2 CODES AND STANDARDS

The work shall conform to the requirements of the following Codes and Standards, unless otherwise specified:

BS 31-79	Steel conduit and fittings for electrical wiring.
BS 89-77	Specification for direct acting indicating electrical measuring instruments and their accessories.
BS 142-82	General requirements for measuring relays used for Part-2 protection
BS 159-57	Bus bars and bus bar connections
BS 161-76	Specifications for tungsten filament lamps for general service
BS 1853-79	Tubular fluorescent lamps for general lighting service
BS 3505-82	Un-plasticized PVC pipe for cold water services
BS 3871-65	Miniature air-break circuit breakers for A.C. Part I-(84) circuits.
BS 4553-70	PVC – insulted split concentric cables with copper conductors for electric supply
BS 4607-71 (P- 2)	Rigid PVC conduits and Conduit fittings
BS 4752-77	Circuit breakers
BS 5419-77	Specification for air-break switches, air-break disconnectors etc.
BS 6004-84	Specification for PVC insulated cables for electric power and lighting.
BS 6346-77	PVC – insulted cables for electricity supply
BS 6360-81	Specification for conductors in insulated cables and cords
BS 6500-84	Specification for insulated flexible cords and cables
BS 6746-84	PVC insulation and sheath of electric cables
CP 1013-65	Earthing

30.1.3 QUALIFICATIONS

a) The Electrification Works shall be carried out by licensed workmen authorized to undertake such works under the provisions of Electricity Act, 1910 and the Electricity Rules 1937, as adopted and modified by the Government of Pakistan from time to time.

b) The installation in general shall be carried out in conformity with the Electricity Rules 1937, and the latest edition of British/Pakistan standard or any equivalent International standard approved by WAPDA. However, in case of conflict between these specifications and the standards, the prevailing ruling will be the one which requires higher quality of workmanship & materials and safety to personnel or as interpreted by the Engineer-in-Charge.

c) The Contractor shall set out the work himself and if any discrepancy is found, he shall report the matter to the Engineer-in-Charge and shall act as directed. Any defective electrification work carried out by the Contractor shall be rectified or made good by the Contractor.

d) The electrical works shall keep pace with the civil works and the works of any other specialist contractor. The Engineer-in-Charge shall be kept informed about the programme and the progress of work so that there is no hindrance in the progress of work at Site.

30.1.4 PERMANENT ELECTRICAL CONNECTION

The Contractor will co-ordinate in getting the permanent electrical connection from the Agency supplying electric power and fulfil formalities as required by the concerned local authorities. Actual charges, as demanded for permanent connections by the agency supplying power shall be borne by the Department.

30.1.5 SUBMITTALS

The Contractor shall submit for approval of the Engineer-in-Charge:

a) All drawings of equipment, appliances, fixtures and accessories that are to be furnished under the Contract. These shall include detailed electrical drawings, wiring diagram, foundation details, etc. for all electrical switchgear, fuse gear and all other systems.

Drawings and data for each equipment to be furnished before commencement of fabrication and manufacture. The drawings to be supplied by the Contractor shall be as follows.

Layout Drawings showing:

- Arrangements
- Dimensional plans, elevations and front view Foundation plans, anchor bolt locations
- Buss bar locations and configurations
- Incoming and outgoing cable terminating positions Terminal blocks locations
- Earthing arrangements

Electrical Drawings showing:

- One-line diagram
- Detailed wiring diagram
- All interconnections
- Instrument transformers
- Relays, their locations and internal wiring diagrams
- Other electrical devices including metres, instruments and their wiring diagram
- Signal and alarm circuits

b) Manufacturer's installation, operation and maintenance manuals wherever applicable.

c) Specimens of all wiring accessories, fittings, fixtures, conduits, pipes, wires, cables and all the materials to be incorporated into the Works along with specifications of each.

d) A list of spare parts required for one year's operation of each equipment where deemed necessary together with unit price of each part.

30.1.6 INSPECTION AND TESTS

a) Factory Tests

All type and routine tests on all equipment shall be performed at the manufacturer's works in the presence of the Engineer-in-Charge or his Representative. Type tests may be waived off in case test certificates are submitted by an Engineer-in-Charge's approved standard laboratory of international repute; but merely producing the test type certificates will not relieve the manufacturer to carry out the required standard/routine tests. The Contractor shall inform the Engineer-in-Charge about the date and time of test of each equipment at least two weeks in advance. The witnessing of test by the Engineer-in-Charge or his representative shall not absolve the Contractor from his responsibility for the proper functioning of the equipment, and for furnishing the guarantees.

b) Site Tests

Upon completion of the installation, the Contractor shall perform field tests on all equipment, materials and systems. All tests shall be conducted in the presence of the Engineer-in-Charge for the purpose of demonstrating equipment or system compliance with the Specifications.

The Contractor shall furnish all tools, instruments, test equipment, materials, etc., and all qualified personnel required for the testing, setting and adjustment of all electrical equipment and material including putting the same into operation.

All tests shall be made with proper regard for the protection of the personnel and equipment and the Contractor shall be responsible for adequate protection of all personnel and equipment during such tests. The cost of any damages or rectification work due to any accident during the tests shall be the sole responsibility of Contractor.

The witnessing of any tests by the Engineer-in-Charge does not relieve the Contractor of his guarantees for materials, equipment and workmanship, or as any other obligations of the Contract.

c) Insulation Resistance Test

Insulation resistance test shall be made on all electrical equipment by using a meggar of 500 volts for circuits upto 250 volts and 1000 volt for circuits between 250 and 500 volts.

The insulation resistance values of cables shall conform to the requirements of BS 6004, BS 6346 and Pakistan Electricity Rules.

Before making connections at the ends of each cable run or joint between cables, the insulation resistance test of each cable section shall be made. Each conductor of a multi core cable shall be tested individually with each of the other conductor of the group and also with earth.

All switch gears shall be given an insulation resistance measurement test after installation but before any wiring is connected. Insulation tests shall be made between open contacts of circuit breakers, switches and between each phase and earth.

d) Earth Resistance Test

Earth resistance tests shall be made by the Contractor on the earthing system, separating and reconnecting each earth connection.

If it is indicated that soil treatment or other corrective measures are required to lower the ground resistance values, the Engineer-in-Charge will determine the extent of such corrective measures.

The electrical resistance of the E.C.C. together with the, resistance of the earthing leads measured from the connection with earth electrode to any other position in the complete installation shall not exceed one ohm.

Earth resistance test shall be performed as per Electrical Inspector's requirements. Where more than one earth electrode is installed, the earth resistance test of each of electrodes shall be measured by means of resistance bridge instrument.

e) Switchgear

Each circuit breaker shall be operated electrically and mechanically. All interlocks and control circuits shall be checked for proper connections in accordance with the wiring diagrams given by the manufacturer.

The Contractor shall properly identify the phases of all switchgear and cables for connections to give proper phase sequence.

Trip circuits shall be checked for correct operation and rating of equipment served. The correct size and function of fuses, disconnect switches, number of interlocks, indicating lights, alarms and remote control devices shall be in accordance with approved manufacturer drawings. Name plates shall be checked for proper designation of equipment served.

f) Completed Tests

After any equipment has been tested, checked for operation, etc., and is accepted by the Engineer-in-Charge, the Contractor shall be responsible for the proper protection of that equipment so that subsequent testing of other equipment do not cause any damage to the already tested equipment.

g) Inspection Tests

The Contractor shall be responsible for submitting the test certificates and getting the installation passed by the Electrical Inspector appointed by the Government. Any special requirements of the local building and or municipal authority shall also be complied with.

h) Ambient Conditions

All material and equipment supplied and installed shall be designed, manufactured and tested to meet the following ambient conditions unless specifically stated otherwise for any material/equipment.

Maximum ambient temperature:	(+) 50 Degree Centigrade
Minimum ambient temperature:	(-) 15 Degree Centigrade
Maximum relative humidity:	100%

30.1.7 DANGER BOARDS AND CHARTS

The Contractor shall provide Danger Boards and Shocks Charts wherever required to comply with the requirements of local Electricity Rules and according to normal practice.

30.1.8 GUARANTEE

The Contractor shall furnish written guarantee against performance of each equipment. Such guarantee shall be for replacement and repair of a part or whole equipment which may be found defective in material or workmanship. The guarantee shall cover a minimum period of 12 months after commissioning of the equipment.

30.2 PRODUCTS

30.2.1 CONDUIT PIPES

a) PVC Conduit Pipe

The conduit for wiring of lights, socket outlets and other systems shall be made of PVC conforming to BS 3505 Class-0.

The conduit shall have following wall thickness and standard weights:

Pipe dia.	Weight / metre	Wall thickness
20 mm	0.111 kg	1 to 1.3 mm
25 mm	0.148 kg	1.1 to 1.4 mm

Bigger diameter PVC pipes shall conform to BSS 3505 and shall be Class-B which can withstand pressure of 6 Kg/ Sq.cm.

b) Steel Conduit Pipe

Steel conduit shall conform to BS 31. The conduit shall be enamelled with good quality non-cracking and non-flaking black paint. Pipe bigger than 25 mm in dia shall be MS galvanized both inside and outside and shall conform to BS 31.

c) Flexible Pipe

Flexible conduit shall be spiral interlocked type made of steel strip construction and coated with zinc.

d) PVC Pipe and Accessories

The PVC pipe shall be rigid. All pipes shall be minimum Class-D (working pressure – 12 bar), unless otherwise stated on drawings or bill of quantities. The buried PVC pipe should be able to withstand the external load acting upon it by continuous movement of heavy duty vehicles such as trucks. Cranes, forklift, etc. Where pipe change direction, manufactured smooth bends shall be used. Bending of pipes by heating or otherwise will be allowed in special cases only where bends cannot be installed as approved by the Engineer-in-Charge. Bending of pipes by heating shall be carried out by first filling the pipe with sand inside and then immediately removing the sand. The use of sharp 90-degree bends and tees will not be allowed. The bends shall conform to same specifications as given for PVC conduits for joining of pipe all precautions and procedures recommended by manufacturer shall be followed.

30.2.2 CONDUIT ACCESSORIES

a) The use of factory made round PVC junction boxes is prohibited. Only cast iron junction boxes of 64 mm dia and 64mm depth conforming to BS 31 having nipples to receive PVC pipe with force fit shall be used for ceiling outlets. The wall type junction box shall also be of cast iron having minimum dimensions of 64 mm dia and 40 mm deep. Each junction box shall be provided with one piece cover which shall be fitted on the box with chromium plated screws.

b) Conduit accessories such as switch boxes, socket outlet boxes, pull boxes and inspection boxes shall be made of 16 SWG sheet steel having dust proof covers. All boxes shall have required number of conduit entry holes and earth terminals for connecting E.C.C. All the rectangular or square shaped boxes shall have nipples to receive PVC conduit with force fit. All these boxes shall be painted inside and outside with black enamel, over a base coat of red oxide antirust paint. Shapes and sizes of these boxes shall be determined on each application.

c) Manufactured smooth bends shall be used where conduit changes direction. Bending of conduit by heating or otherwise shall be allowed only at special situations where bends cannot be installed with the permission of the Engineer-in-Charge. Use of sharp 90 degree bends and Tees is prohibited. Bends shall have enlarged ends to receive the conduit without any reduction in the internal diameter of the PVC pipe.

d) All accessories e.g. boxes, couplings, bends, solid plugs, bushes, reducers, checknuts etc. shall be equal in quality to the specified conduit.

e) Where inspection boxes occur in floor slabs a special non- ferrous metal floor trap shall be required.

30.2.3 LT. CABLES

a) The Low Tension cables shall be manufactured to the requirements of B.S. 6004, B.S. 6500, B.S. 6346 or VDE 0271 and rated at 250/400, 300/500, 450/750 and 600/1000 volts as the case may be. The cables shall be manufactured by M/s Pakistan Cables limited or M/s Newage Cables limited or equivalent as approved by the Engineer-in-Charge.

b) The conductors shall be annealed copper conductors single or standard, circular or shaped as the case may be, conforming to B.S. 6360.

c) The conductors specified for use in the cables shall be of at least 98% IASC conductivity.

d) The conductors shall be insulated with poly-vinyl chloride insulation. The minimum thickness of the insulation shall be in conformity with the specifications to which it is manufactured.

e) On all multi core cables proper markings for core identification shall be provided according to B.S. Specifications.

f) Power cables shall be multicore cables, insulated and sheathed, armoured or unarmoured as required.

g) Various conductors forming the cables shall be laid together and voids shall be filled with non-hygroscopic materials so as to give a circular shape to the cable.

h) A tough PVC shall be extruded over the cable so as to cover the insulated conductors and fillers.

i) Where armouring is required, a soft PVC jacket shall be provided over the laid up cable. Steel wire armouring shall be applied on a tough PVC sheath extruded over the cable so as to cover the insulated conductors, fillers, jacket and armouring.

j) Complete identification of the cable shall be embossed on the final over-sheath of the cable at every metre length.

k) All flexible cables shall have multi-stranded copper conductors insulated with PVC insulation. Where flexible cables are liable to rough handling, they shall have PVC sheath.

l) The following tests if required shall be carried out by the manufacturers:

    - Dielectric Strength Test

- Instantaneous and long time break down strength test
- Temperature rise test
- High voltage test.

Test certificates covering all these tests shall accompany the cables supplied by the Contractor.

After carrying out the tests as laid down in these Specifications both ends of the cables shall be scaled at the manufacturer's works.

30.2.4 WIRING ACCESSORIES

a) Switches

i. ONE-WAY SWITCHES - INDOOR TYPE:

Switches for controlling light and fan points shall be single pole, rated for 5 Amps, 250 Volts A.C. The body of the switches shall be of Bakelite with white face plate suitable for flush mounting on a sheet steel outlet box. The switches shall be piano type having silver tipped contacts and shall operate with snap action. Switches manufactured by an approved manufacturer (M/s CLIPSAL, LEGRAND, BOCH or equivalent approved by the Engineer-in-Charge shall only be used.

a. Unless otherwise specified, wherever switches control only the light points, these shall be plate type gang switches installed on common outlet boxes.
b. Where specified metal front plates shall be used with single switches, the plate shall be finished in golden matt colour or as otherwise directed by the Engineer-in-Charge.
c. For locations where switches and fan regulators are installed together, single switches shall be grouped and fixed on 4 mm thick plastic sheet screwed to a sheet steel box of appropriate dimensions. Except for switches controlling light points, all single switches for fans, sockets, etc., shall have identification symbols on the operating levers.

ii. TWO-WAY SWITCHES – INDOOR TYPE:

Two-way switches for control of lights shall be of same make and specifications as for One-way switches except these shall be of use to control light circuit from two different locations.

SCREWS:

The fixing of switch plate on outlet boxes shall be by means of flat head countersunk galvanized screws with the head of the screw finished flush with the surface of the plate.

SWITCHES - OUTDOOR USE/WEATHER PROOF:

The switches shall be pole rated for 5 Amps, 250 Volt with cast iron or steel body and gasketted cover. The conduit entry hole in the body shall have long threads to provide watertight fitting. Sealing compounds for water-tight connection shall be used at conduit entry in the body of the switch.

b) Switch-Socket Outlets

Switch socket units shall be combined 2 and 3 pin 5 Amp or 3 pin 15 Amp 250 Volt A.C. moulded type with switch and socket on white face plate conforming to the requirements stated above for switches-indoor type. The outlets shall be heavy duty type suitable for mounting on sheet steel outlet box. The 3 pin 15 Amps sockets shall have shrouded live contacts and be designed such that the earth pin of 3 pin plug is engaged to socket earth before mating of live contacts.

Where metal plate switches are installed, the outlets shall also be provided with front plate of similar design as the switches.

In general use of 2 pin 5 Amp 250 Volts socket outlets shall be avoided. Where such outlets are specifically required, these shall conform to the Specification of switches and/or switch socket outlets as applicable.

The 2 pin/5 Amps, 250 Volts sockets outlet, if required for mounting on board in the given areas, shall be of the same shape and dimensions as the piano switches installed with it.

The switch – Socket Outlets shall be of CLIPSAL, LEGRAND, BOCH or other equivalent approved by the Engineer-in-Charge.

c) Outlet Box

The outlet boxes for installation of switches, fan regulators and socket outlets shall be 16 SWG sheet steel or of PVC as specified having appropriate dimensions. The box shall have suitable arrangement for receiving the conduit. An earth terminal shall be provided for connecting the earth wire. The outlet box shall be given two coats of anti-rust red oxide paint.

d) Ceiling Rose

The ceiling rose shall be suitable for 5 amps 250 volts single phase A.C. It shall have white plastic moulded base plate, copper or brass terminals for wiring with 2.5 sq.mm cable. The ceiling rose shall have a cover with cable inlet hole.

The ceiling rose shall not embody any fuse terminal as an integral part of it.

e) Switches for Group Control of Lights

The switches for group control of lights shall conform to the same specifications as stated for miniature circuit breakers in section "*Distribution Boards"* of these Specifications. However, these shall not be provided with over-current protections. The switches shall be installed on sheet steel box with front plate and where stated in the Drawings.

f) Push-Button Station for Remote Control of Lights

These shall comprise of momentary contact ON - OFF push buttons, which shall control lights through contractors in L.T. Switch Boards/Distribution Boards. The push buttons shall have manufacturer furnished front plate suitable for mounting on an appropriate size sheet steel outlet box.

g) Lamp Holder

i. All lamp holder shall be 2 pin type and suitable for 5 watt to 200 watt 250 volts incandescent lamp.
ii. Lamp holder to be used with wall bracket shall be of brass pendant with good quality of porcelain assembly for connection cable and holding lamp.
iii. The holder of hanging lights shall be of backlite with ½" nipple to provide grip to the cord connected to the holder.
iv. For verandah's where wall/ceiling brackets are not provided, bakalite batten holder should be fixed with the outlet or on T-wood round block or otherwise as desired by the Engineer-in-Charge.
v. For incandescent lamp 500 watt and 1000 watts screw type brass holder with good quality of porcelain assembly shall be used. The top of the holder shall have the porcelain nipple for isolating the cable from holder.

h) Screws

i. For fixing switch plates on the metallic boxes brass machines screw flat head not less 4 mm thick shall be used.
ii. To cover the junction/pull boxes with plastic/MS Cover galvanize machine screw 5mm shall be used.

30.2.5 FANS

a) Ceiling Fans

Ceiling fans shall be capacitor type, five speed suitable for 250 volts single phase 50 Hz. The air displacement shall be 330 cubic metre per minute for 1422 mm (56") sweep and 280 cubic metre per minute for 1219 mm (48") sweep at maximum speed. The fan motor shall be capacitor type and bearing shall be groove type to give noiseless operation.

The fan regulator shall have high grade steel laminations and shall have five speed marks and one 'OFF' mark. The regulators shall be recessed or surface mounting type as required. Alternatively fan dimmers rated for 100 W, 250 Volts of approved make (PAK fans, GFC, Millat or as approved by the Engineer-in-Charge could be used.

The fan hook shall be made of 16 mm diameter mild steel rod. It should be in the form of a loop about 75 mm long and about 50 mm wide. The rod should be bent to have at least 200 mm extension on both sides for tying to reinforcement steel of slab. The fan and regulator shall be the first quality product from an approved manufacturer as above.

b) Wall Bracket Fans

Fan motor shall be capacitor type and bearing shall be groove type to give noiseless operation. The fan regulator shall be built-in type with high grade steel laminations and shall have five speed marks and one "OFF" mark. The fan shall be of an approved make.

c) Exhaust Fans

Exhaust fans shall be direct driven type complete with motor, angle iron frame, back draft dampers and mounting accessories. Blades shall be of steel and factory adjusted for pitch. Blades of back draft damper shall have a link rod and the design shall be such that damper remains in full open position without rattling when the fan is operating.

30.2.6 LIGHTING FIXTURES

a) Incandescent Light Fixtures

The glass globes/shades/diffusers of the incandescent light fixtures shall be of first class quality glass free from any air bubbles or voids. The glass shall generally be of opal white colour unless otherwise specified. The shape of the glass may be spherical, hemispherical, flattened bottom or tablet shaped as required.

Surface mounted fixtures shall have white stove enamelled sheet steel body. It may also be satin brass or aluminium anodized finish as required. The fixing holes shall match the outlet box. Wall bracket light fixtures shall have back plates with matching holes of the outlet box and decorative finish as required.

All light fixtures shall have bi-pin brass lamp holders and shall be from an approved manufacturer conforming to BS 161. Light fixtures clear or frosted, shall have a minimum useful life of 1000 hours.

b) Fluorescent light Fixtures

All the light fixtures shall have lamps and ballasts of the wattage specified. The fluorescent lamp shall be either 600 mm - 20 watts or 1200 mm - 36 watts and the colour shall generally be day light, cool day light and/ or warm white with an average output pf 2600 lumens + (5%) for 36 watts and 1030 lumens (+ 5%) for 20 watts. The fluorescent lamps shall be from an approved manufacturer conforming to BS 1853 and having a minimum useful life of 5000 hours.

The ballast shall be totally enclosed type suitable for operation on 220 V, 50 Hz, single phase supply. A wiring diagram, wattage, voltage and current ratings shall be printed on the body of the ballast. The power loss shall not be more than 10 watts for 40 watts ballast. The ballast shall be noiseless in operation without any whistling sound. The manufacturer shall be called upon to guarantee a trouble free life of 3 years, effective from the date of Completion Certificate.

All light fixtures shall be provided with power factor improvement capacitor to give a minimum p.f. of 0.9. The lamp holder shall be lock-in rotary type.

The starters shall be glow type with radio-interference suppressors/by-pass capacitor.

The internal wiring of the light fixture shall be carried out at manufacturer's factory with heat resistance wires of size not less than 1.5 mm square.

The louvers of light fixtures shall be made of anodized aluminium and/or moulded plastic. The diffusers shall be made of acrylic perspex with a minimum sheet thickness of 3 mm.

The body of the light fixture shall be white or grey stove enamel as required. The industrial reflector shall have white stove enamel finish inside and grey / green stove enamel finish outside. Appropriate-sized bushed entry holes and fixing holes shall be provided. The thickness of the sheet steel used in the fabrication of the body and reflector shall not be less than 20 gauge.

The materials for louvers and paint of metal parts shall not deteriorate due to ultra-violet radiation from lamp with a minimum guarantee of 5 years. Pendent type fixtures shall have 2 Nos. 13 mm dia chromium plated pendent tubes for suspension or as per detail shown on the Drawings.

