G O V E R N M E N T O F B A L O C H I S T A N
I R R I G A T I O N D E P A R T M E N T

INTEGRATED FLOOD RESILIENCE AND ADAPTATION PROJECT (IFRAP)

BIDDING DOCUMENT

FOR

PROCUREMENT OF WORKS

1. Construction of 2 Nos. VRBs at different reaches of Uch Canal (Lot-I)

2. Restoration / Strengthening of embankment of Hairdin Main Drain from RD.0 to RD.62 and Construction of 2 Nos VRBs at Different Places (Lot-II)

Package V, Lot - 1 & Lot-II

VOLUME II –
TECHNICAL SPECIFICATIONS

IDA CREDIT NO.	**:**	**7333 – PK / Project ID P180323**
EMPLOYER	**:**	**PROJECT DIRECTOR (PIU-IFRAP)**
ISSUED ON	**:**	**June 2026**
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ANNEXURES

Annexure A Tender Drawings

Preamble

The Specifications for the Works to be carried out under this contract are described in the following chapters. Some of the specifications may not relate to any of the work item as provided in the Bill of Quantities. The bidder shall only concentrate on those items of specification which relate to the work and ignore all other items.

CHAPTER 1 – GENERAL REQUIREMENTS

PART 1 GENERAL

1-1.1 Description of Works

CONSTRUCTION OF 2 NOS VRBS AT DIFFERENT REACHES OF UCH CANAL (Lot-I)

RESTORATION / STRENGTHENING OF EMBANKMENT OF HAIRDIN MAIN DRAIN FROM RD.0 TO RD.62 AND CONSTRUCTION OF 2 NOS VRBS AT DIFFERENT PLACES UNDER (LOT-II), PACKAGE V, PIU-IFRAP

1-1.1.1 Scope of Work

The Uch Canal Subproject includes the construction of two (02) canal crossing bridges at critical locations within District Sohbat Pur. The proposed bridges are designed to provide safe and reliable passage across the canal for vehicular and pedestrian traffic while maintaining uninterrupted canal flow.

Each structure has been designed to ensure adequate waterway clearance, freeboard, and structural stability under the design discharge conditions. The bridge configuration has been developed to preserve the hydraulic capacity of the canal, minimize flow obstruction, and prevent adverse backwater effects during high-flow events.

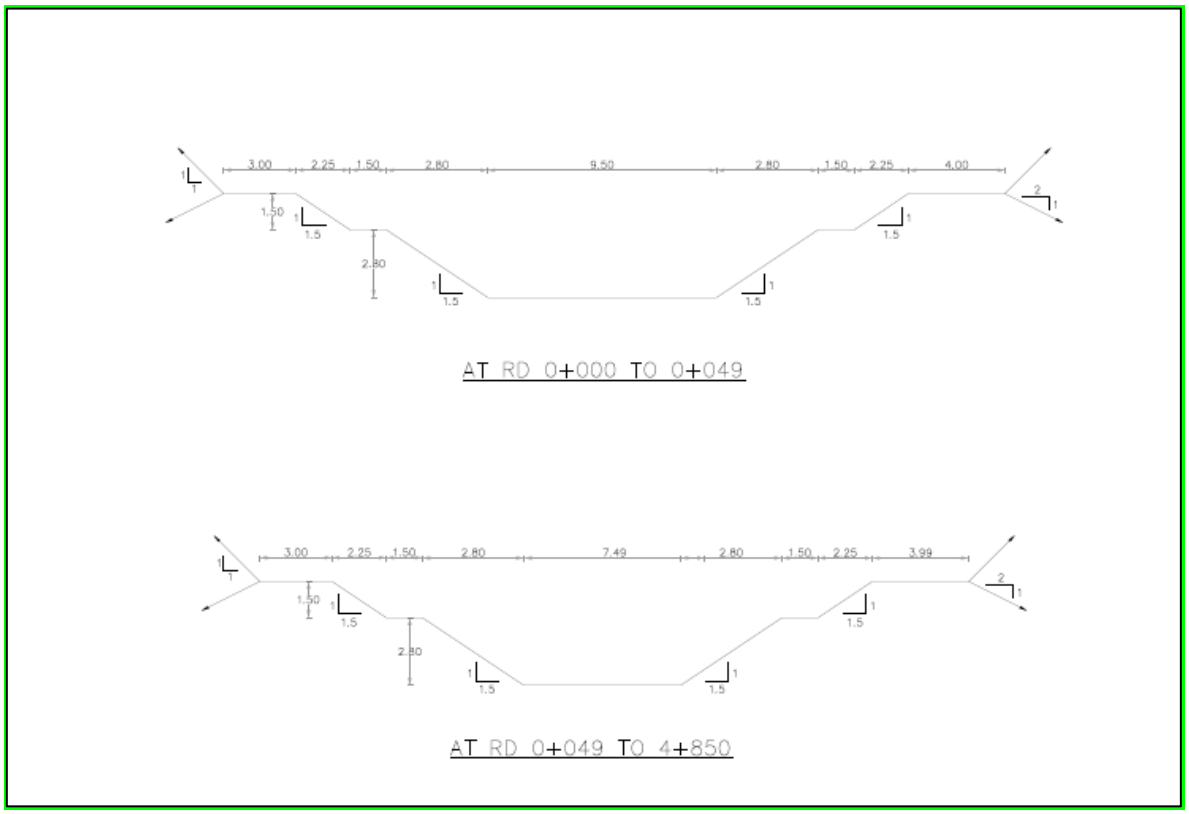
The implementation of these works will enhance local mobility, strengthen rural infrastructure, and contribute to improved flood resilience by ensuring uninterrupted access even during peak irrigation and flood flow periods.