30.2.7 MAIN LT. SWITCH BOARD

a) General

The LT. switchboard shall be indoor type, free standing, self supporting, floor mounted, totally enclosed, sheet steel clad, dust and vermin proof, completely wired, factory assembled and suitable for operation on 3 phase 4 wire system, 415 V, 50 Hz, AC supply. The board shall be suitable for installation and capable of front attendance. The switchboard shall comprise of multipanels suitable for housing air circuit breakers, moulded case breakers or load break switches as shown on the Drawings. The switch board shall be designed to suit service conditions and ensure security and safety during operation, inspection, operation, cleaning and maintenance. The switch board shall be designed and tested to International Electro Technical Commission (lEC) recommendations. Each panel shall withstand a voltage of 2000 volts insulation level for one minute power frequency test. The switchboard shall be divided into panels and panels divided into compartments to accommodate the required number of circuit breakers of fuse switches, bus bars, instrument transformers, protective relays metres, etc.

b) Air Circuit Breakers

The Air Circuit Breaker (A.C.B) shall be triple pole of specified rating, fixed type, trip free, spring charged, quick make, quick break manually operated mechanism and visual ON/OFF position indicator. The circuit breaker shall be suitable for continuous duty for the rated current for indefinite period of time under service conditions. The circuit breaker shall have specified breaking capacity.

The A.C.B. shall conform to BS 4752. The contacts of the A.C.B. shall be heavy duty, spring charged and silver plated. Replaceable electric arc contacts and arc chutes shall be provided. The operating handles if made of metal shall be either earthed or additionally insulated to withstand full insulation voltage. A certified copy of full type tests carried out by an independent agency on identical breakers shall be acceptable in lieu of the following type and routine tests:

- Making capacity, breaking capacity and short time current tests.
- Mechanical and electrical life endurance tests.
- Temperature rise test.
- Power frequency withstand test.
- Milli volt drop test.

c) Meters

The following instruments shall be included in the main switchboard unless otherwise specified:

- 1 - KWH metre
- 1 - Voltmeter 0-500 volts
- 1 - Voltmeter phase selector switch
- 1 - Ammeter commensurate with rating of ACB
- 1 - Ammeter phase selector switch

All the instruments shall be flush mounted and back connected in a transparent dust proof cover with 96 mm or 144 mm Square dial which shall have prominent black graduations on white surface. The instruments shall be manufactured and tested in accordance with IEC Publications 51 or B.S. 89 Part 1.

d) Moulded Case Circuit Breakers

The moulded case circuit breakers (MCCB) shall be triple pole and of the rating specified on the drawings. The MCCB shall be fixed type, having trip-free, manually operated mechanism and on/off/trip position indicators. The MCCB shall comprise of adjustable hydraulic magnetic releases for overload protection and instantaneous adjustable electro-magnetic releases for short circuit protection. The tripping devices shall have related time current characteristics so that positive discrimination and selective tripping is obtained assuring the tripping under fault conditions of only the breaker in the circuit ahead of the fault location. The MCCB shall have a rupturing capacity of 35 KA (or as specified) and shall be manufactured and tested to lEC Publication 157-1 Part I or BS 4752 or BS 3871 Part I.

The MCCBs shall be of BOCH, CLIPSAL, LEGNOL or equivalent approved by the Engineer-in-Charge.

e) Load Break Switches

The load break switches shall be on load type having quick make and quick break mechanism with spring loaded handles and ON/OFF visual indications. The load break switches shall be designed for continuous operation on rated current, rated voltage and rated frequency to BS 5419. The contacts shall be heavy duty made of silver plated copper having 98% I.A.S.C conductivity. When the operating mechanism is in "OFF" position, the fuses shall be completely disconnected. If the handle is metallic it shall be properly earthed. Electric arch chambers with replaceable arch chutes shall be provided.

The load break switches shall be of BOCH, CLIPSAL, LEGNOL or equivalent approved by the Engineer-in-Charge.

f) HRC Fuses

The HRC fuses shall be manufactured and tested to BS 88. A supplement of 100% spare fuses of each size shall be supplied with the switch-board.

The fuse carriers and bases shall be made from moulded phenolic compound and/or porcelain.

g) Bus Bars and Connections

A set of four bus bars, three for phases and one for neutral, made of copper having 98% IASC conductivity shall be provided. The bus bars in panels and chambers shall be tin plated, air insulated having minimum clearance of 80 mm between phase to phase and 25 mm between phase to earth. The neutral bar shall be of the same section. All the bus bars shall be mounted on insulators at suitable intervals and should be extensible on both ends. The marking and arrangement of bus bars, main connections and small wiring shall conform to BS 159. Bus bars and bus bar connections shall also conform to BS 159.

h) Enclosures

The enclosures shall be fabricated from 3 mm thick high grade sheet steel and shall be designed to house all the live parts which shall be accessible through front doors. The enclosures shall be tropical in design completely dust and vermin proof and liquid repellent, with special regard to danger of flashover both in service and in isolated position. Hinged lockable doors shall be provided on the front and bolted plates at the rear. Adequate air circulation by means of vent covered with suitable metal gauze shall be provided in the enclosures. All exterior and interior surfaces of the enclosure shall be thoroughly cleaned and freed of dust, rust and greasy matter. The enclosures shall be given three coats of paint. The primer shall be zinc chromate and/or iron oxide. The second and third coats shall be top quality battleship grey enamel. Enclosures for each panel shall be provided with designation labels as directed by the Engineer-in-Charge.

i) Earthing

The switchboard shall be effectively earthed at two points by means of a copper strip of suitable cross-section bolted to connections near the bottom of the switchboard.

j) Accessories

Designation labels, lifting lugs, foundation bolts, interconnecting nuts, bolts, washers, thimbles, lugs, levelling shims, cable glands and/or cable end boxes for all the sizes of incoming and outgoing cable shall be supplied with the switchboard.

30.2.8 SUBMAIN BOARDS

The sub-main boards shall be similar to the Main L.T. Board and the components in its fabrication may differ and shall comprise of the components as shown on the Drawings. The rupturing capacity of each component for sub-main boards shall be as specified.

All other details and specifications as provided in sub-section 30.2.7 shall be applicable.

30.2.9 DISTRIBUTION BOARDS

a) General

The distribution boards (DBS) shall be either free standing, cubicle type or wall mounting type suitable for surface and/or recessed mounting. Each distribution board (d.b.) shall be tropical in design, fully dust and vermin proof and liquid repellent. The cabinet housing the main components shall be fabricated from mild steel sheets 16 SWG thick and reinforced with structural steel members welded to it. Front access, mechanically locked and hinged doors, fully gasketted, having one or two leafs depending upon the size of the cabinet shall be provided on each cabinet. All openable parts shall be provided with gaskets or lining and screwed to the main body with chromium plated screws. The cabinets after fabrication shall be thoroughly cleaned, completely derusted and degreased before applying one coat of zinc or lead-based primer. Two coats of top quality synthetic emulsion or stove enamel paint in battleship grey colour shall then be applied. All exposed parts of the dbs shall be covered with 5 mm thick bakelite sheet. A load distribution chart shall be provided in each db showing the areas fed by each circuit and a suitably sized pocket inside the front door shall be provided for the purpose. Each db shall be delivered complete with all instruments, accessories, rating plates as approved by the Engineer-in-Charge.

Suitable cable entry glands shall be provided as required for floor mounted boards on the incoming cables but for outgoing cables and/or wall mounted boards exact number of conduit entry holes as are required shall be provided with male brass bushes. The bushes shall be tin plated and fully shrouded or housed in gasketted compartments.

b) Components

The main components e.g. moulded case circuit breakers, load break switches, HRC fuses and instruments that are required for db's as shown on the Drawings shall be the same as described in sub-section 30.2.7.

c) Miniature Circuit Breakers (MCB)

The incoming line shall have triple pole mcb's suitable for use on 415V 50 Hz, AC whereas the outgoing line shall have single pole or single phase mcb's for use on 220V, 50 Hz, AC. The ratings shall be as shown on the Drawings and/or as directed by the Engineer-in-Charge.

The mcbs shall be moulded case type having hydraulic magnetic short circuit releases, contacts, operating mechanism and arcing chambers.

The mcbs shall be manufactured and tested to BS 3871 and shall have a rupturing capacity of 7.5 KA. The final circuit mcb, on the outgoing, shall however, be rated 5 KA. The mcb's shall be manufactured by an approved manufacturer whereas the distribution boards shall be manufactured by any bonafide manufacturer.

30.2.10 EARTHING SYSTEM

a) General

The earthing system shall consist of earth electrodes, earth connecting points, earthing leads, earth continuity conductors and all accessories necessary for the satisfactory operation of the associated electrical system. The earthing system shall also comply with the requirements of CP-1013.

b) Earth Continuity Conductor

The earth continuity conductor (ECC) shall be green or green/yellow coloured PVC insulated copper wire of sizes indicated on the Drawings. The ECC shall comply with the specifications as given for single core cable in Section 30.2.3. For bonding of miscellaneous metalwork, the size of ECC shall be as specified. All sockets, lugs, thimbles etc., shall be provided for a complete earthing installation.

c) Earth Electrodes

The earth point shall comprise of a 600 x 600 x 5 mm electrolytic copper plate, tinned for protection against corrosion. The edges of the copper plate shall be chamfered. The plate shall have holes for connecting each earthing lead or tape to earth terminals. The terminals shall comprise of 16 mm dia. copper bolts and nuts and double spring washers. 13 mm dia G.I. Pipe with a tee at the top end shall be provided for watering purpose during dry season.

d) Earth Connecting Point

The earth connecting points shall comprise of tinned copper bar, rectangular in shape, having dimensions of 350x50x6mm, if not otherwise specified. Terminals for connection shall be arranged as required.

The terminals shall have brass or tinned copper bolts, nuts and washers for protection against corrosion. A hole shall be provided in the centre of the copper bar for fixing to the wall by means of 10 mm dia nut and bolt using brass or tinned copper washers.

e) Earthing Lead

The earthing lead shall connect the earth electrode to the earth connecting point. It shall be of round hard drawn bare electrolytic copper wire of the size shown on the Drawings.

f) Earthing by Earth Rods

The earth rod shall be of mild steel and shall be protected against rusting by a thick exterior layer of copper (not less than 0.33 millimeter), permanently molten or electrolytically deposited on a high strength steel core which shall provide rigidity for easy driving without bending.

g) Earth Rod Dimensions

The earth rod shall have a nominal dia of 16mm with chamfered head of 2mm x 45 chamfer. The overall length of earth rod shall be 3000 + 5mm.

30.2.11 LIGHTING PROTECTION SYSTEM

a) Applicable Standards/Codes

Latest editions of the following standards and codes shall be applicable for the material specified within the scope of this section.

BS 6651	:	Protection of structures against lightning
CP 326	:	Protection of structures against lightning (code of practice).
IEC 1024-1	:	Protection of structures against lightning

b) Material

i) General

The installation of lightning protection system shall comprise;

- Lighting arrestors
- Down/Roof conductors.
- Testing terminals
- Earth electrodes

ii) Air Terminals

The Air Terminals for lightning protection system shall be solid copper to ensure good corrosion resistance. The thread should be roll formed for maximum strength, with a bronze nut. The terminal base and the plate type test clamp shall be cast gun metal, designed with appropriate section thickness, mechanically strong, corrosion resistant with low electrical resistance. All other accessories for fixing of air terminals to the concrete surface and/or roof conductor/down conductor shall be of copper or brass, as approved by the Engineer-in-Charge.

iii) Down/Roof Conductors

The down/roof conductors for lightning protection system shall be bare copper conductor of sizes as per approved shop drawings. All connections between metal work on the roof shall be with the same conductor sizes and material as for roof conductor. All accessories for fixing of copper conductor to concrete surface shall be of copper or brass as approved by the Engineer.

iv) Testing Terminals

For each down conductor, a testing point shall be provided. It shall be installed 1.5 meters above the finished floor level or as convenient for testing purposes and as directed by the Engineer-in-Charge. The testing terminals shall have removable connections.

v) Earth Electrode

The earth electrode for lightning protection system shall comprise 3 meter long, 14 mm dia. copper clad or galvanised steel rod having flat head at drive end and pointed conical tip at the driven end.

The tip shall be hardened to facilitate driving. At the top of the pipe, a clamp for bolted connections shall be provided suitable for connection to the down conductor.

30.2.12 INDOOR TYPE 500 KV, 11/0.4 KV POWER TRANSFORMER

a) General

The transformers shall be complete, with all accessories and attachments as specified or otherwise required for satisfactory operation, service and maintenance.

All details, drawings, data, etc. for each type and rating of the Power Transformer shall be furnished with the bid. Transformer with accessories shall also comply with the General Specifications as of Sub-section 30.1 and with other relevant provisions of the Contract. The transformer shall be supplied taking into account WAPDA system's requirements.

b) Applicable Standards/Codes

Latest editions of the following standards and codes shall be applicable for all materials in scope of this section:

BS90	-	Power transformers
BS14	-	Transformer oil
BS171	-	Specifications for power transformer
BS223	-	High voltage bushings
IEC7	-	Power transformers

c) Material

(i) Power Transformer

The transformer tank shall be constructed of welded boiler plates and provided with external radiating tubes. The tank and radiating tubes shall be designed to withstand, without developing any deformation, pressure at least 25% greater than the maximum operating pressure. The steel cover plate shall be bolted to the tank using gasket for perfect oil seal.

Inspection hole with cover shall be provided on top of the tank. Two earth terminals shall be provided at the base of the tank. The tank shall be anti-corrosive painted and finished in gray colour. The oil preservation system shall have a conservator tank fitted with silica gel breather, oil level indicator and a drain valve.

The transformer core shall be built of non-aging, cold rolled, electrical silicon steel lamination and each lamination insulated to reduce eddy current losses. The core laminations shall be clamped and bolted effectively to reduce humming. The winding coils shall be of high grade electrolytic copper conductor, flat or round, paper insulated, thoroughly dried and impregnated as required. The medium voltage (MV) lead on indoor transformer shall be brought out to glazed porcelain insulator bushings for external connections to cables. Protective spark gaps of suitable design shall be connected in parallel to the MV bushings to protect the transformer from surge voltages. The three LV and one neutral phase leads shall be brought out and terminated at glazed porcelain insulator bushings for Connection to LV side by copper conductor cables.

Off-load tap changer shall be provided on MV side at suitable location preferably on the side of transformer tank. A clear marking illustrated by diagram shall be provided to indicate the tap positions. Double float Buchholz relay shall be provided on the transformer. It shall have required number of contacts for connection to tripping and alarm circuits.

The transformer shall be provided with the following accessories;

- Oil filling valve for vacuum filling of oil
- Oil drain valve with sampling device
- Bi-directional rollers
- Lifting lugs
- Dial type thermometer which shall have maximum temperature indicator pointer
- Stem type thermometer fitted in a pocket for indicating the oil temperature
- Diagram and rating plate
- Jacking pads

- Pressure release safety valve

i) Principal Data of Power Transformer

The Power transformers shall be fully tropicalized, three phase, step down, oil filled, self cooled, core type, double wound, suitable for parallel operation and for indoor installation.

The Power transformers shall meet the minimum technical specifications but not limited to the following:

Description	Data suggested	Data submitted
Type	0.42	
***Capacity (Rated continuous)	As specified	
Voltage ratio at no-load	11000/415 Volts	
Frequency	50 Hz	
Vector group	Dy 11	
Off load tapping arrangement (on HT side)	-7.5%, -5%, -2.5%, 0% +2.5%, +5%,	
HT connection	11 kV Delta	
LT connection	400V with grounded star point.	
Temperature rise of oil over ambient temperature	40^{0} C maximum	
Temperature rise of winding over ambient temperature	50^{0} C maximum	
Impedance voltage (%)	4	
Voltage regulation for normal operating conditions	Not to exceed 2.5% of no-load	
Voltage regulation at 85% pf at full load (%)	3.5	
Rated maximum voltage HT/LT	15kV/0.6 kV	
Basic insulation level	95 kV	
Power frequency withstand voltage	34 kV	
Rated short-time current (kA)	25	
Switching inrush current (Amps)	6-7 times of HV line current	
Power losses at full load (Watts) Iron losses at unity pf Iron losses at 0.85 pf Copper losses at unity pf Copper losses at 0.85 pf	Data to be provided by the supplier	
Efficiency at 0.85 pf % At 25% of rated load At 50% of rated load At 75% of rated load At 100% of rated load	Data to be provided by the supplier	
Transformer Weight (Kg) Total, Weight of oil Windings	Data to be provided by the supplier	
Transformer Oil	Data to be provided	

Type, Quantity for one complete filling	by the supplier	
*The capacity of transformer could be		
25 KVA		
50 KVA		
100 KVA		
200 KVA		
500 KVA		

30.3 EXECUTION

30.3.1 INSTALLATION INSTRUCTIONS

For factory assembled equipment, manufacturer’s instructions shall be obtained by the Contractor (in the form of drawings, descriptions etc) and these shall be followed under the guidance of the Engineer-in-Charge.

The Contractor shall set out the works himself as per the Specifications and Drawings and shall properly position the equipment on the specified foundation/location.

In general, the manufacturer's instructions for installation shall be followed. Any defect or faulty operation of equipment due to the Contractor not following the manufacturer's instructions shall be corrected and repaired by the Contractor at his own cost.

For any deviation from the working drawings that are deemed necessary by the Contractor due to site conditions, he shall submit the details and obtain the Engineer-in-Charge's approval before starting such works.

30.3.2 CONDUIT INSTALLATION

a) Concealed Conduits

Where concealed conduit system is required by the Drawings, the conduit shall be installed concealed in roof, wall, column, etc. Conduits shall be laid under-floor only where specifically stated.

When concealed, the conduit shall have a minimum of 32 mm cover of concrete measured from the top of conduit to finished surface. In reinforced cement concrete (RCC) work, the conduit shall be laid before pouring of concrete. Under no circumstances shall chases be made in the RCC structure for concealing conduit and accessories after pouring of concrete. The conduit shall be supported on top of the bottom reinforcement of the slab. All outlet boxes shall be firmly supported and installed such that they finish flush with the soffit of slab or beam.

Where conduits have to be concealed in cement concrete (CC) block or brick masonry, chase shall be made with appropriate tools and shall not be made deeper than required. The conduit shall then be fixed firmly in the recess and covered with cement concrete mixture. The work of cutting in the masonry work shall be coordinated with the civil work. The Contractor shall obtain approval from the Engineer-in-Charge before starting chasing and cutting.

The termination of conduits at/or near the equipment/switch board shall be as shown diagrammatically on the Drawings or as directed by the Engineer-in-Charge. The exact locations of the termination shall be coordinated with the equipment/ switchboard to be installed. Any extension of conduit to suit the site condition shall be made without any extra cost. Conduit ends shall be properly plugged in order to prevent the entry of foreign materials. All openings through which concrete may leak shall be carefully plugged and boxes shall be suitably protected against filling with concrete. At all terminations of conduit, sharp edges of conduit ends shall be prevented to avoid the cutting or damaging of wires or cables during pulling through the conduits.

Under-floor conduit shall be installed at a minimum depth of 50 mm from the finished floor level or as otherwise shown on the Drawings. The conduits shall be installed empty before laying of floors with an 18 SWG steel wire drawn through the conduit for pulling the cable. No conduits shall be laid in bathroom floors.

The entire conduit system shall be installed and checked before the wiring is carried out. Any obstruction found shall be cleared before the installation of the cable.

Pull boxes and adaptable boxes shall be provided in conduit runs wherever required to facilitate pulling operation and shall' meet the following requirements:

- Pull boxes

  For straight runs, the spacing shall not be more than 20 metres.

  For runs with one 90 degree bend, the spacing shall not be more than 15 metres.

  For runs with two 90 degrees bends, the spacing shall not be more than 10 metres.

- Adaptable boxes

  For conduits upto 25 mm dia, the boxes shall be 50 mm in depth.

  For conduits upto 40 mm dia, the boxes shall be 63 mm in depth. For conduits upto 50 mm dia, the boxes shall be 87 mm in depth.

  The rectangular inspection boxes or pull boxes shall be 16 SWG sheet steel of suitable design to receive conduits. The box shall be painted inside and outside with black enamel paint over a base coat of red oxide primer paint. The minimum length of inspection box shall not be less than four times the bending radius of the cable as recommended by the cable manufacturer. All concealed type pull boxes shall have a white plastic sheet of appropriate size fixed to the box by means of galvanized screws.

  Adaptable boxes shall be 16 SWG sheet steel and painted and finished to the same quality as the distribution boards. Wherever the conduit lengths cross the expansion joint either along the columns or slab, suitable arrangement shall be provided so that when the conduit lengths in the expansion joints are stressed, the conduit shall not crack or break.

b) Surface Conduits

The conduits for surface installation shall be of steel/PVC as shown on the Drawings or approved by the Engineer-in-Charge. The conduits at specified locations shall be installed on the surface of wall, columns, ceiling, etc. by means of steel saddles and clamps of approved design.

The saddles shall be installed on the surface by means of wall plugs and galvanized screws. Appropriate size of holes in the structure shall be made by drilling. The thickness of saddles shall not be less than 4 mm and clamps shall be of 16 SWG sheet steel. These shall be fixed at a maximum of 1000 mm spacing along horizontal and vertical runs of conduit. All accessories for complete installation of conduit system shall be provided by the Contractor. The requirements of pull boxes, etc. as specified for concealed conduits shall also be applicable for surface conduits.

c) Galvanized Iron Pipes

The galvanized iron (G.I) pipes shall be installed at a minimum depth of 900 mm measured from the top of pipes to finished ground level. The pipe shall be laid and checked for soundness before completion of civil works.

The G.I pipes at the entrance of the buildings shall be installed at locations as shown on the Drawings.

At all joints the pipe shall be firmly screwed and cotton yarn with waterproof compound shall be used to make the joint waterproof. At each termination, the pipe end shall have threads and socket screwed on thread for installing soft metal bush.

The soft metal bush shall be of approved quality and shall be male type.

The installation of pipes shall be complete in all respects including its fixing at terminations before wiring work is started. All sharp edges and burrs shall be removed by using reamer or any approved device. The entire conduit system shall be installed before wiring is carried out and conduit shall be checked for continuity. Any obstruction found shall be removed without damaging the installation.

d) PVC Pipe

Rigid PVC pipes shall be installed under roads and paved areas, at crossing with other services and at cable entering building as shown on the drawings. The depth of the pipe shall vary according to the conditions at site, and approval of Engineer-in-Charge shall be obtained prior to installation. In general the pipes shall be installed underground at the following depths measured from the top of the pipe:

a)	Under roads and paved surface	900 mm below the finished surface
b)	When crossing other services for the crossing length.	250 mm vertical clearance. 500 mm horizontal clearance with CC protective cover.