Sr. No.	RD	Structure Type	Description
1	10 + 083	Bridge	Village road bridge
2	14 + 046	Bridge	Village road bridge

The works at Hairdin Main Drain include the following key interventions:

- Raising, widening, and re-profiling of the channel section to restore its design discharge capacity and improve flow conveyance.
- Raising of both berms to enhance the flood protection level and prevent overtopping during high-flow conditions.
- Construction of three (02) village road bridges at selected RDs to maintain road connectivity and ensure adequate cross-drainage capacity.

Sr. No.	RD	Structure Type	No of Cells	Size
1	1 + 023	Culvert	3	4 m x 3 m
2	3+529	Culvert	3	4 m x 3 m



Typical section of Hairdin Protection Bund

1-1.2 Contract Documents and Drawings

1-1.2.1Contract Document and Project Manager's Drawings

The Contractor will be provided with two (2) sets of the Contract Documents for his own use. Unused copies of the Tender Documents in the Contractor's possession, after the Award of Contract shall be destroyed or returned to the Employer and will not be recognised in the administration of the Contract. A complete set of Contract Documents supplied by the Project Manager and all further instructions issued by him shall be kept at all times by the Contractor on the Site and available to the Project Manager and his staff.

The Bid Drawings included in the Bid Documents and which will form part of the Drawings to be used for the construction of the Works, show the work to be carried out in accordance with the Contract in sufficient detail for the Contractor to fully plan his activities.

The Project Manager may issue, the Bid Drawings mentioned as above as construction drawings and any additional construction drawings when required for further details, clarifications or modifications.

The Contractor shall be required to perform the work in accordance with such further drawings and specifications at the applicable rates tendered in the priced Bill of Quantities for such work or work of a similar nature. Although the Drawings may be prepared to scale, work shall be based upon dimensions shown on the Drawings and not on dimensions scaled from the Drawings. The Drawings when read in conjunction with the specifications and instructions that may be issued from time to time by the Project Manager, will show sufficient dimensions, specific details and typical details to define the various features of the work but the details necessary for the construction of any part of the work may have to be deduced from several Drawings. Revision of any drawing details

considered essential shall be provided by the Project Manager prior to carrying out of the specific works.

Two (2) A3 size prints of the Drawings mentioned above will be issued by the Project Manager to the Contractor in accordance with the construction program required under the provisions of this specifications **Clause 1-1.6.2 – Constructor's** program.

On receipt of these Drawings, the Contractor shall check them carefully and advise the Project Manager in writing of any discrepancies, errors or omissions and full instructions will be furnished to the Contractor should any discrepancies, errors or omissions be found.

1-1.2.2 Contractor's Drawings

Based on Project Manager's construction drawings, Contractor shall prepare working drawings based on actual survey and site conditions showing further details and sections.

The working drawing and shop drawings required to be submitted to the Project Manager for approval in accordance with Specification, shall be suitable for microfilming and shall consist of one print of A1 and A3 size specification and parts catalogs in duplicate. All drawings submitted for approval shall be signed, checked and approved by the Contractor prior to submission. The drawings shall be submitted in accordance with provision of this Specification's **Clause 1-1.4 - Submittal Procedures**.

Each drawing submitted by the Contractor shall be both in ISO paper size A1 and A3.

Within thirty (30) days after receiving such parts catalogues, specifications and detailed drawings, the Project Manager shall signify his approval or request modifications. The Contractor shall modify the drawings as may be required by the Project Manager.

The work shall be constructed in accordance with the approved drawings, and a copy of such drawings shall be kept on the Site at all times until the completion of the Contract. All drawings on which changes are made shall have the revisions clearly marked.

Construction, fabrication or manufacture of any portion of the Works shall not commence until drawings have been approved and thereafter no change shall be made to any drawings so approved without the permission of the Project Manager. Permission to make such changes shall be requested by sending one (1) print of each revised drawing for approval, explaining the reason for such a change.

At least thirty (30) days prior to starting construction of any concrete lift or other placement, the Contractor shall submit lift or other placement drawings to the Project Manager for approval. Lift or other placement drawings shall be to such scale as to show clearly all recesses openings and embedded work.

Drawings showing the proposed method of construction and other drawings additional to those referred to herein above required by the Technical Specifications shall also be submitted by the Contractor to the Project Manager for approval.

Any work done prior to the approval of drawings shall be at the Contractor's own risk. The Project Manager shall have the right to request / add any additional details and to require

the Contractor to make any changes which are necessary to conform to the provisions and intent of the design and the Technical Specification without additional cost to the Employer. The approval of the drawings by the Project Manager shall not be construed as a complete check but will indicate only that the general method of construction and detailing is satisfactory. Approval by the Project Manager of the Contractor's drawings shall not be held to relieve the Contractor of the obligation to meet all the requirements of the Technical Specifications or of the responsibility for the correctness of the Contractor's drawings or of the responsibility for correct fitting of assembled parts in final position or of the responsibility for the adequacy of method of construction.