The trench of required dimensions shall be excavated and the bottom of trench cleaned and levelled. A four inches thick bed of fine sand shall be provided over which the PVC pipes installed after proper alignment. Where two or more pipes are installed in the same trench the clearance between pipes shall not be less than two inches. After laying of pipe the trench shall be backfilled with clean-screened earth in layer of four inches. Each layer shall be properly compacted.

Where underground cables enter connection terminal boxes the PVC pipe shall be installed on surface by means of PVC clamps at a maximum interval of eighteen inches. After installation, the ends of the pipe shall be plugged with material impervious to water and chemicals. All joints shall be sealed adequately to prevent entry of foreign elements.

The installation of pipes shall be completed in all respects including its fixing at terminations, before cabling work is started. All sharp edges and burrs shall be removed by using reamer or any approved device. The pipe shall be thorough cleaned of dirt and dust from inside. The pipes shall be installed in proper co-ordination with other works.

30.3.3 WIRING INSTALLATION

a) Conduit Wiring

The wiring through conduit shall be started only after the conduit system is completely installed and all outlet boxes, junction boxes, etc., are fixed in position. The wires shall be pulled in conduit with care, preferably without the use of any lubricant. Where necessary and after approval of Engineer-in-Charge, the cable manufacturer's recommended lubricant shall be used. Use of any kind of oil or soap will not be permitted. Where several wires are to be installed in the same conduit, they shall be pulled together along with the earth conductor. All wires of same circuit shall be run in one conduit. The wires shall not be bent to a radius less than ten times the overall diameter of the wire, or more if otherwise recommended by the manufacturer.

The wiring shall be continuous between terminations and looping- in system shall be followed throughout. Spurr and Tee connections are strictly prohibited. Any joint in wires shall not be allowed. The use of connectors shall only be allowed at locations where looping-in is rendered difficult. The consent of the Engineer-in-Charge shall be required for using connectors. The connector shall be of suitable rating having porcelain body and sunk-in screw terminals. The connector shall be wrapped with PVC insulation tape after its installation. A minimum of 6 inches (150 mm) extra length of cable/wire shall be provided at each termination to facilitate repairs in future.

b) Maximum Capacity of Conduits

The following shall be the maximum capacity of conduits as per B.S 4607 Part 2 for PVC pipes and BS 31 for steel pipes. The number of cables relate to conduit runs incorporating not more than two 90 degree bends or equivalent. Where runs include additional bends or restriction, the No. of wires shall be reduced proportionately.

TABLE 30.3(a)
MAX. CAPACITY OF CONDUIT PIPES

SINGLE CORE CABLE	CONDUIT SIZE (Dia.)		
	(20 mm)	(25 mm)	(32 mm)
1.5 sq.mm (3/.036)	6	13	-
2.5 sq.mm (7/.029)	4	9	-
4 sq.mm (7/.036)	3	7	11
6 sq.mm (7/.044)	2	5	9
10 sq.mm (7/.052)	-	4	6
16 sq.mm (7/.064)	-	3	4
25 sq.mm (19/.052)	-	2	3
35 sq.mm (19/.064)	-	-	2

c) Surface Cable

All cables for installation on surface of wall, column, ceiling, etc., shall be fixed to the surface by means of galvanized steel clips secured to a steel channel by means of suitable stud plate, nuts and washer. The distance between each cable clip shall be such so as to support the entire weight of the cable. The distance between the cable and surface and also the vertical clearance between two adjacent cables at any point shall be 2 inches (50 mm) minimum. Common mounting channels shall be furnished for cable along the same route.

Where flexible cable is connected to fixed or portable apparatus, an additional core coloured green or green/yellow shall be included for connection to the apparatus earth, the size being the same as the neutral core. The flexible cable less than 0.75 sq.mm shall not be used.

The Contractor can offer alternate cable fixing arrangement which shall be approved by the Engineer-in-charge before commencing with installation.

30.3.4 WIRING ACCESSORIES INSTALLATION

a) General

The mounting heights of all wiring accessories fixtures shall be as stated on the Drawings or as directed by the Engineer-in-Charge. The instructions of the Engineer-in-Charge shall be obtained before fixing.

b) Switches And Sockets

Switches and switch sockets units shall be installed on 16 SWG thick sheet steel or PVC box as specified for surface mounting or recessed in wall. Where switches and fan regulators are provided at one place, these shall be grouped together and installed on a common plastic sheet fixed with the surface of the box. The fixing of plastic sheet on sheet Steel/PVC box shall be by means of flat head galvanized screws sunk in the plastic plate so as to finish flush with the surface. The edges of the plastic plate shall be champhered.

c) Ceiling Fan

Fan hook shall be installed in the RCC ceiling at the time of pouring of concrete. Fan hook extending rods shall be tied to the reinforcement before pouring of concrete.

The installation of fan shall include fixing of blades, down-rod, clamp, canopy and fan regulator, including testing and commissioning. The down rod shall be of required length having long threads and shall be provided with check nuts to secure it firmly with the clamp and with the body of the fan. A split pin shall be provided both at the fan body end and at the clamp for safety. Any scratches on the body of the fan or fan rod appearing during installation shall be cleaned and painted properly with the same quality paint as provided by the manufacturer.

d) Wall Bracket Fans

Wall bracket fan shall be installed on wall at locations shown on the Drawings as per manufacturer's recommendations. Wiring between wall fan point and fan shall be with 3 core 0.5 sq.mm PVC insulated, PVC sheathed, flexible cable.

e) Exhaust Fans

The openings for exhaust fan shall be provided by the Contractor at the time of construction of wall at locations shown in the Drawings or as directed by the Engineer-in-Charge. Mounting frame and accessories shall be embedded in concrete and the hole finished smoothly flushed with the ring. Hole shall be closed temporarily until installation of fan unit.

The fan units and the back draft dampers shall be installed, connected to the wiring and tested. The fan blades shall rotate smoothly with a clearance of 1/8 inch (3 mm) from inside of hole if it is an open unit and within its case if it is an enclosed unit.

30.3.5 LIGHTING FIXTURE INSTALLATION

a) General

The mounting heights and position of light fixtures shall be as indicated on the Drawings.

The Contractor must ensure that the light fixtures are installed uniformly with respect to the dimensions of the area. Any modifications due to site conditions may be made with the approval of the Engineer-in-Charge. All fixtures shall be carefully aligned before fixing in position.

b) Fluorescent Light Fixtures

The fluorescent light fixtures on the surface of ceiling shall be installed with the back of the body flush with the ceiling surface, and in a manner so as to facilitate wiring.

Nylon plugs and galvanized steel bolts or screws shall be used for fixing the light fixture to the ceiling. Pendant light fixture shall have two holes in the top of each casing for supporting to the roof by 3/4 inch (19 mm) dia G.I. Pipe. Wiring from ceiling to fixture shall be installed inside the pipe. For light fixtures installation on false ceiling the light fixture shall be supported to the ceiling and installation method/detail shall be coordinated with ceiling design and submitted for approval of the Engineer-in-Charge.

The wiring between ceiling rose and fixture shall be with three core 0.75 sq.mm flexible cable, PVC insulated, PVC sheathed.

c) Incandescent Light Fixtures

The incandescent light fixtures shall be installed on the surface of ceiling or wall by means of nylon plugs and galvanized steel screws, such that their back finish flush with the surface for exposed conduits and flush with outlet box for concealed conduit system. Wherever convenient, screws for fixing light fixtures shall be screwed into the holes of the outlet box. The light on false ceiling shall be installed in a manner as described for fluorescent light fixture.

The wiring between ceiling rose and fixture shall be with three core 0.75 Sq.mm flexible cable, PVC insulated, PVC sheathed.

30.3.6 MAIN BOARDS INSTALLATION

Floor mounting cubicle type main LT. switchboards, sub-main boards or distribution boards shall be erected with levelling shims, foundation bolts, washers, nuts, solder, lugs, clamps etc as shown on the Drawing.

The surface mounting main boards shall be installed on wall and shall be anchored by means of bolts or on steel channels as per manufacturer's instructions for installation. Wherever indicated, main boards for recessed mounting in wall shall be installed such that the door shall finish flush with the surface of the wall. The recess mounted main boards shall be installed before the plastering of walls. The main boards shall be protected to avoid any damage due to the civil work.

All loose parts despatched separately with the main boards shall be installed as per manufacturer's instructions and all adjustments or setting shall be made as required. All screws, nuts and bolts used for fixing the main boards shall be galvanized.

The location of main boards shall be as shown diagrammatically on the Drawings or as directed by the Engineer-in-Charge. The actual location shall however be determined at site, keeping in view the site conditions and in coordination with other equipment. The main boards installation shall include connecting all incoming and outgoing cables. The cable entry in the boards shall be provided from top or bottom as required. .

30.3.7 EARTHING INSTALLATION

a) General

Complete earthing systems as shown on the Drawings shall be installed by the Contractor. The earthing system shall give earth resistance, including the resistance of soil, earth leads and earth continuity conductor (E.C.C), equal to or less than one ohm.

At all connections of earth continuity conductor to switchboard, cable-end box or any other metallic body, proper size copper or brass sockets, thimbles or lugs shall be used to which the copper wire shall be connected by copper brazing. The soldering of copper wire at joints or terminations shall not be allowed. All tee-off connections shall be by copper brazing using suitable socket and clamps. After brazing, the jointed surface shall be protected by oxide inhibiting compound of Iow electrical resistance. For connections to metallic body, the surface shall be thoroughly cleaned before bolting the lug or socket.

Each transformer, switchboard, distribution board, etc., shall be connected at least at two points by two independent earth wires.

The earth wires shall in general run exposed on the surface of wall or cable trench or in conduits as shown on the Drawings. For under floor runs, these shall be installed in pipe/conduit of appropriate sizes. Where laid along underground cables, these shall be laid directly underground in unpaved area and in pipe in paved area.

b) Earth Electrode

The electrode plate shall be installed at a minimum depth of 6.0 metres from the ground or 1 metre below permanent water level whichever is less. The minimum horizontal distance between earth electrodes shall be equal to depth. The electrode shall be installed as per details shown on the Drawings.

c) Earth Continuity Conductor

The earth continuity conductor (E.C.C.) of sizes shown on the Drawings shall be installed all along the cable runs and connected to the earthing bar/terminals provided in the equipment. The body of all switchboards shall also be connected to earth by specified size of E.C.C. All other metal work shall also be connected to earth by specified size of E.C.C. For bonding of miscellaneous metalwork, suitable material shall be used to provide a permanent, low resistance path to the ground. .

At any joint or termination the E.C.C shall be connected using proper accessories. No connection shall be made by twisting of earth conductors.

d) Earth Loop for Body Earth

The earthing loop wherever required shall be installed for earthing of equipment, bonding, etc. Where run horizontally, it shall be installed along the wall at 300 mm above finished floor level by means of copper/brass saddles and clamps of approved design. The tee-off connection from the earth loop wires shall be copper brazed.

30.3.8 LIGHTING PROTECTION SYSTEM

a) Air Terminals

The Air Terminals shall be installed on the roof as per approved shop drawings. The terminal base shall be firmly secured to the concrete surface. It should be ensured that air terminals and/or roof conductors/down conductors shall be firmly fixed together, so that electro dynamic or accidental mechanical forces will not cause any damage to the clamping. The materials used shall withstand the electromagnetic effects of lightning current and predictable accidental stresses without being damaged.

The Contractor shall submit the fixing arrangement for the approval of the Engineer-in-Charge.

b) Roof Conductor

The roof conductors shall be installed on the roof as per approved shop drawings. The copper conductor shall be firmly secured to the concrete surface by means of copper or brass clamps of approved design at a maximum interval of 1000 mm.

The roof conductor shall be connected to the copper rod by means of copper clamps. The clamp to be tightly fixed to the rod and brazed to ensure low resistance path to earth. The contact surface between copper clamp and conductor shall be cleaned, silver painted, brazed after bolting and provided with a coat of anti- corrosive paint after installation.

c) Down Conductors

The down conductor shall be installed along the shortest possible route from roof to earth electrode. It shall be secured on the surface of wall by means of clamps at a maximum interval of 1000 mm. In general, bends shall be avoided along the routes of down conductor and maximum possible bending radius will be provided at turns. All joints between conductors shall be electrically and mechanically strong and effective. Straight joints in the down conductor shall be bolted. The joint shall be given a coat of anti -corrosive paint after connection. All accessories such as nuts, bolts, washers, solder, paint etc. shall be furnished by the Contractor.

For each down conductor a removable terminal shall be provided for testing purpose at approximately 1.5 meter height. The location of testing terminals are not shown on the drawings. The Contractor must ensure that testing terminals are installed so as to facilitate testing. The testing terminals shall be bolted type and made in accordance with the specifications for straight bolted joints. The connecting earth lead from testing terminals to earth electrodes shall be continuous without any joint. All metal work, pipes etc., at the roof and within 2 meters along the route of down conductor shall be bonded to the lightning protection system. The bonding shall be effective and approval of the Engineer-in-Charge shall be obtained for the bonding method.

d) Earth Electrode

In case the soil conditions at site permit, the earth electrodes may be installed by hammering the electrode in soil, until the top of the pipe is about 300 mm below the proposed ground level. If hammering down is not possible due to site conditions, a pit shall be first excavated in bare ground upto the required depth and electrode shall be installed upright in the pit. The excavated pit shall be backfilled in layers of 500 mm, each layer tamped and compacted. At the ground level an inspection chamber of cement concrete shall be constructed having dimensions as shown on the drawings. The inspection chamber shall have a cover supported on angle iron frame. The cover shall be approved by the Engineer-in-Charge and shall finish flush with the ground level.

30.3.9 500 KVA TRANSFORMER

Transformers shall be installed at locations shown on drawings. All civil works including provision of under-floor cable trench, transformer oil pit, openings in wall, steel channel etc. shall be carried out under civil works. The Contractor shall be responsible for general checking and co-ordination with civil works to ensure compliance with the requirements of transformer manufacturer for installation of equipment. For installation, connecting testing and commissioning of transformers, the Contractor shall provide all required labour, materials, tools and testing equipment.

The transformer installation shall be carried out in accordance with specifications and the best-accepted practice. Any loose components supplied by manufacturer shall be assembled, installed and connected in place as to form a complete assembly as per manufacturer instructions. After the transformer is placed in position and aligned for MV & LV termination, the roller wheels shall be locked with the foundation steel channel to avoid any unintentional movement of the wheels.

After the transformer is installed and connected, a thorough check shall again be made for the proper fixing of accessories, neutral connections, oil level, etc. The transformer shall be tested before energizing as per instructions contained in the Section 30.1 of these Specifications.

30.4 TELEPHONE SYSTEM

30.4.1 SCOPE OF WORK

The work under this section consists of design, manufacturing, fabricating, supplying, installing, testing, energizing, operation and commissioning of all material and services for the complete proposed Telephone system as specified herein, as shown on Drawings and stated in the CSR and as directed by the Engineer-in-Charge. The system shall fully comply with the general requirements for telephone system as specified by the Pakistan Telecommunication Corporation Limited (PTCL).

The Contractor shall discuss the layout of the proposed Telephone system with the Engineer-in-Charge and co-ordinate at site with other services/systems for exact route, location and position of various equipments of the proposed system.

30.4.2 GENERAL

The Telephone System is intended to establish efficient communication. The Telephone system shall be suitable for making local, long distance and overseas calls.

The Digital telephone exchange shall be modular in design. The system shall have facility for expansion of Trunk lines and extensions in future.

The complete Telephone system equipment shall be fully electronic, state of the art design with elegant finish.

The proposed Telephone System shall comprise the following equipments but not limited to;

- Main Distribution Frame
- Main Telephone Junction Box
- Digital Telephone exchange
- Mains power supply system
- Back-up power supply system
- Digital Telephone sets
- All required accessories

The Contractor shall provide all equipment including concealed conduits and multi-core, 0.6 mm dia., tinned copper conductor cable, for complete proposed telephone system, as shown on the drawings, as explained in these specifications and as directed by the Engineer-in-Charge.

The Contractor shall also provide any other equipment and materials, which are deemed necessary for the completion of system, without any extra cost.

30.4.3 APPLICABLE STANDARDS / CODES

The latest editions of the following standards / codes shall be applicable for the materials covered within the scope of this section:

BS 7640	-	Telephone cables
VDE 0816		
IEC 189		
BS 6360		
DIN 40040	-	Class & Reliability of units in Telecommunication
DIN 5800	-	Regulations for installation & operation of Telecommunication
CCITT	-	Recommendations and local T&T regulations.

30.4.4 MATERIAL

30.4.4.1 DIGITAL TELEPHONE EXCHANGE (EPABX)

The EPABX shall be state-of-the-art, digital, non-blocking type utilizing Pulse Code Modulation (PCM) and Time Division Multiplexing (TDM) and Stored program Control (SPC). It must be field proven and conform to ITU-T A-Law Companding standard. It shall initially be equipped with subscriber lines and trunk lines as specified. The system shall allow simultaneous voice and data communication over one twisted pair telephone cable. The system shall be capable of connecting telefax and teletext etc.

The system shall be able to operate in the following environmental operating conditions:

Temperature	:	0 to 50º C
Humidity	:	5 to 95 %

The various types of interface circuits required are as follows:

Analogue Extension	:	Two wire Dual Tone Multifrequency (DTMF) according to ITU-T Q.23
Analogue Trunk	:	In accordance with PTC standard
Digital, Trunk	:	2 Mbit/sec (comprising 100 digital trunks)

Extensive and adjustable time-out facilities shall be available in the EPABX to enable the time-out and release in the following cases:

- when a call is not answered within a pre-defined time period
- when during dialing, the inter-digit time period is exceeded
- when an incomplete or invalid number is dialed
- when an extension attempts to access a feature it is not allowed

The EPABX system shall incorporate a wide range of self-initiating diagnostic routines for the monitoring of system performance and identification of errors.

The proposed EPABX should be configured to handle the following traffic:

- 0.35 Erlangs per each extension
- 0.90 Erlangs per each trunk
- Blocking of calls: less than one percent.

The Contractor shall state the maximum number of simultaneous calls possible within the exchange. An adequate range of alarm and test facilities shall be provided in the EPABX to enable the maintenance personnel to rapidly access and localize the fault conditions. The facility of remote access (via dialup modem) of the EPABX for operation and maintenance purposes shall be available.

The system shall also contain appropriate hardware and software for audible and visual display of the whole range of alarms from the EPABX equipment to enable the maintenance personnel to undertake corrective action immediately upon occurrence of the fault. It should be possible to carry out the fault diagnosis and rectification without interruption in the service.

The system shall operate on single-phase 230 Volt 50Hz supply. Power supply of the system shall be based on modular components and shall use low power dissipation. The system shall operate without the need of forced cooling. Backup batteries shall be of sufficient size to keep the system fully operational in case of power failure for one hour.

The EPABX system shall comply to the following interfaces and protocols:

- EURO ISDN BRI & PRI
- ITR6
- Q.931
- QSIG
- DPNSS
- CCS
- V.24/V.25/28/35
- LAP-D

30.4.4.2 MAIN DISTRIBUTION FRAME

The termination equipment for the trunk and extensions circuits shall be wall-mounted type. It shall be sized to accommodate all internal and external circuits plus a twenty percent spare capacity.

The connecting blocks will be of the quick-connect type. Each of the trunk circuits and outside cable pairs will be protected with over-voltage and over-current protectors. These protectors shall be either carbon or gas tube type.

Complete details of the distribution frames together with the over-voltage/over-current protection shall be provided as part of the Contactor's proposal.

30.4.4.3 POWER SUPPLY

In the equipment room, the mains supply provided by WAPDA shall be available. The mains voltage (230 Volt AC/50Hz) will be subject to possible fluctuations and variations normally encountered in the WAPDA power supply network.

The Contractor shall be solely responsible to ensure that its proposed equipment is designed to function from the WAPDA mains voltage and will provide all necessary power supply equipment i.e. rectifiers, chargers, batteries and accessories to ensure a complete and fully functional primary and standby power supply system.

As reserve power, the equipment shall be equipped with a 48 Volt DC reserve system, to provide system operation in the event of a commercial power failure or fault in the primary rectifier. The battery shall be designed to provide a maximum of eight (8) hours reserve power for the ultimate size of the EPABX. The batteries shall be of sealed maintenance free type, supplied complete with cells, connectors, stand and all accessories. The batteries will be so arranged so that they take over the system automatically upon the failure of the primary power supply system.

Complete details of the power supply system shall be included as part of the contract.

30.4.4.4 TELEPHONE SETS

a) Standard Telephone Sets

The standard telephone sets shall be a single–line pushbutton telephone set. The keypad and dialing from the telephone set must conform to the ITU-T Q23 standard. It shall be equipped with a voice level volume control and a ringing signal volume control. It shall be possible to attach a hands free unit if required. The colour of the telephone set must be approved by the Engineer-in-Charge.

b) Executive Telephone Sets

The EPABX shall have the provision to connect 2-channel digital phones if specified. The digital telephone sets of the EPABX shall not require any external power source e.g. 230 Volt AC or batteries and should be able to operate through loop-power.

All programming of the digital sets shall be done in the switch and if a digital set is replaced, there should not be any need for feeding the individual set data again. The range of digital extensions should be expandable. The maximum range shall be specified by the supplier. It should also operate on single pair standard telephone cable.

The digital phones should have the following features:

2 - Channel desktop telephone with;

- 12 Key key-pad
- 12 function keys with LEDs
- Plus/minus Keys for volume control
- Indications for incoming calls: calling party's number/name (internal)
- LCD display – 24 digit alpha–numeric display
- Date/time indication on the LCD display
- Intelligent dialog key control for function selection in the display by scrolling in the menu and selecting the desired function
- Open listing
- Hands free talking
- Options to connect additional function keys with LEDs. It should be possible to program these keys for EPABX features or internal/external numbers

30.4.4.5 AUTO-ATTENDANT SYSTEM

The EPABX will be equipped with an auto-attendant system comprising a PC with Voice Mail Software. All incoming calls to the EPABX will be first routed to the Auto-attendant system. The system will provide recorded instructions to the incoming caller about the various possibilities of connection to the required extension (e.g. self-dialing of extension or routing to the attendant console). The incoming caller will therefore, be able to either dial the required extension number or will be routed to the attendant console.

30.4.4.6 TELEPHONE CABLES

The Telephone cables shall be multi-pair. The cables shall be PVC insulated, 0.6mm dia tinned copper conductor cables.