Any additional drawings, which the Contractor requires to interpret the Drawings to construct the Works or in compliance with this Sub-Clause shall be prepared by the Contractor, and all costs shall be borne by the Contractor. No separate payment shall be made for working, shop, reinforcement lift drawing submitted by the Contractor.

1-1.3 Project Meetings

1-1.3.1 Preconstruction Conference

The Contractor shall attend a pre-construction conference scheduled by the Employer. Work shall not commence prior to the conference.

The Contractor shall address project orientation, personnel contact, safety issues, permits, deficiencies, and the location of the Contractor's office.

1-1.3.2 Project Meetings

The Contractor shall attend project meetings scheduled by the Employer and/or Project Manager.

A Monthly Progress Report shall be submitted with the progress schedule including list of skilled personnel, unskilled labour, and list of essential equipments deployed during the month and shall address potential factors of delay, deficiencies, material delivery schedules, submittals, and safety issues.

There shall be regular coordination between Environment and Social Supervisor/ Community Liaison officer provided by the Contractor and Environment Engineer/ Environmental Compliance Expert and Community Development Specialist, Social Inspectors of the Employer and Project Manager.

1-1.4 Submittal Procedures

1-1.4.1 Scope

The Contractor is required to submit various documents and materials for Project Manager’s review, approval and information in accordance with this Clause and other Sections of the Technical Specifications and Clause 18 and 27 of Conditions of Contract. Requirements of this Clause apply to, and are a component part of, each Section of the Technical Specifications.

1-1.4.2 Submittals

Standard approved transmittal form shall be used to transmit each submittal. Submittal Description (SD): Drawings, diagrams, layouts, schematics, descriptive literature, illustrations, schedules, performance and test data, and similar materials to be furnished by the Contractor explaining in detail specific portions of the work required by the contract.

The following items, SD-01 through SD-12, are descriptions of data to be submitted for the Project. The requirements to actually furnish the applicable items will be called out in each Specification.

SD-01 Preconstruction Submittals
Submittals which are required prior to a notice to proceed on a new contract: Submittals required prior to the start of the next major phase of the construction on a multi-phase contract. Schedules or tabular list of data or tabular list including location, features, or other pertinent information regarding products, materials, equipment, or components to be used in the work, submitted prior to contract notice to proceed or next major phase of construction.

SD-02 Shop Drawings
Submittals which graphically show relationship of various components of the work, schematic diagrams of systems, detail of fabrications, layout of particular elements, connections, and other relational aspects of the work.

SD-03 Product Data
Data composed of catalog cuts, brochures, circulars, Specifications and product data, and printed information in sufficient detail and scope to verify compliance with requirements of the contract documents.

SD-04 Samples

Physical Samples, including both fabricated and un-fabricated, of materials, products, and units of work as complete units or as portions of units of work.

SD-05 Design Data

Design calculations, mix design analyses, or other data, written in nature, and pertaining to a part of the work.

SD-06 Test Reports

Written reports of a manufacturer's findings of his product during field inspections, attesting that the products are installed in accordance with the manufacturer's installation instructions, shop drawings, or other manufacturer's requirements. Written reports by the Contractor or his subcontractors including daily logs reporting on the progress of daily activities or attesting that the work has been installed in accordance with the contract plans and Specifications.

SD-07 Certificates

A document, required through the Contractor by way of a supplier, installer or manufacturer, the purpose of which is to further test the quality or orderly progression of a

portion of the work by documenting procedures, acceptability of methods or personnel, qualifications, or other verification of quality.

Statements signed by responsible officials of a manufacturer of a product, system, or material attesting that the product, system or material meet specified requirements. Statements must be dated after the award of this contract, name the project, and list the specific requirements which it is intended to address.

SD-08 Manufacturer's Instructions

Preprinted material describing installation of a product, system, or material, including special notices and material safety data sheets, if any concerning impedances, hazards, and safety precautions.

SD-09 Manufacturer’s Field Reports

A written report, which includes the findings of a test, made at the job site, in the vicinity of the job site, or on a sample taken from the job site, on a portion of the work, during or after installation. Report must be signed by an authorized official of a testing laboratory or agency and must state the test results; and indicate whether the material, product, or system has passed or failed the test.

SD-10 Operation and Maintenance Data

Data intended to be incorporated in an operations and maintenance manual.

SD-11 Execution Records

Records of execution, construction and installation.

SD-12 Closeout Submittals

Special requirements necessary to properly close out a construction contract. For example, as-built record drawings, manufacturer's help and product lines necessary to maintain and install equipment. Also, submittal requirements necessary to properly close out a major phase of construction on a multi-phase contract.

1-1.4.3 Preparation

(a) Marking

Prepare, review and stamp with Contractor's approval all specified submittals.

Permanently mark each submittal to identify it by contract number; transmittal date; Contractor's, Subcontractor's, and supplier's name, address(s) and telephone number(s); submittal name; Specification or drawing reference; and similar information to distinguish it from other submittals. Submittal identification shall include space to receive the review action by the Project Manager.