30.4.4.7 PVC CONDUITS ON SURFACE

The PVC conduits shall have same specifications as in section “PVC conduits & Pipes” of the specifications for Electrical Installations.

30.4.5 INSTALLATION

30.4.5.1 DIGITAL TELEPHONE EXCHANGE (EPABX)

The EPABX shall be installed at location as specified by the Engineer-in-Charge and in accordance with the manufacturer’s instructions and details.

30.4.5.2 MAIN DISTRIBUTION FRAME

The Main Distribution Frame including Auto-Attendant System and Call Accounting and Billing System shall be installed at location as specified by the Engineer-in-Charge and in accordance with the manufacturer’s instructions and details.

30.4.5.3 POWER SUPPLY

The Power Supply shall be installed at location as specified by the Engineer-in-Charge and in accordance with the manufacturer’s instructions and details.

30.4.5.4 TELEPHONE SETS

The Digital Telephone Sets shall be installed at location as specified by the Engineer-in-Charge and in accordance with the manufacturer’s instructions and details.

30.4.5.5 TELEPHONE CABLES

The Telephone cables for the proposed Telephone system shall be installed in accordance with the manufacturer’s instructions and details.

30.4.5.6 PVC CONDUITS

The PVC conduits shall be installed in or on surface of walls, columns and slabs. If installed on surface, the PVC conduits shall be installed with the use of suitable saddles. The saddles shall be spaced 18 inches center to center.

30.5 MEASUREMENT AND PAYMENT

30.5.1 COMPOSITE RATE

The measurement and payment for the items of the work of Electrical Installations/ Telephone System hereof shall be made corresponding to the applicable CSR item as provided in Contract Agreement and shall constitute full compensation, for procurements, transportations, performance in all respect and completion of work as specified including the site clearance as approved by the Engineer-in-Charge.

30.5.2 LABOUR RATE

The measurement and payment for the items of the work of Electrical Installations/ Telephone System hereof shall be made corresponding to applicable CSR item as provided in Contract Agreement and shall constitute full compensation for procurements transportations, performance in all respect and completion of work as specified including site clearance, as approved by the Engineer-in-Charge except the cost of materials to be provided by Department at designated location as defined in the Contract Agreement.

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31.1 SCOPE OF WORK

The scope of work includes Design, Manufacture, Supply, Installation, Testing, Commissioning and Maintenance of the Solar Power System on turnkey basis in accordance with the technical specifications laid down herein. In case of conflict between the technical specifications herein and provisions present in the other parts of the Bidding Documents, the requirements of these technical specifications shall take precedence.

The Contractor shall be required to perform following activities:

1) Conduct a detailed survey of the site for data collection and verification of site conditions, AC mains power supply and solar insolation available at the site. Determine the energy consumption of the building based on the requirements.
2) Prepare Engineering Design submittal(s) for the SPS giving, as a minimum, the following:
   a) Data obtained during survey
   b) Write up containing complete technical details of the hardware and software of all the components of the SPS system.
   c) Type test reports
   d) Schematic and interconnection drawings of the complete system.
   e) Layout drawings.
   f) Cable schedules and routing plan.
   g) Details of any civil works required.
   h) Installation, testing and local commissioning procedures.
3) Fabricate/manufacture all the equipment in accordance and compliance with the approved system design.
4) Upon completion of manufacture of equipment, conduct in factory acceptance and type tests in accordance with approved test procedures.
5) Segregation (including all hardware and allied equipment) of the existing electrical distribution system(s) of the site to separate the light/small electrical load and the heavy electrical load.
6) Ship equipment to site and install, commission and conduct acceptance test on the equipment under direct supervision of the Engineer.
7) Handover the fully functional system to Engineer-in-Charge
8) Perform preventative and corrective maintenance (including parts and labor) for the complete solar system for a period of three years from date of its handover to the Engineer-in-Charge.

31.2 SOLAR POWER SUPPLY (SPS)

31.2.1 DESIGN CONSIDERATIONS FOR SOLAR POWER SUPPLY

The following paragraphs lay down the design considerations for the solar power supply. Bidders shall explain in detail the design of their system and identify system output in watts and number of running hours per day for building using the meteorological data and simulation tool “PV Syst” for every location. The bidder has to take care those interruptions due to clouds or shadings in the off-grid mode do not lead to a decreased operational life of the electrical load. A PV System performance guarantee of 95% p.a. of the performance at time of system acceptance is required for 5 years after system handover. Bidders shall provide complete details during design stage confirming that above requirements shall be met by their solution. The suggested sizes and outputs of the SPSs are left upon the Bidders’ choice, he being the most knowledgeable authority on his choice of equipment, however under all circumstances the system supplied by the Bidder shall comply with the requirements set under this document. Bidders for their design shall clearly specify the following:

a) STC (Standard Test Conditions) power of SPS along with individual power ratings of PV panels, Inverters, Charge controllers, Batteries, Cables etc.
b) Maximum and average power output of the solar inverter(s).
c) Load profile and cover analysis showing operational hours on solar power and use of AC Power. All such calculations shall be done by using “Meteonorm” data (Latest) and “PVSyst” simulations (Latest).
d) Detailed system configuration including ratings and number of the individual equipment mentioned above.

e) Input parameters comprising of the orientation of the PV panels, detailed losses due to efficiency & normal operating conditions and effects due to shading.
f) Footprint (area required) for the total no of PVPs proposed and the allied equipment.

31.2.1.1 Location and orientation of PVPs (Photo Voltaic Panels)

A survey will be undertaken to identify the location and orientation for adequate placement of the solar panels. The survey shall identify and quantify the cable routes and lengths. Solar panels shall be placed in an area that receives average (max) annual sunlight and can securely support the PV panels. The area should preferably be clear of tall trees and foliage that could obstruct the exposure of the PVPs to the sun. The shadows from trees, neighbouring building or other structures shall also be considered such that the entire lot of PVPs once installed shall be subject to minimal shading (shading losses < 10% for nearby buildings and <5% no buildings in the surrounding) at any time of the day. In case of roof mounting or other overhead installation, the PVP supporting structure should be mechanically sound enough to bear both the dead loads and wind loads subjected to the panels and associated hardware. The Bidder shall provide detailed wind load calculations in the design submittal.

31.2.1.2 System Configuration and Load Classification

The electrical distribution system of the building shall been segregated as under:

Light/Small Load: Includes florescent lights, CFLs (compact florescent lamps or energy savers), ceiling fans and personal computers and other teaching aids (projector etc.).

Heavy Load: This is the circuit that powers all other electrical equipment in the buildings such as air conditioning system, water pumps and other electrical equipment.

The SPS shall only power the light/small load as given above. The heavy load given above will be powered from the Utility electric supply at all times and is completely excluded from the scope of work of these bidding documents.

It shall be possible to configure the SPS in two alternative modes of operation as given hereunder:

1) Integral Mode

The load shall primarily operate on solar power and shall switchover to utility electricity supply in the absence of solar power.

2) Proportional Mode

The light load shall be fully driven from the SPS under the availability of adequate solar insolation. Provision shall be built in such that the SPS can fully or partially power its load. In case the solar power output decreases due to diminishing insolation, then the partial loss of solar power shall be proportionally compensated automatically by the utility electricity supply.

31.2.1.3 System Operation

The SPS shall be so designed to power the light load for six (6) hours per day subject to availability of adequate level of sunshine. The heavy load shall be powered from the utility electric supply at all times. In the event of poor solar system efficiency due to inadequate sunshine, the balance of power shall be provided by the utility electricity supply. In event of any fault/breakdown in the SPS, the light load will be powered from the utility electricity supply.

For both a) and b) the batteries shall be charged by both the utility electricity supply and any surplus solar power available (during peak sunshine) after powering the light load. In event of poor system efficiency due to inadequate sunshine, the balance of power shall be provided firstly by the utility electricity supply and in case of load shedding or no Utility supply, it shall be provided by the batteries up to two (2) hours. In event of any fault/breakdown in the SPS, the light load will be powered from the utility electricity supply.

31.2.1.4 PVP Footprint (Area Determination)

For optimal utilization of a roof top, a roof plan shall be drawn up indicating the dimensions and any physical obstructions thereupon. With these basic dimensions, the optimum scenario for mounting of the solar panels shall be determined. This optimum scenario will act as an upper bound on the size of the system that could be installed. The final placement shall be reflected on a detailed AutoCAD drawing created using the set of plans and the measurements taken on the roof. In order to ensure a precise analysis to more accurately calculate the best possible area for the installation of panels, the selected site shall be visited at different times of day to take detailed measurements of shadow pattern or simulations shall be done using “PVSyst” for calculation of shading losses due to nearby obstructions/buildings. The spacing necessary between panels shall be worked out using software to minimize the shadows and to determine the maximum number of panels as a result of this spacing.

31.2.1.5 Data Collection

Initial activities shall include collection of all available information about the project sites(s) including but not limited to the following:

a) Gathering and summarizing of meteorological data. Within a 10 km radius of the site.
b) A set of plans for the roof of the building with detailed dimensions.
c) Single line diagram(s) of existing electrical distribution system.
d) Electrical Load lists.

31.2.1.6 Connection to the Existing Building/Site Distribution System

The building electrical distribution system shall be studied with a view to understand the types and ratings of loads being served, equipment layout, the automatic change-over to emergency source (if any) in case of failure of the mains supply and vice versa, interconnection with the grid, and protection requirements. Based on this information, the connection of the SPS to the existing distribution system shall be done. The buildings shall have separate light/small and heavy load circuits. The Contractor shall be responsible to segregate the light load and the heavy electrical load, connect the SPS to the light load and install any or all required hardware for automatic switchover of light load to the SPS and vice versa.

31.2.1.7 Meteorological Analysis

Meteorological analysis shall be carried out to determine the amount of energy provided by the sun incident upon the solar panels. Multiple factors shall be considered (but not limited to): average sunny days, clearness of the skies, precipitation, average sun duration, wind speeds, longitude and latitude and temperature variations.

Based on above data specific to the site, average yearly insolation shall be determined for the site using “Meteonorm”. This calculation shall encompass the change in sunlight due to cloudy or partially cloudy days.

Other parameters including Irradiance, temperature and their effect on system sizing shall also be considered. Monthly and yearly variations of these factors shall be considered to ensure sufficient output of the SPS under the worst case. All calculations and simulations performed using “PV Syst” shall be put up for vetting and approval by the Engineer in the detailed design submittal.

31.2.1.8 PVPs – General Characteristics

Modules with higher power output per unit area (higher efficiency) shall be preferred.

PVPs supplied for the building shall have certificate as per IEC 61215 specifications. Modules must qualify to IEC 61730 Part I and II for safety qualification testing. The efficiency of the PV modules should be minimum 16% and fill factor should be more than seventy percent (70%). The terminal box on the module shall have a provision for “Opening” for replacing the cable, if required. There shall be a name plate fixed inside the module which will give, as a minimum, the following information:

a) Name of the manufacturer or distinctive logo
b) Model number
c) Serial number
d) Year of manufacture
e) Peak power rating
f) Short circuit current rating
g) Open circuit voltage rating

The PV panels shall comprise several parallel strings of multiple cells connected in series. The parallel arrays match each other as closely as possible so as to avoid internal current circulation through the cell series. Any unbalance in these internal voltages shall be avoided. Precautions should be taken to reduce the external causes like shadow or wind carried materials which may cause imbalance over the string voltages consequently decreasing the overall efficiency of the PV panel.

The PV Modules shall be guaranteed for output wattage, not be less than ninety percent (90%) of rated power at the end of ten (10) years and not less than 80% of rated power at the end of twenty-five (25) years.

31.2.1.9 System Sizing

The size of the SPS shall depend upon the amount of power that is required (watts), the amount of time it is to be used (hours), and the amount of energy available from the sun in a particular area (sun-hours per day). Bidders shall state the rating in watts of their solar power supply. The rating shall be commensurate, plus a safety factor of thirty (30) percent. Bidders shall provide design calculations using PVSyst showing that the SPS has sufficient equipped capacity to power the required load. A minimum base level design is given hereunder. Bidders shall decide if and whether this base line specification needs to be enhanced. They shall accordingly propose their component capacities for the PVPs, invertors, charge controllers and batteries.

31.2.2 FUNCTIONAL DESCRIPTION AND SYSTEM COMPONENTS

The hybrid SPS shall consist of PV modules, grid connected inverter(s), solar charge controller(s), cables, appropriate mounting structures for system components; AC and DC disconnect switches, grounding equipment, and a metering system.

The system shall be designed based on the design considerations above and the functional description inscribed herein.

The main system components shall include but not limited to

a) PV Solar Panels including mounting hardware.
b) Solar Charge Regulator/Controller
c) Grid tied Solar Inverter
d) Electrical protection devices such as Circuit Breakers and fuses.
e) Battery Bank with battery stands/racks
f) Cables, Wires

31.2.2.1 Photovoltaic (PV) Panels/Modules

To transform the radiant light into direct current (DC), solar panels of nominal voltage ratings of 12, 24, or 48 V shall be provided. Panels shall be of Polycrystalline/Monocrystalline silicon (Si) cells, protected by anti-reflective glass and by a special synthetic material. The number of panels to be used in a system shall be determined by the voltage current and power ratings of the PV Panels.

The sizing calculations to determine the number of modules, number of strings and number of arrays shall be calculated by the Contractor on the basis of design parameters, functional characteristics and the Schedule of Technical Data (STD) given in the Bidding Documents.

The output power, voltage, and current profile of the solar module will dictate the number of modules needed and ratings of the inverters or charge controllers to be deployed.

Basic mechanical characteristics, such as dimensions, frame profile, and static load rating, as well as grounding and mounting locations shall be considered while designing the system.

Orientation of the panels and arrays shall be such that they are always exposed to the maximum amount of solar radiation on a yearly average basis.

The Solar Panels must be of renowned brand. Solar panels shall have frame module with type-A junction box (rain tight) accepting PG 13.5 conduit/cable fitting.

Manufacturer of solar panels and the place where panels have been manufactured must be clearly stated in the Bid.

31.2.2.1.1 Mounting Structure

Following considerations must be checked while installing the system.

a) Hot dip galvanized iron mounting structures shall be provided for mounting the modules/panels/arrays. These mounting structures shall be used to mount the modules/panels/arrays on the ground or roof tops at an angle of tilt with the horizontal in accordance with the altitude of the place of installation. The Contractor shall state the angle of tilt in their detailed design submittal.
b) The solar array shall be supported by galvanized steel pillars with concrete foundations and shall be at suitable height from the ground/roof level.
c) They shall be designed for maximum durability and corrosive resistance in all environments.
d) The mounting structure should be able to withstand wind speed of 120 km/ hr.

31.2.2.2 Solar Inverter

The solar inverter shall be provided for voltage conversion and regulation of the varying amounts of DC voltages and currents generated by the PVPs. Solar inverter capacity shall be determined in accordance with the parameters specified and quantified in the Schedule of Technical Data (STD) and multiple solar invertors shall be used in parallel.

Maximum Power Point Tracking (MPPT) solar invertors shall be provided so as to optimize the voltage of the PV array to maximize PVP power output then convert that power to the correct AC voltage at the output of the inverter. This process shall cause a significant increase in the harvesting of the power output from a solar array.

The variations caused by temperature and type of module used shall be considered while defining the typical control set points (the voltages at which the controller changes the charge rate) or output power.

The DC input voltage of the inverter shall conform to output of the SPSs and shall be in multiples of 12 Volts.

It shall be preferred to design a higher voltage system which will result in less current, reducing the gauge of the system wiring. The inverter shall be certified by an independent testing laboratory.

Power capacity of the inverter including Continuous, Limited-Time and Stack rating shall be clearly stated. Detail specifications including important values like Total Harmonic Distortion (THD), RMS (Root Mean Square) Voltage and Peak Voltage regulation shall be according to the STD.

The peak efficiency of the inverter should not be less than two thirds of its capacity.

31.2.2.2.1 General Features

The inverter shall contain (but not limited to) following features:

a) Pure Sine Wave for European
b) Output voltage Filter
c) Automatic ON/OFF
d) Stack/Modular arrangement (connecting two or more inverters in parallel to perform as one unit).
e) Under/Over Voltage & Over Current protection
f) The inverter shall be a grid tied, off-grid or hybrid type (according to the system requirement).
g) The inverter shall be of single/three phase type.
h) MPPT function should be available. (Eurpoean)
i) In case of grid-tied/hybrid system, inverter shall be able to automatically synchronize with the grid supply and shall have built-in features for this purpose.
j) The inverter shall support multi-string input with string failure detection.
k) AC short circuit protection.
l) Ground fault monitoring.
m) Grid monitoring. (European)
n) Ingress protection rating / electrical connection area shall be IP66.

31.2.2.2.2 Test Standards

EN 62109-1 2010 (Safety) (European)

EN 61000-6-2:2005 (EMC compatibility) (European)

31.2.2.2.3 Micro Invertors

Micro-inverters shall be low power inverters designed to handle the output of a single PV panel. Instead of connecting and sizing an inverter to multiple PVPs one inverter shall be used per PVP. In a conventional system one central (string) inverter would normally cover an entire building. Micro-inverters, on the other hand shall mount on the back of each solar panel and shall have the following advantages over traditional string inverters:

Advantages of micro inverters

a) No string/array calculations.
b) Individual MPPT controllers shall control the output of each module which shall insures most available output power from each panel.
c) Minimal DC wiring.
d) Less space requirement and heat dissipation.
e) No single point of failure.
f) Easy expansion of the system.

Bidders are free to provide solutions based on Micro Invertors as long as they can show that theirs is the best techno economical solution.

31.2.2.2.4 Charge Controller

Charge controller shall act as an electronic voltage regulator to keep the voltage to the battery within acceptable limits. The charge controller shall automatically taper, stops, or diverts power when batteries become fully charged. Charge controller capacity shall range from according to the specifications in Schedule of Technical Data (STD) and multiple charge controllers shall be used in parallel for larger systems. Additional features, like charge status display, data logging, automatic battery equalization charging, generator starting are preferred.

Maximum Power Point Tracking (MPPT) charge controllers shall be provided so as to optimize the voltage of the PV array to maximize total power output then convert that to the correct voltage to charge the battery. Charge controller shall significantly increase the power from a solar array particularly in low temperatures when battery voltage is significantly below the PV array voltage.

The MPPT charge controller shall be capable of working with higher array voltages, enabling the use of larger solar modules (which can be more economical on a cost per watt basis), minimizes the required wire size between the array and the charge controller and maximizes the distance between the power source and battery bank.

Charge controller shall be able to be used with multiple 12, 24, 36, 48, and 60 VDC battery systems and with PV array operating voltages up to 400VDC. It shall support the Bulk, Absorption and Float charging modes.

The variations caused by temperature and the battery type used; shall be considered while defining the typical control set points (the voltages at which the controller changes the charge rate) of the controller.

a) General Features

The charge controller shall contain (but not limited to) following features:

a) Built-in Ground Fault Protection (GFP).
b) Maximum Power Point Tracking (MPPT).
c) Reverse current blocking capability
d) Over/Under charge protection.
e) Battery temperature sensor.
f) Low Voltage Disconnect (LVD).
g) LCD Display.

31.2.2.2.5 Rectifier

Rectifier converts standard AC supply voltages into stable nominal DC voltage adjustable to the needs of the application. Rectifier shall be of constant power rectifier designed with the latest DSP (Digital Signaling Processor) functionality for efficient operation. A rectifier cabinet shall be in the particular NEMA enclosure. The rating of the rectifier will be such that it is able to fully charge the batteries in a time period of two (2) hours.

a) <u>General Features</u>

a) Compliant with global standards delivers quality, performance and reliability.
b) Efficiency up-to 92%.
c) Hot Pluggable facility
d) Operating Ambient Temperature range (-10°C to +45°C)

31.2.2.3 Battery

The batteries shall be of sealed maintenance free; tubular gel Valve Regulated Lead Acid (VRLA). Schedule of Technical Data shall be followed while considering the technical requirements.

a) <u>General Features</u>

The batteries shall contain (but not limited to) following features:

a) The storage batteries shall be sealed maintenance free; tubular gel Valve Regulated Lead Acid (VRLA) type.
b) The storage batteries shall be provided with battery racks, necessary connectors, name plate, battery transparent cover, etc.
c) Deep-cycle lead-acid batteries of the sealed type.
d) The container shall be strong enough to withstand rough handling.
e) Explosion proof vent plug shall be provided at the upper part of the container.
f) The batteries shall be designed for operation in ambient temperature of –10oC to +60oC.
g) Lead Plated Solid Copper Connectors.
h) Layout of batteries shall be such that it permits easy access and sufficient flexibility at the time of cell unit replacement, and also easy to check the status.

31.2.2.4 Installation Cables/Wires

a) Stranded and flexible insulated copper DC wires and cables must be used for all outdoor and indoor installations.
b) The cables are selected such that the voltage drop must not exceed 1% on DC side of the power inverter and 1.5% on AC side of the power inverter. The calculation on the basis of which cables shall be sized will be submitted.
c) The wiring that leads into the pole shall be protected in a PVC Spiral / Flexible conduit.
d) External cables should be specifically adapted to outdoor exposure as per IEC 60811. The outer insulation shall be sunlight (UV)-resistant and weather-proof.
e) All wiring should be colour coded.
f) All exposed wiring must be in UV-resistant conduits and firmly fastened to the support structure. Cable binders, clamps and other fixing material must also be UV-resistant. All underground cabling shall be done in metal conduits.