(b) Drawing Format

Drawing submittals shall be prepared on ISO A3 size, except for full size patterns or templates. A soft copy of all drawings shall be submitted on CD-R. The Contractor's working, shop and design drawings shall be both in ISO A3 sizes. The Drawings shall be prepared to accurate size, with scale indicated, unless other form is required. Drawing reproducible shall be suitable for microfilming and shall be of a quality to produce clear, distinct lines and letters. The Drawings shall have dark lines on a white background.

Copies of each drawing shall have the following information clearly marked thereon:

(a) Job name, which shall be the general title of the contract drawings.

(b) Date of the drawings and revisions.

(c) Name of Contractor.

(d) Name of Subcontractor.

(e) Name of the item, material, or equipment detailed thereon.

(f) Submittal number (e.g., first submittal to last submittal) in a uniform location adjacent to the title block.

(g) Technical Specification section to which submittal applies.

(h) The Project contract number shall appear in the margin, immediately below the title block.

The Drawings shall be numbered in logical sequence. Contractor may use his own number system. Each drawing shall bear the number of the submittal in a uniform location adjacent to the title block. The Project Contract Number shall appear in the margin, immediately below the title block, for each drawing.

A blank space, no smaller than 100 millimeter shall be reserved on the right hand side of each sheet for the Project Manager's disposition stamp.

(c) Data Format

Required data submittals for each specific material, product, unit of work, or system shall be collected into a single submittal and marked for choices, options, and portions applicable to the submittal. Marking of each copy of product data submitted shall be identical.

(d) Samples

Samples shall be physically identical with the proposed material or product to be incorporated in the work, fully fabricated and finished in the specified manner, and full scale. Where variations in color, finish, pattern, or texture are inherent in the material or product represented by the sample, multiple units of the sample, showing the near-limits of the variations and the "average" of the whole range not less than 3 units, shall be submitted. Each unit shall be marked to describe its relation to the range of the variation. Where samples are specified for selection of color, finish, pattern, or texture, the full set of

available choices shall be submitted for the material or product specified. Sizes and quantities of samples shall represent their respective standard unit.

1-1.4.4 Submission Requirements

(a) Schedules

Within 30 calendar days of notice to proceed, provide, for approval by the Project Manager, the following schedule of submittals:

(i) A schedule of shop drawings and technical submittals required by the Specifications and drawings. Indicate the Specification or drawing reference requiring the submittal; the material, item, or process for which the submittal is required; the "SD" number and identifying title of the submittal; the Contractor's anticipated submission date and the approval need date.

(ii) A separate schedule of other submittals required under the contract but not listed in the Specifications or drawings. Schedule will indicate the contract requirement reference; the type or title of the submittal; the Contractor's anticipated submission date and the approved need date (if approval is required).

(iii) Submittals called for by the contract documents will be listed on one of the above schedules. If a submittal is called for but does not pertain to the contract work, the Contractor shall include the submittal in the applicable schedule and annotate it "N/A" with a brief explanation. Approval of the schedules by the Project Manager does not relieve the Contractor of supplying submittals required by the contract documents but which have been omitted from the schedules or marked "N/A".

(iv) Re-submit copies of both schedules and annotate monthly by the Contractor with actual submission and approval dates. When all items on a schedule have been fully approved, no further re-submittal of the schedule is required.

(b) Drawings Submittals

Submit 3 prints (A3 size/ A1 size as required by the Project Manager) of each drawing . One print, marked with review notations by the Project Manager, will be returned to the Contractor. All required installation; fabrication and connection drawings shall be submitted and approved prior to the start of work detailed on these drawings.

(c) Data Submittals

Submit three (3) complete sets of indexed and bound product data. One set, marked with review notations by the Project Manager, will be returned to the Contractor.

(d) Samples

Submit one (1) set of identified samples. A copy of the transmittal form, marked with review notations including selections by the Project Manager, will be returned to the Contractor.

Samples that are intended or permitted to be returned and actually incorporated in the work are so indicated in the individual sections of the Specification. These samples will be

returned to the Contractor, at his expense, to be clearly labeled, with installation location recorded. Samples shall be in undamaged condition at the time of installation.

Where mockups and similar large samples are required by individual sections of Specification, it is recognized that these are a special type of sample which cannot be readily "transmitted" as specified for submittal of samples. Otherwise, and except as indicated in the individual Section of the Technical Specifications, the requirements for samples shall be complied with and a transmittal form shall be processed for each mockup, to provide a record of the activity.

1-1.4.5 Project Manager's Review

(a) Review Notations

Project Manager will review submittals and provide pertinent notation within 30 calendar days after date of submission. Submittals will be returned to the Contractor with the following notations:

(i) Submittals marked "approved" authorize the Contractor to proceed with the work covered.

(ii) Submittals marked "approved as noted" authorize the Contractor to proceed with the work covered provided he takes no exception to the corrections. Notes shall be incorporated prior to submission of the final submittal.

(iii) Submittals marked "return for correction" require the Contractor to make the necessary corrections and revisions and to re-submit them for approval in the same routine as before, prior to proceeding with any of the work depicted by the submittal.

(iv) Submittals marked "not approved" or "disapproved" indicate noncompliance with the contract requirements and shall be re-submitted with appropriate changes. No item of requiring a submittal shall be accomplished until the submittals are approved or approved as noted.