31.2.2.5 Tests and Certifications

31.2.2.5.1 PV Panels (PVPs)

The Bidders shall offer PVPs from one of the following manufacturers.

a) Trina Solar
b) Canadian Solar
c) JinkoSolar
d) JA Solar
e) Hanwha Q CELLS
f) First Solar
g) Yingli Green
h) SFCE
i) ReneSola
j) SunPower Corp
k) Other

Bidders/successful Contractors shall provide complete test reports listed herein from testing labs mentioned herein demonstrating that the PV modules being proposed have passed the following tests in accordance with the latest IEC standards or the product fully complies with IEC 61215/61646. **Note that complete test reports showing test parameters, test equipment and test procedures are required whereby submission of a single page certificate alone shall be sufficient cause for the Engineer-in-Charge to disqualify the Bidder.**

In addition the following specification will have to be met and guaranteed:

a) flash tested data supervised by an accredited (IEC 17025 or national pendant) independent certified module testing agency shall be provided for each module at STC. The sun simulator must meet the class AAA requirements of IEC 60904-9. The sun simulator must be calibrated with a reference cell, which itself was calibrated by a member of the WPVS scheme, with a maximum uncertainty of Isc of 1%. The flash-test data must be equal to or higher than the sum of the nameplate ratings of the module supply.
b) Power at 200 W/m² shall be measured with the same test procedure and must be equal or more than 95% of the efficiency at STC (European).
c) A narrow range of module power tolerances is expected.
d) All modules must undergo Electro luminiscense (EL) inspection with a resolution of minimum 4 MPixel prior to shipment. The EL pictures must be sharp and inspected by an independent module testing agency. A maximum of 5 minor defects and no major defects per module are allowed.
e) Peel off test (force >60 N/cm at interface glass/encapsulant; 20N /cm at Backsheet/encapsulant)
f) EVA cross-linking analysis, Soxhlet analysis or comparable Cross-linking rate between 75% and 90%.

i. Requirements of Type Tests and Test Reports to Qualify Acceptable Manufacturers

In case a Bidder is unable to provide type complete test reports from laboratories listed here above, then he shall arrange at his own cost to have the said tests be performed. The Engineer-in-Charge and/or his representative shall in such a case witness the tests. All costs of testing and witnessing by the Engineer-in-Charge and or his representative shall be deemed to be included in the contract.

ii. Guaranteed Performance

The Module shall have an IEC 61215 Certificate from an acknowledged third party laboratory- see iv. below. The complete type test reports shall be provided with the Bids.

Warranties and evidence shall be given by the bidder that their selected modules have been tested for susceptibility to Potential Induced Degradation (PID).

Additionally the Engineer-in-Charge and/or his representative shall witness the following tests at the factory or place of production, on sampling basis on each lot of panels to be shipped. The test lot shall be 100 panels and sample size shall be five percent. The maximum allowable failure rate per lot shall be 5%. For failure rates exceeding the allowable limit the entire lot shall be rejected or tested on a 100% basis as directed by the Engineer-in-Charge and/or his representative.

a) Visual Inspection Tests
b) Insulation Test (Wet Leakage)
c) Performance at STC and at Low Irradiance 200W/m²
d) Electro luminescense Test
e) Peel off test (force >60 N/cm at interface glass/encapsulant; 20N /cm at Backsheet/encapsulant)
f) EVA cross-linking analysis, Soxhlet analysis or comparable. Min. cross-linking rate > 75%.

iii. Life Expectancy Tests

Only those PVPs shall be acceptable that have undergone Life Expectancy Tests (LETs) and full reports of the procedure and results of the LETs is provided. LETs shall be conducted as per IEC 61215.

Those PVPs shall be preferred whose manufacturers can provide proof that their PVPs have survived twice the duration of testing according to IEC 61215. These tests shall have been conducted at the third party labs of Section (iv) below.

iv. Testing Laboratories

All the test reports shall preferably be from either of the following independent laboratories.

a) NREL USA
b) TUV (all locations)
c) CESI Italy
d) Fraunhofer ISE Germany
e) Intertek, UK
f) Fraunhofer, Germany, U.S.A
g) Florida Solar Energy Centre, U.S.A
h) ScienLab Electronic Systems Germany (for Inverters Only)
i) Korea Testing Laboratory, Korea (for Inverters Only)
j) Japan Photovoltaic Expansion Center, Japan
k) Renewable Energy Test Centre, U.S.A
l) CFV (by CSA Group Canada, Fraunhofer USA, VDE Germany)
m) VDE Institute , Germany
n) PI Berlin
o) PV Lab Germany
p) CSA Group, (Canadian Standards Association), Canada

v. Third Party Inspectors

All testing shall either be witnessed by a team comprising the Engineer-in-Charge and Engineer, or a neutral third party inspector who shall be well versed with the testing procedure. The Bidder/Contractor will submit for the Engineer-in-Charge's approval the names of three internationally acclaimed neutral party inspectors. Bidders shall quote the rates of such third party inspection teams/companies in their Bids.

vi. Pre-Shipment and Site Testing

Upon shipment and before installation of the Engineer-in-Charge, following tests shall be arranged and performed again at site before installation of modules in the presence of Engineer-in-Charge and Consultants' personnel; selection of modules for these tests shall be in accordance with IEC standard (IEC 60410, single sampling plan normal inspection):

a) Pre-shipment
b) Flash tested data supervised by an accredited (IEC 17025 or national pendant) independent certified module testing agency shall be provided for each module. The flash testing report shall contain the unique barcode and labelled performance headlines (maximum power, short-circuit current, open-circuit voltage, maximum current, maximum voltage) of the module. The flash-test data must be equal to or higher than the sum of the nameplate ratings of the module supply.
c) All modules must undergo Electro luminiscense (EL) inspection with a resolution of minimum 4 MPixel prior to shipment. The EL pictures must be sharp and inspected by an independent module testing agency. A maximum of 5 minor defects and no major defects per module are allowed

Site Testing

a) Visual Inspection for major visual defects only (Level II)
b) Bypass Diode Thermal Test (Level S1)
c) Wet leakage test according to IEC 61215. Minimum insulation shall be >40mOhm*module area (if module area is over 0.1 square meter) (Level S4).
d) Maximum Power Determination Test according to IEC Test (Level I)
e) The STC-power and power at 200 W/m² shall be measured on a class AAA simulator (IEC 60904) which is calibrated with a primary calibrated reference cell (reference cell for example calibrated by NREL/USA or AIST/Japan or comparable institution providing first level calibration, uncertainty of Isc max. 1%) by an independent laboratory.

From the results the percentage of deviation the STC flash tests of the Manufacturer for the tested lot shall be calculated to establish a correction factor for all STC-power of the project.

Power at 200 W/m² shall be measured with the same test procedure and must be equal or more than 95% of the efficiency at STC for more than 90% of the samples.

vii. <u>Performance Guarantee</u>

The PV system must be able to power the requested load for 2000 hrs p.a. in Off-grid mode under the meterological conditions provided by Meteonorm for the specific location.

A PV System performance guarantee of 95% p.a. of the performance at time of system acceptance is required for2years (European).

Any actual irradiation deviations independently measured at the meterological stations of this project will be taken linear into account.

The guarantee has to to backed with an irrevocable bank guarantee accepted by the Engineer-in-Charge

31.2.2.5.2 Site Testing

Upon shipment and before installation of the equipment, following tests shall be arranged and performed at site before installation of modules in the presence of Engineer-in-Charge and Engineers' personnel; selection of modules for these tests shall be in accordance with IEC standard (IEC 60410):

a) Visual Inspection for major visual defects only
b) Bypass Diode Thermal Test
c) Wet Leakage Test
d) Insulation Test
e) Maximum Power Determination Test

31.3 GENERAL TECHNICAL REQUIREMENTS

31.3.1 Service Conditions

31.3.1.1 Climate Conditions

Air temperature and relative humidity conditions are specified as a function of climatic characteristics of the location where the equipment is to be installed. The table below shows the ambient temperatures (see definition 1) and the relative humidity rates to which the equipment can be submitted according to the category they belong; the latter may be stated by the particular specifications.

Category	I		II		III	
Rated operating range (2)	T1: + 15°C	T2: + 30°C	T1 - 5°C	T2: + 40°C	T1: - 25°C	T2: + 55°C
Maximum operating limits (3)	T3: + 5°C	T4: + 40°C	T3: - 10°C	T4: + 55°C	TI: - 40°C	T2: + 70°C
Maximum relative humidity	75% at + 23°C		80% at + 23°C		100% at + 45°C	
Storage and transport conditions (4)	- 40°C	+ 70°C	- 40°C	+ 70°C	- 40°C	+ 70°C
Operating location example	Air conditioned room		Non air conditioned room		Outdoor	

Definitions:

1) Ambient temperature (IEC 441-02-06):
Temperature determined within specified conditions of the air which surrounds the whole equipment.

2) Rated operating range:
Range of values at which the equipment performs within specifications

3) Maximum operating limits:
Range of values at which equipment can still work without deterioration or degradation of its operating qualities when it works again at its rated operating conditions

4) Storage and transport conditions:
Set of climatic conditions to which the equipment can be submitted, when not operating, without deterioration or degradation of its operating qualities when it works again in its rated operating conditions.

The above definitions are extracted from IEC 61359.

Unless otherwise specified in the relevant particular specification (or in the scope of work):

- For Site (i.e. for equipment to be installed outside) all equipment will be at least of category III.
- Indoor equipment (if any) to be installed in air-conditioned rooms shall be, at least, of category I; all equipment installed in non-air-conditioned indoor environment shall be at least of category II.

Temperature and irradiance are specified as a function of climatic characteristics of the location where the equipment is to be installed. The table and graphs below shows the ambient temperatures and the irradiance level to which the equipment can be submitted according to the category they belong; the latter may be stated by the particular specifications.

31.3.1.2 Service Experience

The Bidder shall supply details of the proposed location of manufacture of all systems and equipment, indicating the number of years the system or equipment being offered has been under manufacture at that particular location. The Bidder shall also include a reference list of locations and clients to whom the specific system and equipment being offered has already been supplied. The system or equipment being offered shall have a minimum of a five year proven service record.

31.3.2 Design Manufacturing and Installation Requirements

31.3.2.1 Quality Control & Quality Assurance

The products and systems to be supplied and installed under this Contract shall conform to the requirements of the Technical Specification, to the best accepted international practice and to the severe requirements imposed by the service conditions. As a means of ensuring these objectives, the Contractor shall maintain a documented quality control and quality assurance system, which shall be generally in accordance with ISO 9001 or approved equivalent. The Contractor shall ensure that the same requirements are applied to products, systems, and services supplied by sub-contractors and suppliers. The Bidder shall submit with his Bid an outline statement of his quality control and quality assurance policies and procedures.

31.3.2.2 Country of Origin

All equipment shall be new and all associated equipment shall be manufactured by bonafide manufacturers having their registered countries of origin as Europe, USA, Japan or Australia. However, PV panels shall be from the manufacturers listed in 2.2.5.1.

Equipment manufactured in Israel and India shall not be acceptable. The Bidder shall clearly mention in his Bid, the country of origin of all equipment proposed. In case any minor subassembly or part assembly is from any country other than that mentioned above, the bidder shall disclose this information with his bid. No major electronic component of system hardware shall be locally built or customized.

31.3.2.3 Alternate Brands

The Bidder will propose two alternative independent brands of equipment for the Engineer-in-Charge to choose from.

31.3.2.4 System of Units

The SI system of units and Imperial system shall be used. Temperature shall be in degrees Celsius, power in watts and irradiance in kWh/m^2 etc.

31.3.2.5 Suitability of Proposed Design

The design shall make adequate provision for:

a) Safety of operation and maintenance personnel.
b) Reliability and continuity in service.
c) Ease of inspection and maintenance.
d) Ease and clarity of operation.
e) Ability to withstand the severe service conditions specified.
f) Freedom from undue vibration.
g) Exclusion of vermin, birds and animals.
h) Precautions to minimize fire risk.

31.3.2.6 Interchangeability

To limit the required stock of spare parts to be inventoried by the Engineer-in-Charge all equipment and parts thereof performing similar duties shall be interchangeable.

31.3.2.7 Degree of Protection provided by Enclosure

All probes, terminal boxes, kiosks, cabinets and equipment enclosures shall have degrees of protection provided by enclosure according to IEC 529 as follows:

- Outdoor IP 55 (minimum)
- Indoor IP 51 (minimum).

31.3.2.8 Labels and Plates

Each item of equipment shall be provided with a rating plate giving the type and serial number together with its ratings and service conditions and any other information required by IEC/ISO/ITU Recommendations and by other sections of the Technical Specification.

Labels and nameplates shall be provided to clearly identify the function and circuit designation of the equipment.

All cabinets shall be labelled front and back and at each operating position. All removable equipment including detachable doors/panels shall be labelled both on the removable item and on the fixed part with which it mates.

All rating plates, nameplates, labels and wiring plates shall be of non-corrosive material. Where etched labels are proposed, clear Perspex covers shall be provided to prevent dust accumulation obscuring inscription text. Inscriptions shall be clearly legible from the operating distance and shall be in English throughout. Notices indicating danger to personnel shall be in English and Urdu.

In general, all labels shall be screw fixed in an approved manner, except where otherwise agreed by the Engineer-in-Charge/ Engineer. When system and equipment are fully erected, additional labelling shall be provided where in the opinion of the Engineer the labelling already provided is inadequate.

Full details and locations of all plates, labels etc. shall be clearly shown on the drawings and shall be subject to the Engineer's approval.

31.3.2.9 Support Structures for Equipment

All support structures for equipment shall be designed to suit the service conditions specified, the loads imposed on them, and any appropriate electrical clearance requirements.

All outdoor structures shall be hot-dip galvanized. Steel structures for indoor use shall be hot-dip galvanized if specified in the technical sections of the specification.

31.3.2.10 Small Wiring

All small wiring shall comply with the provisions of the Electricity Regulations in Pakistan.

31.3.2.11 Equipment and Materials

All equipment and materials shall be new and of the highest quality, and shall be capable of withstanding the stresses imposed on them under the most severe electrical, mechanical and atmospheric conditions which may occur in service. Repair of damaged equipment or materials shall not be allowed without the approval of the Engineer-in-Charge.

31.3.2.12 Surface Treatment of Metals

Due to incidence of dust storms the surface finish proposed for outdoor equipment shall be sufficient to prevent accelerated deterioration due to dust abrasion and dust contaminants.

All exposed metal surfaces shall be either painted, galvanized, anodized, plated or otherwise finished to take account of the metal and the climatic conditions to be encountered in service.

31.3.2.13 Protective Treatment for Metal Work

31.3.2.13.1 Galvanizing

All galvanizing shall be carried out by the hot-dip process to BS EN 1461. The zinc coating shall be smooth, continuous and uniform. It shall be free from acid spots. There shall be no impurities in the zinc or additives to the spelter bath, which could have a deleterious effect on the durability of the zinc coating. Before pickling, all welding, drilling, cutting, grinding etc. shall be completed and all grease, paint, varnish, oil, welding slag etc.

completely removed. All protuberances, which would affect the life of galvanizing, shall also be removed. The weight of zinc deposited shall be in accordance with BS EN 1461.

31.3.2.13.2 Welding

Welding of proprietary items shall be carried out in accordance with an approved standard or code of practice. The welding plants and processes used shall be suited to the materials, configurations and purposes of the welded parts. Only qualified welders, certified for the type of welding required, shall be employed. The Contractor shall exercise strict control over the welding conditions and parameters and shall continuously monitor the standard of welding achieved in accordance with the requirements of the Clause on Quality Control and Quality Assurance, to the satisfaction of the Engineer.

31.3.2.14 Interface with Existing Equipment

Where modifications or extensions to existing system and equipment are involved, the design and execution of the Works shall be such as to cause minimum interference with existing equipment and minimum interruption to supplies.

Where a norm is established by the existing station design, work completed under the Contract shall be compatible with this standard to the satisfaction of the Engineer. This requirement applies to both physical and electrical features.

Except as otherwise provided no separate payment will be made for any necessary repositioning and re-commissioning of existing equipment. Any such repositioning shall be indicated clearly in the Bid. All equipment made redundant by such repositioning shall be disposed delivered and handed over to the Engineer-in-Charge.

No separate payment will be made for any temporary works or equipment required to maintain supply or to safeguard personnel.

Access to existing substations shall be subject to the Engineer's written approval. The timing and duration of shutdowns of existing equipment shall be agreed in advance between the Contractor and the Engineer-in-Charge and the Engineer.

When working within existing stations the Contractor shall maintain a high level of tidiness and cleanliness and shall provide at all times safe access to existing equipment for the use of Engineer-in-Charge's Personnel.

Sites, buildings, equipment and facilities disturbed during the execution of the Works shall be fully restored in performance and appearance.

31.3.2.15 Contractor’s Responsibility for Construction Facilities and Sufficiency of Means Employed

The Contractor shall make his own arrangements with the relevant utility companies, for all necessary supplies of electricity, water, gas, telephone etc. required for construction and testing and shall pay all installation and running costs charged by the authorities. Where such supplies are not available for any reason, the Contractor shall make provision for adequate site supplies as may be necessary for the installation and testing of the Works.

The Contractor shall also provide at his expense all necessary machinery, lifting equipment, tools, scaffolding, etc. required for construction. All such equipment shall be maintained throughout the Contract in good working order.

The Contractor shall take upon himself the full and entire responsibility for the sufficiency of tools and Contractor's equipment and generally for all means used for the fulfillment of the Contract, whether or not such means may have been approved of, recommended by, or commented on by the Engineer-in-Charge.

31.3.2.16 Care of the Works and Equipment

Till such time that the plant has not be installed and tested, the Contractor will be held responsible for the care of the works generally until their completion, including all work executed and materials deposited on the site by him or by Sub-contractors and suppliers.

31.3.3 Documentation

31.3.3.1 Contractor's Responsibility

All relevant designs and drawings shall be approved by the Engineer prior to commencement of installation on site. Approval by the Engineer of any design or drawing shall not relieve the Contractor of responsibility for the correctness of designs and drawings or for the safety, adequacy and suitability of any part of the equipment manufactured or constructed in accordance with that design or drawing.

31.3.3.2 Design and Information with the Bid

The Bidder shall submit with his Bid the necessary drawings and information as specified in the Schedule of technical Data appearing at the end of the document.

31.3.3.3 Design Submissions

31.3.3.3.1 General

All designs shall be submitted for the Engineer's approval. Designs approved by the Engineer shall not be altered without his written agreement. All symbols used in electrical drawings shall be in accordance with IEC Publication 60617 and the SI system of units shall be used throughout.

Design submissions shall be made within the times named in the particular sections of the Specification. They shall be made in an orderly and timely manner so that the Engineer shall have adequate time for their detailed examination and for checking and approving any necessary revisions. A period of two weeks shall be allowed for the Engineer's checking and approval of any design submission from date of receipt of each submission to date of notification of approval or comments.

Each design submission to the Engineer shall be serially numbered and dated and shall refer to one subject matter only. Each submission shall be accompanied by a summary sheet, which lists the documents comprising the submission. Where a submission includes revisions of documents previously submitted the summary sheet shall include a reference to the original submission number.

Two copies of each design submission shall be furnished to the Engineer.

Submissions made to the Engineer relating to matters normally handled at site level shall be similarly numbered serially but in a distinctive series.

Documentation includes but not limited to:

1) Description of system and components including nameplate data and lists of equipment.
2) Operating procedures including step-by-step instructions for normal and emergency operation.
3) Maintenance procedures, including routine maintenance procedures, guides to trouble-shooting, procedures for dismantling, cable jointing instructions, repair and reassembly procedures for alignment, adjusting and checking.
4) General arrangements and detail drawings for interfacing between the components and integration with the existing system, cabinets, cables and all other items of system or equipment.
5) Schematic circuit diagrams.
6) Detailed wiring diagrams and cable lists.
7) Detailed records of all type tests, routine tests and site tests.
8) Spare parts lists.

31.3.3.3.2 Drawings

Drawings shall be complete in all respects, accurate numerically and geometrically correct and shall be sufficiently detailed to enable system and equipment erection to proceed without the need for further supporting drawings, details or interpretation. All drawings and calculation sheets shall have title blocks, which shall be correlated one with the other.

The Contractor shall maintain drawing reproduction facilities, to the approval of the Engineer in his office for the duration of the Contract.

31.3.3.3.3 Deviations

Where the Contractor proposes a deviation from the detailed requirements of the Technical Specification he shall make a written application for approval of such deviation to the Engineer and he shall highlight the proposed deviation on the relevant drawings and design sheets of the submission. Except in the case of a deviation specifically approved by the Engineer the Contractor shall be responsible for ensuring the conformity of the Works with the Specification, notwithstanding any general approval or lack of approval of design submissions by the Engineer.

31.3.3.3.4 Site Documents File

The Contractor shall maintain at the site a Site Document File incorporating all changes and modifications as they occur. The file shall include a Drawing/Document List, a Master Drawing File and a Master Technical Instruction File. The Contractor's proposals for the Site Document File shall be submitted for the approval of the Engineer.

The Drawing/Document List shall be prepared and updated regularly at periods to be decided by the Engineer. The first issue shall be made within thirty (30) days of award of the Contract and shall indicate the various types of drawings and documents which will be prepared during the period of the Contract and the anticipated numbers thereof. The list shall be updated as necessary and the status of each drawing/document shall be indicated under one or other of the following headings:

- Issued for review
- Approved
- Not approved
- Approved with comments
- Issued for construction
- Issued "as built"

All changes and modifications to the Master Drawing Files and the Master Technical Instruction Files shall be highlighted in red markings.

31.3.4 Operation & Maintenance Instructions

Operation and Maintenance instructions shall be prepared in the form of a manual for use by the Engineer's personnel.

Draft copies for the Engineer's approval shall be submitted two weeks before erection of equipment commences.

The preparation of the manual shall be carried out by personnel who are trained and experienced in the operation and maintenance of the system and equipment described, who are skilled as technical writers to the extent required to communicate essential data and who are skilled as draughts-persons competent to prepare the required drawings.

31.3.5 Program and Project Management

31.3.5.1 Outline Works Program

The Bidder shall submit with his Bid an Outline Works Program showing in bar chart form the key dates, commencement dates, duration and completion dates of the main activities for each site. Where the work in a site is to be completed in more than one phase the work sequences associated with each phase shall be shown separately.

The following items shall be shown:

- System and equipment design and approval.
- Supply of drawings and information necessary for civil design.
- Manufacture of system and equipment.
- Factory Acceptance Tests
- System and equipment erection.
- Tests on Completion.
- Guaranteed Dates for Completion.

The Contractor shall perform the Works in accordance with the Outline Works Program submitted with the Bid until the Engineer approves a detailed Works Program.

31.3.5.2 Detailed Works Program

Within 30 days from the date of Award of Contract the Contractor shall submit to the Engineer for approval a detailed Works Program showing the activities and sequence needed for the orderly and coordinated performance and completion of each separate part of the Works in order to meet the major contract events set out in the approved Outline Works Program, except as otherwise approved in writing by the Engineer.

31.3.5.3 Training

The Contractor shall submit a Training Plan, which shall describe in detail how the Contractor proposes to train the Engineer-in-Charge's staff pursuant to the provisions of the Contract.

31.3.5.4 Putting into Service

The Contractor's responsibility shall include the commissioning and putting into service of all system and equipment. No system or equipment shall be put into service without the written approval of the Engineer-in-Charge.

Prior to putting system or equipment into service it shall be subject to a "Safety Clearance Certificate" system in a form to be approved by the Engineer-in-Charge, and thereafter subject to the provisions of the Sub-clause on Work in Operational Areas.

31.3.6 Tests

31.3.6.1 Tests and Inspection

Within two weeks after of the approval of the contractor's design, the Contractor shall submit for the approval of the Engineer a Test and Inspection Plan for all items whether at the manufacturer's location, the Site or elsewhere up to the date of taking over certificate in accordance with the provisions of the Contract. Such plan shall be in two parts covering factory tests and site tests respectively. The plan shall include a description of the item or part of the Works to be inspected or tested, the nature and frequency of the inspection and testing, the type and size of samples to be taken (if any), the means of recording the test and inspection data, the name and specific responsibilities of any proposed test and inspection agency and all other information necessary to describe the test or inspection to be performed. Not later than two weeks prior to the commencement of any particular test full details of the proposed method of test, test parameters and test circuits shall be submitted for the Engineer's approval and following such approval shall become part of the Test and Inspection Plan.

Such plan, as approved and modified by the Engineer, shall be used for the inspection and testing of the System and shall be revised and resubmitted for the Engineer's approval if the Contractor desires to change the sequence, method or nature of the test or inspection or if such a change is required by changes in the Work Program or scope of the Work.

Measuring equipment shall be subject to the Engineer's approval and, if required by the Engineer, it shall be calibrated at such independent laboratory as may be agreed. The cost of any such calibration shall be demand to be included in the BoQ rates and prices.

The cost of all tests required by the Specification, including the cost of providing samples where needed, shall be borne by the Contractor.

Approval of tests or inspection of the Work or portions of the Work by the Engineer shall not relieve the Contractor of his responsibility to complete the Work according to the Specification, including the satisfactory execution of all necessary site inspections and tests nor shall it relieve him of his duties and obligations under the Contract.

31.3.6.2 Preliminary Factory Testing (Pre-FAT)

The pre-FAT shall be a complete dry run of the FAT, following the test plans and procedures. The intent is for the Contractor to detect and correct most design, integration, display, and performance problems prior to the FAT. The Contractor’s project manager shall sign off each test. All tests shall be conducted using the Engineer-in-Charge-specific databases (where applicable) unless the Engineer-in-Charge authorizes the Contractor to use a test database.

The Contractor shall notify the Engineer-in-Charge at least thirty days prior to the start of the Pre-FAT, and the Engineer-in-Charge shall have the option to witness all or parts of it. The Contractor shall notify the Engineer-in-Charge when the pre-FAT has been successfully completed and the system is ready for FAT. The completed test results shall be sent to the Engineer-in-Charge for inspection and approval before the Engineer-in-Charge’s personnel travel to the Contractor’s facilities for the FAT.

31.3.6.3 Factory Acceptance Tests (FAT)

Prior to the Factory Acceptance Test, the Contractor shall submit to the Engineer-in-Charge the updated List of Deliverables.

Type and routine tests shall be performed on all equipment as set out in the Bidding Documents. The type test certificates where available, shall be submitted with the Bid. Where the particular section of the Specification calls for type tests to be carried out at an independent testing laboratory or witnessed by an independent third party testing agency the type test certificates shall show proof of such independent witness.

In the case of equipment for which specific type tests or routine tests are not called for in the Bidding Documents, the Contractor shall include in the Test and Inspection Plan details of all tests proposed prior to shipment. Certificates of all such tests shall be submitted to the Engineer.

All tests shall be carried out to the satisfaction of the Engineer and no equipment shall be dispatched prior to the Engineer's written approval of the test results.

The Contractor shall give the Engineer thirty (30) working days written notice of the date after which he will be ready to carry out the Tests on Completion.

All tests will be witnessed by the Engineer-in-Charge and/or the Engineer, at their discretion and all costs pertaining to these visits will be entirely to the Contractor’s account. The Contractor shall quote in his bid the rates for third party testing if conducted.

The in-factory tests to be conducted shall include but not be limited to the following:

Prior to shipment to site, at least the following tests shall be performed at the manufacturer’s premises, or at the manufacturer’s recommended test facilities equipped for such tests.

- Verification of IP class of all field mounted cabinets and equipment enclosures.

- Operating temperature test for Solar Panels, Batteries, Inverters, Charge Controllers and other equipment, demonstrating satisfactory operation over the manufacturer's operating temperature range.
- Functional tests for Panels, Batteries (if used), Inverters and Charge Controllers for the measurement of technical characteristics.
- For all batteries, capacity test for the batteries, on a sample basis, according to IEC recommendation 60896-1.

The cost of pre shipment inspection incurred by the Engineer-in-Charge and Engineer including in land transportation, round trip air fare, loading in four star hotel or equivalent and daily allowance of 200 US Dollars or equivalent shall be deemed to be included in the total bid price. Following receipt of such notice, a joint team comprising one engineer each of the Engineer-in-Charge and Engineer shall conduct testing and pre shipment inspection of the plant/ equipment or erection equipment or any part thereof including the packing at manufacturer's / supplier's premises and will issue a pre shipment test and inspection report.

In case the Engineer-in-Charge and the Engineer cannot or do not attend pre-shipment inspection, the Engineer shall issue with the approval of the Engineer-in-Charge, a letter of waiver to ensure timely shipment. The Goods or any part thereof shall be shipped or delivered only upon issuance of pre-shipment inspection report or waiver to pre-shipment inspection by the Engineer.

31.3.6.4 Modifications to the System during FAT

No changes shall be made to the System after factory testing has started without the express authorization of the Engineer-in-Charge and at its discretion.

This requirement does not apply to Preliminary FAT. It is the Engineer-in-Charge's intent to carefully control the test environment so that all changes can be readily identified and so that any changes installed for any purpose can be removed and the previous test environment restored. The Engineer-in-Charge shall have the right to suspend testing, to revert to a previous version of any software or hardware, and to restart any testing previously performed if, in its opinion, changes have been made to the system under test without authorization.

31.3.6.5 Tests on Completion

Prior to taking over of the system or any section of the Works or to putting any portion of the Works into service the Contractor shall carry out Tests on Completion in accordance with the provisions of the specifications. The tests shall be carried out in the presence of the Engineer-in-Charge and/or Engineer and to their satisfaction. Such tests shall be carried out at the Contractor's risk.

The Contractor shall submit for the Engineer's approval a detailed schedule of all tests and inspections to be carried out together with complete sets of the proposed measurement, recording and reporting forms for each part of the Works. Following their approval by the Engineer these submissions shall become part of the Test and Inspection Plan.

The Contractor shall be responsible for the measurement, recording and reporting of Tests on Completion. As each item is completed its completion shall be certified by the Contractor and countersigned by the Engineer-in-Charge and Engineer.

The Tests on Completion shall verify the correct functioning of individual parts of the Works and of systems involving more than one item of equipment. The tests shall include tests for dielectric withstand, insulation resistance, earth resistance, correct wiring and connections, correct functions and operating characteristics, calibration of measuring devices and other tests as may be directed by the Engineer.

If in the opinion of the Engineer the Tests on Completion are being unduly delayed he may by notice in writing call upon the Contractor to make such tests within 10 days from the receipt of such notice and the Contractor shall commence such tests on such day or days within the said 10 days as the Contractor may determine and of which he shall give notice to the Engineer. If the Contractor fails to carry out such tests within the time aforesaid the Engineer may proceed to carry out such tests himself. All costs and losses incurred by the Engineer-in-Charge by reason of such failure and/or by the carrying out such tests by himself shall be borne by the Contractor.

If any portion of the Works shall fail to pass the Tests on Completion then tests on the said portion shall, if required by the Engineer-in-Charge, be repeated within a reasonable time upon the same terms and conditions, save that all costs and losses incurred by the Engineer-in-Charge in consequence of such failure and/or by such repetition shall be borne by the Contractor.

Proximate notification of each particular test or inspection shall be given to the Engineer-in-Charge on an approved form not later than 24 hours prior to the scheduled commencement of the particular test.

31.3.7 Notice to Deliver

The Plant or any part thereof shall be shipped or delivered only upon an authorization in writing (hereinafter called the "Notice to Deliver") which shall be applied for and obtained by the Contractor from the Engineer that the Plant or any part thereof may be shipped or delivered. The “Notice to deliver” will be issued within fifteen (15) days from the date of receipt by the Engineer of the Contractor's valid application.

31.3.8 Spare Parts

Bidders shall quote for the items listed in the List of Spare Parts submitted by the Bidder and finalized by the Engineer-in-Charge during the evaluation of the bids during the first stage. The list of spares will be prepared by the Bidder on the following basis.

1) At least one module of each type shall be included in the spare parts list, if the total amount of modules is less than or equal to ten (10).
2) If the total number of modules is more than ten (10), the spare modules to be supplied shall be at least ten percent (10%) of the total number of modules (the fractions shall be rounded off to the nearest higher integer).

Bidders shall also list in the Price Schedules of Additional Spares those additional spare parts which the manufacturers recommend should be held to cater for three years operation of all equipment supplied under the Contract. A firm price shall be quoted for all items, which shall include delivery to the Engineer-in-Charge's stores.

Parts shall be separately packed. A drawing which clearly identifies the part, quotes the part's serial number and gives a clear reference to the maintenance manual shall be enclosed in each pack. In addition, installation instructions shall be included in all packs containing spares for cable joints and terminations.

32 Digital PAX Equipment

SCOPE OF WORK

The digital PAX shall cater to the specified operational speech requirements for the Project. The equipment shall be field proven and already working satisfactorily in telecom networks operated by power utilities. Thus, it shall be suitable for operation in harsh environment with electromagnetic interference and high temperature/humidity and shall have a high reliability and security. Evidence shall be provided with the bid in the form of reference lists, clients' certificates and type test reports regarding installation and operation of proposed PAX in power utility environment.

In the event that the Contractor and Manufacturer are different, the Manufacturer's representative shall commission the PAX in strict accordance with established installation practices.

33 Operational Requirements

A. Network Organization

The Contractor shall be responsible for fully integrating the offered PAX into the above operational telephone network. Complete integration requires that the exchange supports all network facilities (in particular priority intrusion and forced release) over the digital and analog trunks and shall be fully compatible with the PAXs to be implemented under the other Upgrade project. The compatibility of the new PAX shall be demonstrated in the field before formal approval can be accorded. This shall take place before site testing and commissioning.

B. Numbering Scheme

The new PAX shall use a closed numbering scheme in which a singular number shall be dialed for a given extension irrespective of the calling party. The numbering scheme shall be uniform and consist of four digits. The selection of appropriate trunk lines shall be as flexible as possible and shall be made through the analysis of the dialed number. Only digits that are required for determination of the call direction shall be analyzed.
Changes in the numbering plan by the Engineer-in-Charge shall be possible in a flexible and easy manner without any modifications in hardware or wiring.

C. Channel Routing

Whenever several routes are possible within the meshed network for connecting stations, the PAX equipment shall allow free line selection, so that when one trunk or a group of trunks (route) is busy/occupied, the call is automatically transferred to the next available line according to a pre-programmed sequence. Such selection shall be programmed in the PAX according to traffic considerations and network topology. Whenever extra equipment is required for this purpose, it shall be stated and if not stated shall be deemed to be included in the Bid.

D. Caller Number Identification

The PAX equipment must have the capability of transferring the caller number identification throughout the network to enable the appearance of this information (on a per call basis) on the control telephone.

34 Technical Requirements

A. General

The PAX shall be state-of-the-art digital, non-blocking type utilizing pulse code modulation (PCM), time division multiplexing (TDM) and stored program control (SPC). The transmission shall conform to the ITU-T A-Law Companding standard (ITU-T Rec. G.711 and G.712). Centralized circuits shall be provided for tone generation and detection. The system shall use digital technology and microelectronics, with minimum 32 bit main processor control, and fully modular hardware to allow future expansion in extension and trunk lines. The software of the system shall be written in open standard software architecture and a high level programming language recommended by ITU-T.

The proposed system shall comprise integrated and discrete components of a high level of reliability to guarantee a system availability of 99.98% over a fifteen year operating period.

The PAX shall be suitably designed to operate over any kind of transmission media such as FO, digital microwave and pilot cable. The Contractor shall provide details of the signaling schemes, in accordance with the ITU-T standards.
Plug-in printed circuit boards shall have gold plated connectors, if applicable, and shall be connected by means of printed back panels.
Line terminals shall consist of solderless connectors of well-proven design for easy wiring, testing etc.

Extensive and adjustable time-out facilities shall be available in the PAX to enable the time-out and release in the following cases:

- when a call is not answered in a predefined period.
- when while dialing, the inter-digit time period is exceeded.
- when an incomplete or invalid number is dialed.
- when a station user attempts to access a feature he is not allowed.

The PAX shall incorporate a backup memory on flash ROMs/magneto optical disk to protect the system against loss of memory due to power failure or breakdown of the system. Upon restoration of power to the system, the backup memory shall automatically reload the required system and customer data files into the active memory area within a period of less than ten seconds whereas in case of a complete blackout requiring reload of the operating system, the PAX would be operational within a period of less than two minutes.

The programs and data of the system shall also be stored on removable disks which can be used to load the system in case of a main system disk failure.

The PAX system shall incorporate a wide range of self-initiating diagnostic routines for the monitoring of the system performance and identification of errors i.e. major and minor hardware and software faults, faulty line/trunk card, power supply, etc. Details of hardware and software covered by self-diagnostics shall be explained with the bidder’s proposal.

The PAX system shall incorporate with the PAS system. The interface between two systems is connected with a communication wire for the emergency announcements as an alternate to the existing microphone.

B. <u>Interface Circuits</u>

The various types of interface circuits shall be in accordance with the following standards/ protocols:

Analogue Extension	:	Two wire Dial Tone Multi-Frequency (DTMF) according to ITU-T Q.23
Digital Extension	:	Standard BRA 4 wire ISDN S0 bus (ITU-T I.430) UPn 2 wire interface (in 1B+D or 2B+D modes), Uk0 2 wire interface
Analogue Trunk	:	2 wire/4wire E&M Interface with MFCR2 (ITU-T Q.400 TO Q.490) 2 wire loop disconnect Interface
Digital Trunk	:	30B+D interfaces conforming to ITU-T G.703/G.704 with 1TR6, DPNSS and QSIG protocols 2 MB/s CAS protocol 2B+D interface conforming to ITU-T I.430 with 1TR6, DPNSS and QSIG protocols

C. <u>Software Features</u>

The PAX system shall possess, as a minimum, the following software features.

- Linux: Linux Kernel 2.6.29.6
- Unified Directory access, call by name
- Unified call log
- Unified Instant messaging
- Multiline telephony
- Call options, speed dial
- Audio conferencing
- Smart Call Routing (SCR)
- Maximum entries: 10000
- Routing criteria (customer code, CLI, DDI)
- Routing destinations
- ACD, MLAA, any destination
- 2 per entry, planning based
- Planning: 10
- Security Authentication
- User authentication: login/password (4 or 6 digits)

The features shall be fully transparent to the network.

i. Call Priority

Call priority can be assigned to certain extensions or Network Tie Lines as a fixed attribute; calls originated by these extensions or on these lines will always have priority over routine calls. Alternatively, extensions may be given a Service Class which allows them to obtain Priority on a call-by-call basis when needed. During the application of priority, priority intrusion is used to intrude upon an established call when congestion is encountered upon initiating a call to another extension. The Priority feature is a mandatory function which must function over the PAX network. It may be inhibited either manually or automatically.

ii. Automatic Priority Intrusion

If a call is initiated with Priority, a busy line in the first choice route will be selected once congestion has been detected in the alternative routes. The caller will then automatically enter into a conference with the parties in conversation on this line, after a short intrusion tone has been provided to all parties, including the intruding party. The duration of this conference is limited to a configurable amount of time (default duration of thirty seconds), after which the intruding party will be disconnected.

iii. Manual Priority Intrusion

If the call has not been initiated with Priority and congestion is found on the line, the caller shall receive an audible and visual indication of this. The caller shall then have the option of upgrading the call's priority. This is accomplished by pressing the appropriate PRIORITY key on his telephone within a configurable period of time (default duration of fifteen seconds), otherwise, the caller will be disconnected.
Once manual intrusion has been performed, a busy line is selected and a conference established as described above for Automatic Priority Intrusion. At this time, the call will be tagged as a Priority call in each node along the route to the destination, as the intrusion order is transmitted from node to node.

iv. Forced Release of Call

A Forced release order is used by the intruding party to forcibly release the parties in an established call which has been intruded on, in order to free the line for use by the intruding party. Once the caller has intruded on an established call, he may initiate a Forced Release Order by pressing the PRIORITY key before the maximum duration of the intrusion has elapsed.
After application of the Force Release Order, the intruding party will be either automatically connected to its destination without any redialling or further dialling by the intruding party or by redialling of some number or code to establish the connection. The Bidder will state the provision available in the proposed PAX.

v. Hot-line Extension

This type of extension shall have the facility to automatically call a pre-designated number by only lifting the handset.

vi. Call Diversion on Busy

Calls to an extension are diverted to a predefined directory number when the extension is busy.

vii. Call Diversion on No-answer

Calls to the extension are diverted to a predefined Directory Number (DN) when the call is not answered within a specified period of time (default duration of ten seconds).

viii. Call Transfer

Allows an extension user on any two party call to Hold the existing call, originate a call to a third party and then transfer the call to a third party. The station user can then consult privately with the third party before completing the transfer, or can return to the original caller.

ix. Call Forward

All incoming calls to a station user can be automatically forwarded to another pre-selected destination within or outside the PAX to which the station user is connected.

x. Call Waiting

Alerts the station user, busy with an established call that additional calls are waiting to be transferred.

xi. Ring Again

Allows a station user, on encountering a busy connection, to be alerted when a called party or trunk route becomes free. The system will then automatically redial the desired destination.

xii. Call Pick-up

Enables the definition/programming of specific call pick up groups whereby a station can pick up an incoming call for another station in his call pick up group by lifting his handset and dialling a pre-designating call pick up code.

xiii. Conference

Allows a station user to establish a three-party conference. Conferences may be inside or outside the PAX to which the station user is connected.

xiv. On-hook Dialling

Enables a station user to originate a call without lifting the handset.

xv. Privacy

When a station user is engaged in a two party conversation, no other party can enter the conversation.

xvi. Authorization Code

For the purpose of overriding the access restrictions, a specific two to three digit pre-programmed code is dialled by a designated station, to enable him to gain free access to the network. Dial tone is returned to the station user after dialling the code and he is able to call the destination without restriction.

D. <u>Equipment Design</u>

The equipment configuration shall be flexible to enable implementation of point to point, tandem as well as ring topology communication with other substations. The PAX system shall be expandable without any interruption in service.

The proposed PAX equipment shall incorporate at least a 30% spare equipped capacity in the user interfaces and shall be expandable to 100% of the equipped capacity by simple addition of plug-in modules. The equipped capacity shall be fully wired up to the MDF.

The PAX system structure shall be based upon a multi-processor hierarchy, in which the processing requirements are subdivided on the basis of both the type of function to be carried out and the time limits set. The architecture shall allow for the optimum use of system resources by use of a combination of advantages of distributed processing with the low costs and efficiency of centralized management. The system shall consist of the following functional units.

i. Common control group

In order to avoid the duplication of information and allow for a set up of a reliable and flexible structure, this group centralizes the decisional-management system functions, operator interface functions and system functions such as down-loading programs to processing subsystems (peripheral equipment modules). This group collects all pertinent information relating to the state of the various parts of the PAX system, activating if necessary alarm procedures and regulating access to the system's memory areas in order to optimize their use.

It contains all the system programs, semi-permanent system data, subscriber categories and features, numbering schemes, network characteristics and all other information used to provide services.

The Input/Output communication shall be achieved via a terminal (VDU) which displays/prints on request all system information, alarm messages, traffic and call recording data.

ii. Switching group

This portion of the system performs the switching functions of the communication channels in a non-blocking mode, with a bit transfer rate according to ITU-T standards. It consists of the appropriate digital/analogue converters for the subscriber and trunk modules/cards plus a memory time switch for establishment of the connections required by the Common Control Group.

The data exchange between the Switching Group and the Common Control Group shall be via the high speed data bus incorporating a bidirectional V.24 interface, through which the Common Control unit gives instructions for;

- Controlling the switching operations.
- Injecting audible signals.
- Setting up conferences.

iii. Peripheral equipment group

This group shall consist of the various types of line and trunk modules and associated bus extension units. It shall be possible to incorporate both the analogue and digital versions of the line and trunk cards.

iv. Operation/maintenance ports

The PAX system shall incorporate at least two EIA RS232C serial ports for connection of input/output terminals to enable the program of customer data information and recording and monitoring of traffic data.

v. Operation/maintenance facilities and alarms

An adequate range of alarm and test facilities shall be provided to enable the maintenance personnel to rapidly access and localize the fault conditions. The exchange shall be supplied with system management & diagnostic software.
The facility of remote access of the PAX for operation and maintenance purposes shall also be available.

The system shall also contain appropriate hardware and software for the audible and visual display of the whole range of alarms from the PAX equipment to enable the local maintenance personnel to undertake corrective action immediately upon the occurrence of a fault.

The Bidder shall provide complete technical details of the operation/maintenance facilities and alarm display and rectification.

E. <u>Equipment Cubicle</u>

The exchange equipment shall be installed in racks mounted in a free-standing swing rack cubicle, of completely enclosed type with a protection class of IP 54 and shall preferably not require any rear access. The cubicle shall be dust and vermin-proof with suitable dust filters and ventilation provided. Accessibility shall be provided from the front for testing, commissioning and maintenance purposes. The cubicle shall have the provision of being locked from the outside. Entrance of the cables shall be through a gland plate provided at the bottom of the cubicle.

All modules shall be identified as to their shelf location and it is preferred that coded key slots are used in the edge connectors in order that modules cannot be plugged into the wrong shelf position.

F. <u>Telephone Sets</u>

i. Desk telephone set

Desk telephone shall be a standard single line push button analogue tone dialing set. The keypad and the dialing from the telephone set shall conform to the ITU-T Q23 standard. It shall be possible to attach a hands-free unit, if required.

ii. Wall mounted telephone set

Wall mounted telephone shall be a push button analogue tone dialing set designed for installation on the wall only. The keypad and the dialing from the telephone set shall conform to the ITU-T Q23 standard.

iii. Executive telephone sets

Executive telephone shall be a push button tone dialing set with display of at least 2x24 characters to show Names and CLIP, at least 24 programmable memories, digit display, provide full hands-free operation, have programmable function keys with LED indication, support context sensitive features, name dialing and display as well as Message display.