(v) Contractor shall make corrections required by the Project Manager. If the Contractor considers any correction or notation on the returned submittals to constitute a change to the Bid Drawings or the Technical Specifications; notice as required under the Clause 6 of Conditions of Contract shall be given to the Project Manager. Approval of the submittals by the Project Manager shall not be construed as a complete check, but will indicate only that the general method of construction and detailing is satisfactory. Contractor shall be responsible for the dimensions and design of connection details and construction of work. Failure to point out deviations may result in the Project Manager requiring rejection and removal of such work at the Contractor's expense.

(vi) If changes are necessary to approved submittals, the Contractor shall make such revisions and submission of the submittals in accordance with the procedures above. No item of work requiring a submittal change shall be accomplished until the changed submittals are approved.

(b) Sample Approval

Furnish, for the approval of the Project Manager, samples required by the Technical Specifications or by the Project Manager. Shipping charges shall be paid by the Contractor. Materials or equipment requiring sample approval shall not be delivered to the site or used in the work until approved in writing by the Project Manager.
Each sample shall have a label indicating:

(a) Name of project

(b) Name of Contractor

(c) Material or equipment

(d) Place of origin

(e) Name of producer and brand

(f) Specification section to which samples applies

(g) Samples of furnished material shall have additional markings that will identify them under the finished schedules.

Contractor shall submit to the Project Manager two samples of materials where samples are requested. Transmit to the Project Manager with each sample a letter, original and two copies, containing the above information.

Approval of a sample shall be only for the characteristics or use named in such approval and shall not be construed to change or modify any contract requirements. Before submitting samples, the Contractor shall assure that the materials or equipment will be available in quantities required in the project. No change or substitution will be permitted after a sample has been approved.

Materials and equipment incorporated in the work shall match the approved samples. If requested, approved samples, including those which may be damaged in testing, will be returned to the Contractor, at his expense, upon completion of the contract. Samples not approved will also be returned to the Contractor at its expense, if so requested.

Failure of any materials to pass the specified tests will be sufficient cause for refusal to consider, under this contract, any further samples of the same brand or make of that material. Project Manager reserves the right to disapprove any material or equipment which previously has proved unsatisfactory in service.

Variations from contract requirements shall be specifically pointed out in transmittal letters. Failure to point out deviations may result in the Project Manager requiring rejection and removal of such work at no additional cost to the Employer.

Samples of various materials or equipment delivered on the site or in place may be taken by the Project Manager for testing. Samples failing to meet contract requirements will automatically void previous approvals. Contractor shall replace such materials or equipment to meet contract requirements.

Approval of the Contractor's samples by the Project Manager shall not relieve the Contractor of his responsibilities under the Contract.

1-1.4.6 Progress Schedule

(a) Bar Chart

(i) Submit the progress chart, for approval by the Project Manager, at the Preconstruction Conference in one reproducible and 4 copies.

(ii) Prepare the progress chart in the form of a bar chart utilizing form "Construction Progress Chart" or comparable format acceptable to the Project Manager.

(iii) Include no less than the following information on the progress chart:

- Break out by major headings for primary work activity.
- A line item break out under each major heading sufficient to track the progress of work.
- A line item showing contract finalization task which includes punch list, clean-up and demolition, and final construction drawings.
- A materials bar and a separate labor bar for each line item. Both bars will show the scheduled percentage complete for any given date within the contract performance period. Labor bar will also show the number of men (man-load) expected to be working on any given date within the contract performance period.

  The estimated cost and percentage weight of total contract cost for each materials and labor bar on the chart.

  Separate line items for mobilization and drawing submittal and approval. (These items are to show no associated costs.)

(iv) Update the progress schedule in one reproduction and 4 copies every 30 calendar days throughout the contract performance period.

(b) Project Network Analysis

Submit the initial progress schedule within 14 calendar days of Letter of Acceptance. Schedule shall be updated and resubmitted monthly beginning 7 calendar days after return of the approved initial schedule. Updating shall entail complete revision of the graphic and data displays incorporating changes in scheduled dates and performance periods. Redlined updates will only be acceptable for use as weekly status reviews.

Contractor shall provide a single point contact from his on-site organization as his Planning Engineer. Planning Engineer shall have the responsibility of updating and coordinating the schedule with actual job conditions. Planning Engineer shall participate in

weekly status meetings and present current information on the status of purchase orders, shop drawings, off-site fabrication, materials deliveries, Subcontractor activities and any problem, which may impact the contract performance period.
Include the following in the project network analysis:

(i) Graphic display shall be a standard network or arrow diagram capable of illustrating the required data. Drafting shall be computer generated on standard on 279 by 432 millimeter minimum sheets with separate overview and detail breakouts. Provide a project network analysis that is legible with a clear, consistent method for continuations and detail referencing. Clearly delineate the critical path on the display. Clearly indicate the contract milestone date on the project network analysis graphic display.

(ii) Data shall be presented as a separate printout on paper or, where feasible, may be printed on the same sheet as the graphic display. Data shall be organized in a logical coherent display capable of periodic updating.

(iii) Data shall include verbal activity descriptions with a numerical ordering system cross referenced to the graphic display. Additionally, costs (broken down into separate materials and labor costs), duration, early start date, early finish date, late start date, late finish date, and float shall be detailed for each activity. A running total of the percent completion based on completed activity costs versus total contract cost shall be indicated. A system for indicating scheduled versus actual activity dates and durations shall be provided.