G. Cabling

All cabling, between the telephone sets and the PAX and between the PAX and MDF/communication equipment shall be supplied and installed by the Contractor in trenches/ducts and/or cable trays. The telephone cables shall be multi-pair, twisted and screened with suitable protection against vermin/rodent attack.

H. Power Supply

The PAX equipment shall be powered from the 48V DC power system.

35 Main Distribution Frame (MDF)

The termination frames shall be housed in a self-standing 19" cabinet (separate from the PAX cubicle) lockable from the outside. The cabinet shall be dust and vermin proof, designed to a protection class of IP54. Provision shall be made to earth the cabinet to the grounding system within the substation. The entry of cables shall be from the bottom through suitable glands provided in the plates and care shall be exercised that the glands are tightly closed after the installation of cables.

The connecting blocks shall be of the quick-connect type, each capable of accommodating at least 10 pairs. It shall incorporate over-voltage and over-current protection on all external trunk and subscriber circuits. These protectors shall be either carbon or gas tube type. Access to the connecting blocks shall be from the front. One (1) quick connect tool shall be provided with the MDF cabinet.

36 CCTV Cameras Surveillance System

8.1 SCOPE OF WORK

The scope of works shall include the design, supply, installation, testing and commissioning of CCTV Cameras Surveillance System, complete with associated electrical and communication wiring works, control consoles, digital video recorders, copper to fiber signal converters, fiber to copper signal converter, mounting brackets and accessories. The Contractor shall be responsible for providing complete CCTV system solution including auxiliary equipment for best quality of service e.g. signal repeaters etc. and all such equipment shall be deemed to be included in the scope of Contractor. The system shall include NVRs, PTZ cameras, Dome Cameras, Box type cameras, PTZ controller, LCD screens, wiring, termination, electrical boxes, and all other necessary material for a complete operating system. All bidders shall have to visit the site to take physical dimensions of hoist way, pits overhead and machine room to verify their horizontal / vertical lengths etc. before submission of proposals. The bidders may raise the queries for any clarification, missing information or ambiguity if any, within one week after issuance of tender documents. Any work to be carried out by the owner / main contractor, should be mentioned clearly along with the bid, otherwise no claim against extra work shall be acceptable. Specification, Drawings and BOQ etc. should be read carefully to comply specified loads, serving landings and other general and special safety features. Any deviation from specification / BOQ should be mentioned well in time before submission of bid.

8.2 Standards

Except where otherwise stated in the Specification, materials shall be designed, manufactured, tested and installed according to relevant IEC/ISO/ITU Recommendations. Where no such Recommendations have been issued to cover a particular subject then a recognized regional or national standard shall be applied. The latest edition and amendments shall apply in all cases. In case of conflict between the Specification and any of the IEC/ISO/ITU Recommendations, regional or national standards, then the Specification shall take precedence.

The Bidder shall state in his bid the standards and codes of practice which he proposes for any items of system or equipment not covered by IEC/ISO/ITU Recommendations. If required by the Engineer-in-Charge, the Contractor shall submit two English language copies of any standard or code of practice.

All equipment shall be of imported origin. CCTV equipment and design shall comply with international standards.

37 PASSENGER ELEVATOR

9.1 SCOPE OF WORK

The scope of work shall cover design, supply, installation, testing & commissioning, of entire elevator equipment including hoisting machinery, sheaves and girders, controller, car, ropes, counterweights, supports, brackets and guides for car & counterweights, car & landing doors, door operator, switches & control, safety devices, signals, governor, safety gears, buffers, pit screens, well trimming girders, trap door and such related accessories complete in all respects as specified herein. All labor, erection equipment, (i.e. winches, scaffolding etc.), erection tools, appurtenances, embedded parts and materials, etc. necessary to supply, install, test and commission the elevator all in perfect operating condition in accordance with these Specifications and Drawings are included in the scope of works.

All relevant civil works as per BOQ, Cutting, patching and repairing of damaged civil works required during installation of new equipment. Repairing of damaged civil works and architectural finishes are also included in the scope of work

Providing drawings showing final arrangement of equipment, dynamic & static loads imposed on the building, openings, location of embedded parts etc. wiring and control logic diagrams is also part of scope of works.

Providing and installing, from designated electrical power supply point, all required cabling, distribution boards and accessories .

Maintaining the works during defect liability period. In addition to routine periodic maintenance, executing all such work of repair, rectification, parts replacement and making good defects occurring during this period.

Providing Operating and Maintenance Manuals to the Employer.

9.2 Design Requirements

9.2.1 CODES AND STANDARDS

All equipment & materials under this works shall be furnished in conformity with latest edition of applicable standards of ANSI, ASME, BS/EN, AWS, NFPA, ASTM, NEMA, IEE, etc. and applicable Government and Local Codes governing the same. In case of conflict, the strict requirements shown/specified shall govern. All equipment shall be rated and tested as per relevant standard (latest edition).

Where possible, the same codes and standards shall be used throughout a particular facility. However, the final decision on which codes and standards shall be applied shall remain with the Engineer.

Abbreviation for codes and standards referred to in the contract are as under

EN	European Norms
ANSI	American National Standard Institute, USA
ASME	American Society of Mechanical Engineers, USA
AWS	American Welding Society
NFPA	National Fire Protection Association
ASTM	American Society for Testing and Materials, USA
NEMA	National Electrical Manufacturer's Association
IEE	Institute of Electrical Engineers, London

9.2.2 Elevator System General Requirements:

a) Elevators shall be designed specifically for the operation, loading and environmental conditions, and shall have a minimum design life of 25 years.

b) The final assembly of all components shall not pose hazardous conditions to the public or maintenance personnel. Surface irregularities, sharp edges, or protrusions in public or maintenance areas shall not be permitted.

c) Provide convenient and safe equipment access for inspection, cleaning, maintenance, repair, and replacement.

d) All gaps and running openings within regulatory tolerances shall be properly closed by the use of appropriate sealant or another approved means installed in accordance with the manufacturers' instructions.

e) For parts and equipment subject to wear and requiring periodic replacement, furnishing key and seat, nut, screws, or other removable and replaceable type mechanical fasteners. Such replacements shall not diminish original structural integrity. Use of rivets or similar type fasteners requiring physical deformation
during field positioning will not be permitted.

f) The elevator equipment shall be quiet and smooth running and shall not exceed the following maximum noise output levels during all phases of operation:

i) 70 db measured in the elevator car
ii) 70 db measured at the elevator hoistway entrances

g) Fire Protection: providing non-combustible materials for components including Halogen-free cables.

9.2.3 Seismic Criteria:

a) Installation and equipment designed for static and for seismic conditions shall be provided in accordance with regulatory requirements.

b) Provide hardware necessary to protect motors, drives, and door operators

c) Seismic design shall be based on the assumption that structures and equipment will be subjected to a maximum horizontal ground acceleration of 0.7g (70 percent of gravity).

9.2.4 Power:

The main elevator power shall be 400 Vac, three phase, 50 Hertz or as per project specific requirement.

9.2.5 Elevator Controller:

a) The controller for Elevators shall be a field programmable microprocessor based, automatic operation with open loop, variable voltage, variable frequency control.

b) Elevator operation shall be by means of pushbuttons in the car, numbered to correspond to landings served, by CALL pushbuttons/touch buttons at terminal landings, and by UP and DOWN pushbuttons/touch buttons at intermediate landings.

c) All options or parameters shall be field programmable without the need for external devices. Programmable settings shall be stored in non-volatile memory.

9.2.6 Elevator Door and Hoistway Door Operation:

a) Hoistway doors and car doors shall:

i) Open automatically and simultaneously when the car arrives at the destination landing.
ii) Be equipped for readily and independently adjustable door hold open times when car stops for a car or hall call. Main floor door hold times shall be adjustable independently of other floors.
iii) Close after hold open time interval has elapsed and no obstruction has been detected, or when the car is called or dispatched to another landing, or when either the car door close button or a car call is pushed.

b) Activation of the door close button in the car shall cancel door timer and close the doors provided there is no obstruction

c) All closing times shall be adjustable from 5 seconds to 30 seconds without exceeding closing force specified herein.

9.3 MATERIALS & WORKMANSHIP

9.3.1 Material

All materials shall be of the highest grade, free from defects and imperfections, of recent manufacture and unused, and of the classification and grades designated, conforming to the requirements of the latest issue of the appropriate specifications and standards. All materials, supplies, and articles not fabricated by the Manufacturer shall be the products of recognized reputable manufacturers.

All materials including electrical wirings shall be weather proof.

9.3.2 Workmanship

All work shall be performed and completed in a thorough workmanlike manner and shall follow the best modern practice in the manufacture of high-grade machinery, notwithstanding any omissions from the Bid Documents. All work shall be performed by mechanics skilled in their various trades. All parts shall be made accurately to American Standard or other approved gage, where possible, so as to facilitate replacement and repairs. All bolts, nuts, screws, rivets, threads, pipes, gages and gears shall conform to applicable American or other approved standards.

9.4 PRODUCT DESCRIPTION

9.4.1 General

Elevators shall be installed in the shaft at location shown on the project drawing. The dimensions of respective elevator wells and pits shall meet the project drawing requirement.

It is recommended to visit the site to examine the existing structures and details to verify and confirm suitability of the existing structure for the installation of the equipment.

Providing opening in Elevator well for suitable ventilation and for escape of gases and smoke in case of fire.

The control cabinet/ panel of MRL elevator shall be located at the last serving floor. The dimensions/ location shall be given on buildings drawing by the elevator Manufacturer.

The location of drive machinery and control cabinet shall suit the elevator orientation so as to allow easy access and sufficient space for maintenance work and to provide a good looking architectural outlook.

The acoustically insulation of the elevator shaft and appropriately isolation of the equipment to prevent disturbances in the surroundings area due to operating machinery.

- Sound reducing materials to isolate motor set from civil structure, balance rotating parts to eliminate vibrations and flexible electrical conduits shall be provided. The operation of elevator car and doors shall be completely free from all abnormal jerks, vibrations and sound. The maximum sound level within the car must be within comfortable limits defined in relevant standards/codes.

The characteristic details of the elevator to be supplied are listed under para 6.0. The construction and functional details are given hereunder:

9.4.2 Civil Construction

A. Elevator Well

The elevator shall be installed in the completed elevator wells of dimensions as available on site.

The top of the well shall be enclosed and watertight.

Minor correction for the purpose of installation of guides in perfect plumb and other equipment to ensure perfect installation and operation of the elevators.

B. Pit Access Ladder

A rugged steel ladder for easy access to the pit shall be provided.

C. Pit Screen

A suitable rigid screen shall be provided and fixed at the bottom of the elevator well where the counterweight comes down to its buffers and between elevators if required. The screen shall have a minimum height of 7 ft. as per code requirements.

9.4.3 Elevator Car

A. Car Frame & Platform

The car frame, consisting of upper yoke with cross yoke side braces and bottom frame shall be made of welded or bolted steel channel sections, sufficiently rigid to withstand the operation of the safety-gear without permanent deformation of the car frame. The elevator car, platform, door operating mechanism, safety doors, etc. shall be mounted on car frame.

The deflection of the members carrying the platform shall not exceed 1/1000 of their span under static conditions with the contract load evenly distributed over the platform.

Roller guides, mounted on car frame, shall have individual suspension to cushion jolts and minimize noise and vibration.

The platform shall be of fabricated frame of formed and structural steel shapes gusseted and rigidly welded, with provision for a floor covering as specified with the car body work. Rubber pads of sufficient size shall be provided between the car frame and the platform to provide sound and vibration isolation. The underside of the platform will be covered with sheet steel to provide adequate fire resistance.

An aluminum sill grooved to suit door spuds shall be fitted to the platform together with a toe-guard.

The car bodywork shall be carried on the platform with the top fixing to the car frame being suitably isolated.

All auxiliary equipment shall be mounted and supported from the car frame.

B. Car Body Work

The car bodywork shall be of steel construction with provision for interchangeability of décor finishes and ceiling designs. The roof shall be constructed to withstand the weight of two men without deformation.

One side of the car shall have vision panel. Vision Panels shall be installed in such a way that vision panels on car and hoist way shall be aligned.

The car top shall have provision for emergency communication and roof trap door with micro-switch. A3 pin socket outlet shall be fitted on top of the Elevator car, besides two outdoor protected type lights one each at the bottom and top of the car operated through an MCB.

C. Finish

The car enclosure shall have decorative applied stainless steel wall finish panels except that the inside front of the elevator car and car doors shall be satin finish stainless steel. Recessed kick plate 6” high of stainless steel shall be provided on the three walls of the elevator car. The floor shall be provided with sheet steel and granite flooring.

Ceiling shall be of removable type with modular light fittings.

Handrails on three side walls shall be provided with satin finish standard stainless steel hollow section. Fixing brackets shall also be in stainless steel.

The design and finish of car interior together with suspended ceiling, light fittings, floor covering and other fittings shall be to the Engineer’s approval. The various options of car finish shall be provided.

D. Telephone

A telephone compartment shall be provided in each car in the front return panel above the car operating pannels. The compartment shall be provided with hinged door flush with the panel. The entire compartment and door shall be of stainless steel.

telephone set in the compartment which shall be connected to the machine room shall be part of the supply. Alternatively, intercom system with speaker set shall be provided.

E. Recessed Motion Sensing Unit

The motion sensor unit shall be recessed into the ceiling. Provide a mounting bracket flush to the ceiling for the motion detector unit. The motion detector shall be located and adjusted so that movement of the doors does not generate a false occupancy. Provide the 120 Vac-power supply to the power pack unit of the motion detector.

Programmed Operation: If after a programmable length of time, an elevator car call has not been activated and the sensor detects elevator car occupancy, the car shall be programmable to proceed with either one of two courses of action. The choice of action shall be selectable by the motion detector switch in the service panel on the Car Operating Panel. The logic and circuitry of this alarm shall be incorporated into the controller circuit. Any auxiliary relay contact required to accomplish this feature shall be provided. This circuit shall be depicted in the schematic diagram of the controller. All occupancies, regardless of operation, shall be reported to the Communication Room.

Automatic Car Call Mode: Upon occupancy detection, the elevator shall automatically generate a car call to the opposite floor if a car call is not activated within an adjustable time of 5 to 30 seconds.

Nuisance Occupancy Mode: If an occupancy is detected without a car call for an adjustable time of 5 to 30 seconds, then the doors shall reopen and remain open with audible alarm until a car call or hall call is generated or the car is vacated.

F. Camera

A 360° camera shall be mounted in the ceiling corner on the front wall opposite of the side of the Car Operating Panel. The camera shall be adjusted to observe patrons inside the Car. The camera shall be housed in a vandal resistant enclosure. The display of the camera shall be available in the control room. All necessary hardware shall be provided.

9.4.4 Doors

9.4.4.1 Landing Doors

Each landing shall be provided with center opening doors. The doors, frames and architrave shall be made of stainless steel in satin finish. The door panels shall have a fire resistance rating of at least one hour. The panels shall be interconnected by a maintenance - free self-tensioning synchronizing wire rope.

Each landing shall be equipped with a toe-guard apron at the hoistway entrance side. The toe-guard apron shall be of sheet steel not less than 16 gauge thick, and shall extend not less than 50mm beyond the entrance jamb at each side. Toe-guard apron shall be approximately 2 feet deep, adequately fastened and braced, the lower edge turned inward.

The frames shall be of 14 SWG (min.) and panels fascia, toe-guards, dust and hanger covers shall be of 16 SWG. All other features not covered above shall be similar to that specified under Car Doors.

Each landing entrance shall be equipped with an approved type factory tested interlock as required by the code. The interlock shall be designed to prevent moving of the car away from the landing until the doors are locked in the closed position as defined by code and shall prevent opening of the doors at any landing from the corridor side unless the car is at rest at that landing or is in the leveling zone and stopping at that landing.

Landing door unlocking device as specified by the ANSI A17.l or B.S. 5655: part 1 Code shall be provided to permit authorized persons to gain access to hoistway when Elevator car is away from the landing.

Each Landing door or door panel shall be furnished with sheave type two-point suspension hangers and tracks complete in all respects. The sheaves shall have polyurethane tires with ball bearings sealed and lubricated for life. Hangers shall be provided with an adjustable slide to take the up-thrust of the doors. Tracks shall be of cold drawn steel shapes with smooth surface and shaped to conform to the hanger sheaves. Tracks shall be removable for replacement.

9.4.5 Car Doors

The car doors shall be center-opening type. The door-gear shall operate by a fractional kilowatt AC motor with VF drive. The door gear shall be built-in unit with the car door top track support, mounted on the car entrance column extensions.

A retractable car door coupling shall be provided to connect the car and landing doors to eliminate any backlash and ensure complete door synchronization.

The car doors, frame and front shall be of stainless steel (brush finish) with panel construction and other features such as fire rating, etc. similar to the Landing Doors.

The door panels shall be suspended from sheave hangers with polyurethane tires and sheaves running on a polished steel track, and guided at the bottom by non-metallic shoes sliding in an extruded aluminum threshold groove.

If the car is stationary at floor level with the doors closed, it shall be possible to open the car doors from inside the car by pushing the car door in the opening direction. To open the doors from the landings, the triangular key must be used.

A. Door Safety Devices

a) Full Width Light Curtain:

The car doors shall be fitted with light barrier system extending from 25mm above floor level upto a height of 1600mm, operating between car and landing doors. The barrier system shall comprise of a transmitter and a receiver strip containing several pairs of transmitters & receivers generating a large number of invisible light rays. In case if any one of these rays is interrupted, the control unit immediately reverses the door motion. The light curtain shall recalibrate itself at regular interval to update its scanning cycle.

In addition to above, the car doors shall be provided with an additional safety such as Door closing force limiting device or photoelectric beam etc. to maintain operational safety in case of failure of the main light barrier system.

b) Door Open Timing Feature:

The door operation shall also have door open timing feature operation in conjunction with light rays to provide adjustable, reduced, hold open time once rays are broken and re-established. In the event rays are broken beyond an adjustable time, a buzzer shall sound and doors to close at reduced speed.

B. Door Operator

A variable frequency controlled variable speed door operating unit capable of opening and closing car and landing doors simultaneously shall be mounted on the car frame independent of the car bodywork. The mechanism shall be designed to achieve smooth acceleration and retardation of doors without the use of dashpots. All pivot and bearing points shall be of steel and nylon or bronze bushed pins, ball or roller bearings suitably lubricated shall be fitted.

The driving mechanism shall be designed such that:

The closing force applied to the doors shall meet the requirements of B.S. 5655: Part I.

The car doors can be opened by hand in the event of a mains failure.

The motion of the doors will be reversed if they meet an obstruction. An AC motor with VF drive to provide variable speed shall be provided to obtain the performance required by the control system.

Mechanical Control Station, carrying controls and equipment as specified in B.S. 5655 shall be fitted on the top of the operator.

9.4.6 Hoisting Equipment

A. General

The elevators shall be MRL (Machine Room Less) type. The complete drive machinery and convertor shall be installed in the well on steel beams. The exact location of Drive Machinery and other equipment to be suitable for elevator shaft orientation so as to allow sufficient access and space for maintenance.

Anchor bolts, templates, inserts, signal boxes, and sleeves for installation shall be furnished. Additional structural members such as steel angle, steel beam supports for governors, motors, controller, and rope guards shall also be supplied.

Each hoisting machine and corresponding controller shall be numbered with 100mm high numerals giving elevator numbers.

Sound reducing buffers of elastic material shall be provided under the base of the hoisting machines to isolate sound and vibrations from the building structure. The rotating parts shall be dynamically balanced to eliminate vibration.

B. Hoisting Machines

a) Gearless Traction Type:

The hoisting machine shall be of the permanent magnet gearless drive with motor, brake and other integral parts mounted as one assembly on steel bed plates so that proper alignment of these parts is maintained under all conditions.

Means shall be provided on all elevator machines to enable the elevator cars to be raised or lowered in an emergency by manual operation. The direction of winding corresponding to the raising and lowering of the elevator car shall be clearly indicated.

Manual operation shall be by a smooth-rimmed detachable, spoke less wheel fitted to the shaft.

b) Brakes:

The brake shall be spring actuated, electrically released and of adequate proportions for the duty involved and fitted with two self-aligning shoes actuated by compression springs.

The brake shall be instantly and automatically applied in the event of interruption of the power supply.

The brake shall be capable of bringing the car to rest smoothly, under maximum conditions of load and speed, and capable of sustaining static load of 150% of the contract load.

c) Motor:

The variable voltage (VVVF) variable frequency, motor specially designed to meet all elevator duty requirements shall have a duty cycle rating of a minimum of 180 starts per hour. The motor speed shall have controls to allow smooth transition between acceleration and deceleration phase. The motor shall be capable of stable operation at all speeds upto the stated maximum and no abrupt speed change shall be permitted. It shall have a drip proof enclosure and may be force ventilated.

The drive motor shall be rated to provide sufficient power to accelerate the elevator to full speed in the shortest period while maintaining passenger comfort.

The power system shall incorporate solid state equipment controlling the speed of the elevator motor. Smooth performance with steeples acceleration and deceleration are to be provided with a leveling accuracy of ± 0.25” and the final stop at floor level is to be achieved dynamically after which the machine brake shall be applied to hold the elevator car stationary.

9.4.7 Hoist-way Equipment

A. Suspension Ropes/Belts

Suspension ropes of high grade steel, specially designed for elevator duty shall be provided in conformity with the requirements of B.S. 329. The material of the rope shall conform to B.S. 2763. It shall be free from loose wires, distorted strands or other irregularities. All rope terminals shall comply with B.S. 461. Independent adjustment shall be provided for each rope.

The length of each rope/Belt shall be so adjusted that it loses traction with sheave when the counter-weight touches its buffers.

An automatic device shall be provided for equalizing the tensions of suspension ropes at least at one of their ends.

Suspension belts as per International Standards may be provided as an alternative to suspension ropes. However, trouble/ jerk free operation in suspension belt due to power break down problem shall be ensured.

All necessary equipment/ material shall be provided for trouble free operation. Manufacturer certificate on letter head for the same is required with use of suspension belts.

B. Guides, Fixings and Inserts

The guides shall consist of high quality 'T' section steel of adequate strength and dimensions suitable for travel, car weight, speed and elevator capacity. Guiding surfaces shall be accurately machined. The joints shall be spotted and joined by machined steel finish plates.

Guides shall be of sufficient length to prevent any of the car or counterweight shoes from running off the guides.

All guides are to be securely fixed to the walls of the elevator well by steel brackets bolted to metal inserts or by other approved means. Rag bolts shall not be permitted. All metal inserts, fixings, guide rails, anchor bolts etc. shall be provided.