(iv) Schedule shall be of sufficient detail to facilitate the Contractor's control of the job and to allow the Project Manager to readily follow progress for portions of the work.

1-1.4.7 Status Report on Materials Orders

Within 30 calendar days after notice to proceed, submit, for approval by the Project Manager, an initial material status report on all material orders. This report will be updated and re-submitted every 30 calendar days as the status on material orders changes.

Report shall list, in chronological order by need date, materials orders necessary for completion of the contract. The following information will be required for each material order listed:

(a) Material name, supplier, and invoice number.

(b) Bar chart line item or CPM activity number affected by the order.

(c) Delivery date needed to allow directly and indirectly related work to be completed within the contract performance period.

(d) Current delivery date agreed on by supplier.

(e) When item d exceeds item c, the effect that delayed delivery date will have on contract completion date.

(f) When item d exceeds item c, a summary of efforts made by the Contractor to expedite the delayed delivery date to bring it in line with the needed delivery date, including efforts made to place the order or subcontract with other suppliers.

1-1.5 Road Access to the Site

1-1.5.1 Road Access

The project sites are accessible from Sohbatpur through a metaled road network. The construction of VRBs at Uch Canal (Lot-I) and the Restoration / Strengthening of Hairdin Main Drain with construction of two VRBs (lot-II) at different locations are situated within the administrative boundaries of Sohbatpur District, Balochistan. The district headquarters, Sohbatpur, serves as the primary access point to the project areas. The sites are well connected through existing road infrastructure, and access roads and tracks from Sohbatpur provide convenient connectivity to the project locations.

1-1.5.2 Practicability of Use

The Contractor shall ascertain for himself the practicability of using the existing roads for access.

1-1.5.3 Protection and Strengthening of Existing Facilities

The highways, roads and bridges have widely varying load limits, and the Contractor shall be responsible for determining the load limits existing at and during Contract period and ensuring that his Constructional Plant does not exceed such limits. Before moving any heavy construction traffic onto highways, roads and bridges, the Contractor shall make suitable arrangements with the appropriate Government authorities and obtain their approval for the passage of such traffic. Where the authorities require and specify any special protection or strengthening of highways, roads or bridges, the Contractor shall submit to the Project Manager his proposals for such work after their approval by the authority concerned and shall carry out this work to the satisfaction of the Project Manager. Separate payment will not be made for any special protection or strengthening required by Government authorities and carried out at the direction of the Project Manager. All costs payment shall be deemed to be included in the rates and lump sum prices in the priced Bill of Quantities.

1-1.5.4 Use of Bituminous Sealed Roads

The Contractor shall not travel tracked vehicles or plant on any bituminous sealed road surface. Rubber tyred vehicles conforming to applicable load restrictions will be permitted to use bituminous sealed roads.

1-1.5.5 Additional Roads

All additional roads required by the Contractor as access and haul roads on the Site shall be provided by the Contractor in accordance with Clause 1-1.15 of this Specification. The payment will be made if so permitted through item of work in the Bill of Quantities for full compliance with requirements of this Sub-Clause.

1-1.6 Project Schedule

1-1.6.1 Commencement, Execution and Completion of Works

The Contractor shall start the works under the Contract in accordance with **Sub-Clause 1.1 of the Conditions of Contract**.

Pursuant to **Sub-Clause 1.1 of the Conditions of Contract**, the Contractor shall execute for mandatory completion of the different sections of the Works in accordance with the Implementation Schedule within the number of days specified herein under taken from the day of issue of the Project Manager's written order to commence the Works.

1-1.6.2 Contractor's Construction Program

The Contractor shall submit a revision of the construction program attached to the Bid for approval to the Project Manager within the period stipulated in the conditions of contract. The submission shall be in accordance with the provisions of **Sub-Clause 1-1.4** of these specifications. The program shall be prepared according to **Sub-Clause 1-1.6.3** of this section so that the operations under each item of work submitted by the Contractor shall be broken down in greater detail than that shown on the Construction Programme submitted with the Tender.

Whenever the Contractor proposes to change the Construction program he shall immediately advise the Project Manager in writing and if the Project Manager considers the change is a major one the Contractor shall submit a revised program for approval. If such a change in the construction program affects the Project Manager's design and drawings program, the Employer will not be responsible for the consequences of the late issue of any drawings which are attributable to that change.

If the Contractor falls behind the approved construction program he shall, within fourteen (14) days of the date of such default, submit a revision of the Construction program showing the proposed measure to complete the Permanent Works on time, for approval.

When requested by the Project Manager, the Contractor shall promptly furnish a detailed sub-program of the Construction program for particular sections of the Permanent Works.

1-1.6.3 Requirements of Construction

(a) General Requirements

The Contractor shall designate an authorized representative who shall be responsible for the preparation of all required Construction program reports. The scheduling of construction shall be the responsibility of the Contractor. Contractor management personnel shall actively participate in its development. Subcontractors, and Contractor’s Designers, and suppliers working on the project shall also contribute in developing and maintaining an accurate Construction program. The approved Construction program shall be used to measure the progress of the work, to aid in evaluating time extensions.

(b) Computer Software

The computer software system utilized by the Contractor to produce the Construction program shall be capable of providing all requirements of this specification. Failure of the

Contractor to meet the requirements of this specification shall result in the disapproval of the program. Manual methods used to produce any required information shall require approval by the Project Manager.

(c) Use of the Critical Path Method

The Critical Path Method (CPM) of network calculation shall be used to generate the Construction program. The Contractor shall provide the Construction program in the Precedence Diagram Method (PDM) format on Primavera/MS Project software.

(d) Level of Detail Required

The Construction program shall include an appropriate level of detail. Failure to develop or update the Construction program or provide data to the Project Manager at the appropriate level of detail, as specified by the Project Manager, shall result in the disapproval of the program. The Project Manager will use, but is not limited to, the following conditions to determine the appropriate level of detail to be used in the Construction program.

(i) Design and Permit Activities

Design and permitting activities, including necessary conferences and follow-up actions and design package submission dates, shall be integrated into the Program.

(ii) Procurement Activities

Tasks related to the procurement of long lead materials or equipment shall be included as separate activities in the Construction. Long lead materials and equipment are those materials that have a procurement cycle of over 90 days. Examples of procurement process activities include, but are not limited to: submittals, approvals, procurement, fabrication, and delivery.

(iii) Critical Activities

The following activities shall be listed as separate line activities on the Contractor's Construction:

(a) Submission and approval of mechanical/electrical layout drawings.
(b) Submission and approval of O & M manuals.
(c) Submission and approval of as-built drawings.
(d) Performance Verification testing.
(e) Other systems testing, if required.
(f) Pre-final inspection.
(g) Correction of punch list from pre-final inspection.
(h) Final inspection.

(iv) Project Manager and Employer’s Activities

Project Manager, Employer or other agency activities that could impact progress shall be shown. These activities include, but are not limited to: approvals, design reviews, environmental permit approvals by State regulators and inspections.

(v) Responsibility

All activities shall be identified in the Construction Program by the party responsible to perform the work. Responsibility includes, but is not limited to, the subcontracting firm or contractor work force, performing a given task. Activities shall not belong to more than one responsible party.

(vi) Work Areas

All activities shall be identified in the Construction Program by the work area in which the activity occurs. Activities shall not be allowed to cover more than one work area. The work area of each activity shall be identified by the Work Area Code.

1-1.6.4 Construction Program Submissions

The Contractor shall provide the submissions as described below. All necessary data disks, reports, and network diagrams required for each submission shall be provide with the program.

(a) Preliminary Construction Program Submission

The Preliminary Construction program, defining the Contractor's planned operations for the first 60 calendar days shall be submitted for approval within 14 calendar days after the Letter of Acceptance is acknowledged. The approved preliminary program shall be used for payment purposes not to exceed 60 calendar days after NTP.

(b) Initial Construction Program Submission

The Initial Construction program shall be submitted for approval within 40 calendar days after Letter of Acceptance. The program shall provide a reasonable sequence of activities which represent work through the entire project and shall be at a reasonable level of detail.

(c) Periodic Program Updates

Based on the result of progress meetings, specified in "Periodic Progress Meetings," the Contractor shall submit periodic program updates. These submissions shall enable the Project Manager to assess Contractor's progress. If the Contractor fails or refuses to furnish the information and Construction program data, which in the judgment of the Project Manager or authorized representative is necessary for verifying the Contractor's progress, the Contractor shall be deemed not to have provided an estimate upon which progress payment may be made.

1-1.7 Performance Security and Insurance

1-1.7.1 Performance Security

(a) **Sub-Clause 52** of the Conditions of Contract specifies the Contractor providing an irrevocable bank guarantee for the due performance of the Contract.

No payment shall be made for the cost of complying with the requirements of the Conditions of Contract.

1-1.7.2 Insurance

Clause 13 of the Conditions of Contract requires that the Contractor shall take out certain insurances relating to the Contract.

The insurances drawn shall be in accordance with the requirements stated under insurance in the Conditions of Contract. The Insurance Policies drawn shall be approved by the Project Manager.

For fulfilling his obligations under Sub-Clause 13.1(a), 13.1(b), 13.1(c), 13.1(d) of the Conditions of Contract, the Contractor shall be reimbursed on a prime cost basis the actual amount of premium paid by the Contractor for providing the required insurance.

Provisional sum has been allocated in the priced Bill of Quantities (refer Item A1) for payment for the cost of complying with the requirements of the Conditions of Contract.

1-1.8 Materials to be furnished by the Contractor

The Contractor shall furnish all materials required for the execution of the Works.

Unless specifically stated otherwise, any reference in the Technical Specifications or on the Bid Drawings to trade names or catalogue numbers or to a particular manufactured product does not imply that the article or product so mentioned is the only one that may be supplied or used. Any reference made is purely given as a standard of the quality, class, type and finish of the items specified to be used. Articles or products of similar type and quality produced by other manufacturers shall be submitted by the Contractor for approval.

All materials that will become part of the Permanent Works shall be new and shall conform to the Technical Specification. Where the requirements for any materials are not stated in the Technical Specifications, the material shall conform with the appropriate and most recent Pakistani and/or American and/or British Standard Specification or such other specifications as may be approved.