Guides shall be so jointed and fixed to their brackets that they do not deflect by more than 3mm under normal operation.

Guides and their fixing shall withstand the application of the safety-gear without permanent deformation when stopping a fully laden car or the counterweight.

C. Guide Shoes

The sliding guide/Roller guide shoe shall comprise three slide elements, wherein each slide elements forms a respective. The arrangement shall be suitable for an oil-free mode of operation. Three fastening grooves each for preferably (with respect to the direction of insertion or longitudinal direction) mechanically positive reception of a respective slide element shall be provided in the support element. Support element shall comprise at least one bearing pin formed, preferably monolithically, at the support element. The guide shoe housing shall have a cut-out, which is complementary with the bearing pin.

The sliding guide shoe shall comprise a preferably separate protective element for protecting the slide surfaces from contaminations. The protective element in that case be positioned at the holding element on an inner side facing at least one slide element. In completely assembled position the protective element shall bear against the slide element or slide elements shall sealingly protects these.

D. Counterweight

A counterweight equal in weight to the car plus 40% to 50% of the specified load shall be provided to each elevator. Structural Steel frame shall support requisite number of cast iron weights. It shall be fitted with guide shoes and suspension arrangements and accessories suitable for specified elevator capacity.

Car and counterweight are to be fitted with roller guide shoes.

E. Safety Gear and Governor

A friction type progressive safety gear actuated by centrifugal over speed governor shall be securely bolted to the car frame under the car platform.

The governor wire rope operating the safety gear mechanism shall not be less than 8mm diameter.

The tension weight fitted with an electrical safety device shall be provided to cause the hoist motor to stop should the governor rope break or slacken.

The governor shall be fitted with a direct driven unit to relay to the control system both the speed and position of the elevator in shaft.

The governor shall be equipped with two electrical switches, preset to operate progressively in case of over speeding to reduce the elevator speed in the first stage and it the elevator speed is not brought under control, operate to cut of power supply to the hoist machine and apply brakes.

If the car continues to travel downwards at excessive over speed, the mechanical trip shall operate causing the governor jaws to grip the rope to bring the safety gear mechanism into operation causing the jaws to grip the guide rails equally through self-aligning friction shoes thus bringing the car to rest gradually and smoothly. The governor and safety gear shall be released by raising the car.

The governor and safety gear shall be adjusted to operate as specified by B.S. 5655.

F. Buffers

Oil buffers of spring-return type shall be supplied and installed in pit under car and counterweight for each Elevator. The minimum total stroke of the buffer shall be based on the retardation of 32 feet/sec^2 based on 115% contract speed. The maximum rate of retardation of the oil buffers based on 115% contract speed shall be 80.5 feet/sec^2 excluding any transient declarations having duration not exceeding 0.04 sec.

The buffers shall be mounted on continuous channels securely anchored to the pit floor and fastened to the guide rails. The channels, anchors and any additional supports required for buffers shall be provided.

The buffers shall be fitted with means of ascertaining the correct amount of oil in the buffers.

Each buffer shall be permanently and legibly marked to indicate the type and quantity of oil to be used within the buffer.

The buffers shall be self-setting type fitted with safety device to ensure its return to their normal position after operation.

G. Final Limit Switches

The elevators shall be equipped with an automatic device arranged to bring the car to a stop at the terminal landings independent of the regular operating devices in the car. Final limit switches should stop the car and prevent normal operation should it travel beyond the normal stopping device.

Separate control devices for normal stopping and final limit switches shall conform to the requirements of BS 5655: Part I.

9.4.8 Controller & Control System

H. **Controller**

The controller shall be floor mounted, upright type enclosed in enamel finish steel cabinet with either hinged doors at the front and removable panels at back or hinged door both at front and back.

The control system shall be microprocessor based and fitted with all safety devices to protect equipment and motors from damage in the event of overload or other malfunction. Protection against phase reversal shall provided as per code.

The driving unit control module, comprising of power and command module, shall control drive performance parameters. The controller unit shall control acceleration & deceleration, speed and the jerk rates during change in acceleration or deceleration to provide steeples speed variation for maximum passenger comfort. The jerk rates shall be individually adjustable to user's satisfaction. Upon receiving signal to perform journey, the command module shall evolve optimum speed profile for each journey and trigger power module for AC/DC and DC/AC conversion for necessary drive current and voltage to obtain desired motor torque.

The controller shall control car motion on feedback from motor-mounted tachometer and operate the brakes of hoisting motor through the signals received from micro switches and load weighing devices.

The controller shall be arranged to cut off the power supply, apply the brake and bring the car to rest upon failure of operation of any of the electrical safety devices.

The controller shall meet the requirements as specified in BS 5655.

I. Control System

a) General:

The design of control system shall be based on functionally arranged section modules featuring high degree of efficiency, economy of operation, adaptability to changing operating conditions, safety and reliability in operation through maintenance free electronic circuitry.

The control equipment shall be microprocessor based electronic solid state. The total system shall be designed to operate in normal machine room ambience and incorporate full protection against noise and electrical interference generated within the power section, controller and switchgear. The system design shall allow the control algorithm to be reprogrammed by software changes.

The Controller shall be state-of-art microprocessor based controller capable of high- speed data transmission and analysis for optimization of traffic control.

All modules shall be tested at the manufacturer's works prior to installation. System component shall be subjected to environmental endurance, thermal shocks and salt spray in test chambers.

b) Supervisory Operational Mode:

The operational mode of the Passenger/Patient Elevator shall be automatic control as specified in para 6.0 with special operation features, viz emergency operation and fireman switch.

The control system shall be provided with a parking feature, which returns the car to the main floor when there are no calls in the system.

The elevator shall be provided with individual landing station and operated from interconnected landing buttons including two operating devices in the car. Single touch buttons shall be mounted at each terminal landing.

On touching car or landing buttons, (other than those for landing at which car is standing) shall start the car provided interlock circuits are established and causes car to start traveling in the direction of registered call. Car shall stop at the designated landings for which calls are registered with stops made in order in which landings are reached, irrespective of sequence in which calls are registered, provided call for a given landing is registered sufficiently in advance of arrival of car at that landing to permit stop to be made.

If there are no car calls and car starts up in response to outside landing calls, car shall proceed first to the highest down call and then reverses to collect other down calls. Up landing calls shall be collected similarly when car starts down in response to such calls. If car stops for a landing call and a car call is registered within a predetermined interval after stop for a landing corresponding to direction car was travelling, car shall proceed in the same direction regardless of other landing calls registered.

If DOWN landing buttons are touched while car is travelling up, car shall not stop at these landings, but calls remain registered. After highest car and landing calls have been answered and door interlock circuit is established, car shall reverse automatically and respond to down car and landing calls. When travelling down, car shall not respond to up landing calls, but calls shall remain registered and answered on next up trip. No double door operation shall be permitted.

c) Load weighing:

Means shall be provided for weighing passenger load. Control system shall be designed to provide dispatching in advance of normal intervals and to provide landing call by-pass when the car is filled to approximately 80% of full capacity load.

Settings shall be individually adjustable. A buzzer shall be provided to indicate overload in elevator.

d) Door Operation:

Doors shall open automatically when a car arrives at a terminal to permit egress of passengers. When another car is at the terminal and is loading for departure or upon expiration of a timed interval, the doors shall close until car is designated for loading. In the event a passenger has entered the elevator, the doors shall reopen upon registration of call on the car button or by pressing the door open button. If no other car is at the terminal, an arriving car shall have its doors open until the car is dispatched or expiration of a timed interval with no demand.

e) Automatic leveling:

An automatic 2-way leveling device shall be provided, designed to govern the leveling of the car to within 6mm above or below the landing sill. The leveling operation shall avoid over-travel, under-travel, of the car and maintain the leveling accuracy regardless of the load in the car, direction of travel, rope slippage or stretch in ropes.

f) Independent Operation:

Controls shall be provided for operation of the elevator from car buttons only. A key operated switch shall be provided in each car.

g) Emergency Features:

i) Emergency operation: The Elevator shall be equipped with control system to operate and recall the cars in fire or other emergency conditions and to allow the elevator to run on emergency power supply.

The operation of elevator on emergency service shall be as follows:

- The Elevator shall be operable only by a person in the car.
- Elevator shall not respond to Elevator corridor calls.
- The Elevator will stop at the next level.

The opening of power operated doors shall be controlled only by buttons or switches. If the switch or button is released prior to the doors reaching the fully open position, the doors shall automatically re-close. Open doors shall be closed by either the registration of a car call or by "door close" switch or button.

Elevators shall be removed from emergency service by moving the emergency service key-operated switch in the car to the 'off' position with the car at the main floor.

ii) Emergency Lighting and Emergency alarm unit: An emergency light shall be included for each elevator car. An automatic change over switch shall be provided in the controller so that upon normal supply failure Emergency power supply shall be available for the light fixture, exhaust fan, and alarm unit.

supply of a suitable button in the car control wired to a terminal box fixed in the elevator shaft near the bottom floor served. A suitable alarm bell shall be provided and fixed including all necessary wiring connecting upto the terminal box.

The power for the emergency lighting, exhaust fan and alarm bell shall be from the same emergency supply consisting of rechargeable nickel cadmium battery unit with trickle charger and 10 years minimum life expectancy.

iii) Emergency power transfer: In the event of normal power failure, adequate power will be supplied through Employer furnished stand-by generator to run the Elevator.

iv) Operation under Standby Power: A control signal from the generator shall be provided to the elevator controller or elevator group to place the elevator or group of elevators in emergency power mode, which will cause the elevators to return to the designated floor and remain there with the doors open. If there are a group of elevators, power shall be provided to only one elevator at a time and automatically switch to the remaining elevators until all elevators have returned to the designated floor with the doors open.

v) Intercom: installation for each elevator, an intercom facility with control room or at location designated by Employer for 24 hours communication. All necessary cabling and conduiting is included in scope of works.

vi) Earthquake control: In the event of an earthquake, the elevator facility shall be provided with a seismic detector which will bring all cars to stop at the next floor and open the doors.

vii) Emergency Rescue Device (ERD): In the event of an power break down, the elevator shall be provided with ERD which will bring all cars to stop at the next floor till the power is resumed.

9.4.9 Signals & Fixtures

provide fixtures and signals as follows, test complete system, correct any deficiencies in wiring and function and make complete system fully functional. Location and arrangement of fixtures and signs shall comply with the ADA and other code requirements.

A. Integrated Hall Indicator

An integrated hall indicator consisting of digital car position indicator (revealing floor position of car) and illuminated arrows indicating the arrival and departing direction, as determined by the control system shall be installed above each individual elevator and at each landing. A two tone electronic gong shall also be provided for audible announcement of the arrival of the elevator car.

The digital car position indicator shall be either of 2 character 7/8 segment type with character height of 35-40mm.

The direction arrows shall be of acrylic and protrude from the faceplate for lateral visibility.

The integrated hall indicator shall be of horizontal configuration. The stainless steel face plate, min. 2mm thick, of satin finish containing the digital car position indicator and direction arrows. The hall indicator shall operate on 24 V D.C. supply.

B. Landing Call Station

Landing call station fitted with call buttons shall be installed at each landing. It shall be designed for mounting on the landing door frame or on adjacent side wall, subject to Engineers' approval.

The call buttons shall be of micro-movement type, constructed of stainless steel pressel suitable for long arduous duty. The translucent surround of the button shall illuminate to indicate acceptance of call signal. The pressel shall incorporate two light emitting diodes. The pressels shall be mounted flush with the faceplate. The faceplate shall be of stainless steel 2mm thick, fixed with tamper resistant screw.

The call buttons of each landing station shall be inter-linked such that with the pressing of call button of any elevator, call buttons of elevators in the same direction shall light up and record the call.

C. Car Station

The car station shall be integral with the front return of the car and constructed from 1.6mm thick stainless steel, plate of natural satin finish.

The hinged full height front panel of the car station shall carry the controls and indicators. The panel shall be fitted with a secret release, which can only be opened from the back of the trough. When the hinged panel is opened an isolate/ normal switch shall be available. The car operating panel shall be recessed in the wall of lift cabin and edges of car operating panel shall be flushed with the wall of lift cabin.

The car-operating panel shall contain at least the following controls with touch buttons:

- Alarm button
- One floor button for each floor served
- Open door button/hold on button
- Key operated car independent service switch
- Key operated fan switch
- Digital car position indicator and direction arrows
- Intercom

All buttons shall be set flush with the panel surface for maximum resistance against abuse. When operated, a LED illuminated halo shall surround the buttons thereby informing that the call has been registered. The buttons shall be plastic pressel engraved with the appropriate floor marking.

The digital car position indicator and direction arrows shall be positioned above the buttons.

9.4.10 Power Supply & Electrical Installations

A. General

The power supply at load break switch will be available in the Elevator machine room. All further wiring, controls and providing proper distribution boards, along with necessary material and accessories beyond the power supply points shall be supplied and installed. The electrical installation and appliances shall comply with B.S. 5655: Part I.

B. Wiring Installation

All wiring shall be carried out in accordance with the IEE regulation, NEC standard and B.S.S. wherever applicable.

All cables shall be PVC insulated, and if required PVC sheathed also, single or multicore having tinned copper conductors. Cables for different voltage circuits which are run together must have the insulation rating, suitable for the highest voltage present. Wherever cables are subjected to high temperature such as termination to car light, it shall be protected by suitable heat resistant sleeve. At all terminations, cable ends shall have numbered ferrule to match with the mark on respective component and control drawings. All wiring shall be continuous between terminations.

Travelling cables between the elevator well and elevator car terminal boxes shall be suspended by looping over reels or by suitable clamps. The connections in the terminal boxes shall be marked for identification purposes.

Travelling flexible cables shall be fire resistant and shall comply with B.S. 6977

C. Trunking and Conduits

i. All wiring from machine room to motor controls at each floor and to other circuits shall either be run in 16 SWG galvanized steel conduit or trunking, the selection and route of which shall depend on the number of cables and ease of installation and maintenance. If trunking is installed it shall have removable covers, and the trunking finished in dark grey enamel as per B.S. 381C. Fixing arrangements of conduit of trunking shall be vibration proof suitable for the existing conditions. All connections from trunking or conduits to motors or other equipment subjected to vibration shall be with flexible galvanized steel conduit. All trunking and conduit shall be continuous through out the length to ensure good earth continuity.

D. Earthing

Earthing of all equipment and metal work which can be subjected to dangerous voltage under normal operating and fault conditions shall be earthed in accordance with NEC Standard. One PVC insulated earth conductor of suitable size having yellow colour with green tracer shall be run along the trunking or conduit as main earth. All branch circuits in conduit or trunking and other metal work shall have branch earthing cable connected to main earth. All length of trunking shall also be bonded to main earth.

E. Testing

Testing of electrical installations shall be carried out to the satisfaction of the Engineer in accordance with standard practice and recognized international standards/codes.

Fire Protection

All precautions will be taken to eliminate the potential sources of fire and smoke sources and prevent flame propagation. In particular:

- Halogen-free cables will be used,
- Oil, grease and dust will be collected,
- No plastic materials shall be used in these systems.

Each elevator will be equipped with a fire and smoke detection unit and linked to the fire detection system.

9.4.11 Local Materials

A. Separator Beams & Well Trimming Girders

Properly designed separator beams and trimming girders shall be supplied and installed at proper location in Elevator well to suit fixing requirement of offered elevator. The separator beams and trimming girders installed in elevator shall be of at least 200mm rolled I-beams of prime quality structural steel (ASTM A-36 or equivalent).

B. Trap Door

Trap doors of rugged construction in the machine rooms at location shown on relevant drawing to enable access of the hoisting machinery into the machine rooms shall be provided. The trap door shall be strong enough to temporarily withstand/support heavy machinery. It shall be installed flush with the finished floor when closed and be lockable only from inside the machine room.

9.5 TECHNICAL DATA

Patient & Passenger Elevators Schedule

Sr.No.	Description	Minimum Requirement
01	Type	Machine Room Less (MRL) VVVF Patient bed Elevator for building use, fully complied with latest EN 81 standards. (For handicap lift compliance of EN 81-70)
02	Capacity	As Specified in BOQ
03	Elevator Speed	1.0 m/sec
04	Travel Height	16 meter
05	No of Stops/Openings	04 stops/04 openings
06	Internal Car Sizes (w x d x h)	As per requirement
07	Machine Type	VVVF AC gearless drive
08	Car & Counterweight Guide Shoes	Sliding guide shoes
09	Drive Location	Above in shaft (MRL Type)
10	Control System	As per requirement
11	Architraves	Full width of Stainless Steel satin finish at all floors.
12	Elevator Shaft Size	As per architectural drawings
13	Pit Depth	As per architectural drawings
14	Head Room	As per architectural drawings
15	Buffers	Oil buffers of spring return type (Energy Dissipation type) or as recommended by EN 81 Standards
16	Door Size	As per Requirement
17	Door Operation & Type	VVVF control, Power operated, Centre opening stainless steel panel construction and fire rating of 2 hr

18	Indicators	- Digital car position indicator on each landing with direction arrows. - Digital position indicator inside car with direction arrows. - Two tone electronic gong announcing arrival of car.
19	Landing Call Station	- Raised, micro-movement touch button with call acceptance illuminated indications.
20	Car Station	- Integral with the front return of the car and constructed of Stainless Steel/glass and recessed/flushed with wall. Including handicapped car operating panel. - It shall include alarm buttons, floor call buttons, door open/hold button, key-operated attendant switch, fan switch, intercom (connection with building safety/security system is included
21	Car Design	- Walls of stainless steel (hairline # 304 finish) construction or as approved. - Front return and car door of stainless steel (hairline finish) construction. - Full width half height mirror on rear wall - Ceiling removable type full extended poly carbonate diffuser with modular light fittings as approved by engineer - Ventilation Blower (Pre-Installed) - Handrails on one side - Steel Plate Floor with Granite tiles - Inter Telecommunication system - Emergency exit - Load measuring device with overload buzzer and inter-lock till overload is removed. - LED Lighting
22	Door Safety Devices	- Full height Light curtain protection (2D) - Door opening timing feature
23	Special Features	- Attendant control - Emergency operation and fireman switch. - Emergency lighting & alarm unit. - Earthquake control system - Voice guidance system - Connected with building control - Suitability for 40^{o}C ambient temperature - Phase reversal failure indication & interlock - Manufacturer Security Cameras for surveillance (Connection with building safety/security is included) - ERD Device (Emergency Rescue Device with battery backup) - Halogen Free cables.

24	Interior Finish	Superior/Highest/Executive quality as per approval of engineer on submitted samples.

25	Minimum Functions	- Direct Leveling - Optimum travel curve - Re-running automatically when elevator is re-powered - Car location adjusted automatically - Load compensating - Travel Counter - Over/Under voltage protection - Phase trip protection - Over current protection - Over heat protection - Encoder trip protection - Contact adhered protection - Bi-directional over speed protection - Reversal protection - Travel over time protection - Final terminal protection - Over load protection - Anti-door lock bridge - Automatic by-pass hall call while full load - Level for self-helping - Travel to next floor when open door trip - Emergency illumination in car - Emergency alarm - Automatic car fan - Automatic car lighting - Fire return feedback - Settable landing number - Automatic parking, parking floor - Car call cancelable - Parking key switch, landing - Fire return (Phase I), Main landing - Hoist way lighting - Car door button
26	Power Supply	3 Phase / 400V / 50 Hz.(or as per project requirement) - 1Phase/230V/50 Hz. (for lighting)

27	Ambient Condition	-10°C to 45°C
28	Inspection & Test certificate version	English
29	Elevator Mode	Two Mode: - Normal Mode: From the car or from the landing. - Maintenance Mode: Low speed (inspection running).
30	Design Life	25 Years

9.6 INSTALLATION

A. General

The installation of elevator equipment including its electrical installations shall comply with applicable standards, manufacturers' instructions and recommendations. Electrical work required during installation shall comply with NFPA 70 or approved equivalent.

The scope of installation and civil works shall include the following:

- Providing and/or cutting all necessary holes, chases and openings and making good after installation of equipment.
- Supplying and fixing all supports, beams, ladders etc. necessary for the installation of the machinery, guide brackets, doors, buffers etc.
- Furnishing all necessary cement and/or concrete for 'grouting-in' brackets, bolts, etc.
- Providing and fixing suitable scaffolding and protection of work in progress.

B. Welded Construction

Welded construction shall be provided for installation of Elevators wherever bolted connections are not required for subsequent removal or for normal operation, adjustment, inspection, maintenance, or replacement of worn parts. Welding workmanship and qualification of welding operators shall comply with American Welding Society (AWS) standards or approved equivalent.

C. Sound Isolation

Rotating and vibrating Elevator equipment and components shall be mounted on vibration - absorption mounts designed to effectively prevent the transmission of vibrations of the structure, and thereby eliminate the sources of structure - borne noise.

D. Lubrication

Operating parts of the system including ropes, guides, etc., shall be lubricated as per manufacturer's recommendation.

E. Alignment

Proper co-ordination of installation of hoist way entrances with the installation of elevators' guide rails shall be done for accurate alignment of entrances. Wherever possible the final adjustment of sills and doors shall be delayed until the car is operable in the shaft. The clearance shall be reduced to minimum, safe, workable dimensions at each landing.

F. Sills

Sill unit shall be set at each floor landing accurately aligned, slightly above structural floor, to suit level of scheduled floor finish.

G. Painting, Retouching & Re-finishing

After completion of installation and testing to the satisfaction, carryout all finishing, retouching and refinishing operation on the entire equipment accessories and installation matching the original finish in an approved way. All auxiliary works carried out as the finished installation shall also be painted in the approved standard after applying anticorrosive base.

9.7 TESTING AND INSPECTION REQUIREMENTS

The shop tests, to be conducted prior to shipment and field tests after installation prior to commissioning.

Pre-shipment inspection of the equipment as per project requirements

Testing after installation shall be carried out for each elevator before it is put into normal service in accordance with B.S. 5655 Part 10 and appropriate certificate shall be completed. The tests shall include but be not limited to the following

- Functioning of all system and devices
- Operational test of all safeties
- Protection against false signals
- Earth fault test on cable/controller & switch gears
- Insulation resistance test for cables

A thorough inspection of all equipment shall also be undertaken at this stage and appropriate certificate shall be completed.

Elevator shall be periodically re-examined during defect liability period and at the end of guarantee/defect liability period appropriate certificate shall be completed to assess operational performance.

All equipment and personnel required to complete testing and inspection. All erection work and tests shall be performed by the suitably qualified and experienced persons to the satisfaction.