When a separate item, which includes the furnishing of any materials, is provided in the priced Bill of Quantities, the cost of furnishing, transporting, storing and handling such materials shall be deemed to be included in the rate or lump sum tendered for that item in the priced Bill of Quantities.

Where no separate item is provided in the priced Bill of Quantities for furnishing any materials required to be furnished by the Contractor the cost of furnishing, transporting, storing and handling such materials shall be deemed to be included in the rate or lump sum tendered in the priced Bill of Quantities for the items for which the materials are required.

The Contractor shall make diligent effort to procure the specified materials, but where, because of priorities or other causes materials required by the Specification are not available, approved substitute materials may be used, which approval will state the amount of price adjustment, if any, to be made. The Project Manager's decision as to whether substitution will be permitted and as to what substitute materials may be used will be final, binding and conclusive.

Materials and equipment furnished by the Contractor, which will be incorporated in the Permanent Works, shall be subject to inspection, examination and test as provided in the Contract. To allow sufficient time to provide for inspection, examination and testing, the Contractor shall submit at the time of issue, copies in duplicate of all orders, including drawings and other pertinent information, covering the materials and equipment to be furnished by the Contractor, or shall submit other evidence in the event of such orders being issued verbally or by letter, to the Project Manager. The inspection, examination and testing of materials and equipment or the waiving of inspection, examination and testing thereof shall in no way relieve the Contractor of the responsibility for furnishing materials and equipment meeting the requirements of the Technical Specifications.

The responsibility for so ordering and delivering materials and manufactured articles and samples that they may be tested sufficiently far in advance of the work as not to delay it shall rest upon the Contractor and he shall not be entitled to any time credit for delays occasioned by his neglect to order sufficiently well in advance or to payment of any costs he may incur as the result thereof.

1-1.9 Standard Specifications

1-1.9.1 Standards

Except as otherwise specified in the Technical Specifications, all materials and workmanship shall comply in all respects with the requirements of the appropriate specifications and codes issued by Pakistani and/or the British Standards Institution and/or American or such equivalent standards of other such countries as may be approved and current at the date of Invitation for Tenders as may be applicable to any part of the Permanent Works. If, after the date of Invitation for Tenders, there is an amendment to a standard specification relevant to the Contract, the Project Manager will direct whether the amendment is to apply.

1-1.9.2 Copies of Standards, Codes and References

The Contractor shall have available in his site office at all times at least one (1) copy of every standards, codes and references referred to in this Specification.

Separate payment will not be made for compliance with this Clause and all such costs shall be deemed to be included in the rates and lump sums tendered in the priced Bill of Quantities for the items for which the standards and codes are applicable.

1-1.10 Setting-Out Works

The Contractor shall be solely responsible for the correct setting out of the Works and shall employ experienced qualified surveyors acceptable to the Project Manager for this purpose.

The Project Manager will establish free of charge to the Contractor necessary reference marks to define datum lines and the reduce levels of suitably located reference bench-marks to enable the Contractor to set out the Permanent Works. Any reference marks damaged as the result of action by the Contractor will be replaced by the Project Manager at the expense for the Contractor.

The Contractor shall furnish all materials, labour and equipment including stakes, templates, patterns, platforms and special labour that may be required in setting out any part of the Works.

Separate payment will not be made for complying with the provisions of this Clause and all costs shall be deemed to be included in the various rates and lump sums tendered in the priced Bill of Quantities.

The Project Manager may make checks as the Work progresses to verify lines or lines and grades established by the Contractor and to determine the conformance of the work as it progresses with the requirement of the Technical Specifications and the Drawings. Such checking by the Project Manager shall not relieve the Contractor of his responsibility to perform all work in accordance with the Drawings and the Technical Specifications and the lines and grades given therein.

1-1.11 Safety Precautions

1-1.11.1 General

The Contractor shall comply with any Safety instruction given by the Project Manager. The Contractor shall prepare comprehensive health and safety plan. In the performance of the Works, the Contractor shall exercise every reasonable precaution to protect persons or property from injury. The Contractor shall erect and maintain all necessary temporary fencing, barricades, barriers, signs and lights and provide fire alarm, fire extinguishing and fire-fighting services at strategic points on the Site. The Contractor shall adopt and enforce such rules and regulations as may be necessary, desirable or proper to safeguard the public and all persons engaged in the work and its supervision.

1-1.11.2 Safety Officer

The Contractor shall constantly assign, during the progress of the Works, an employee qualified in safety, and familiar with the type of work being performed, whose assignment

shall include initiation of measures for the protection of health and the prevention of accidents and who shall see, by personal inspection, that all safety rules and regulations are enforced. The Contractor shall hold regularly scheduled safety meetings at least once each month with his Project Managers, supervisors and foremen. When directed additional meetings will be held. The Contractor shall keep the Project Manager advised as to when these meetings are to be held and shall provide the Project Manager with a copy of the proposed agenda.

The Safety Officer shall impart health and safety training to the site personnel.

1-1.11.3 Safety Measures

With limits the generality of Clause 19 of Conditions of Contract, the Safety measures taken by Contractor shall include but shall not be limited to the following:

(a) Temporary Fencing – The Contractor shall erect, maintain and remove suitable and approved temporary fencing to enclose such areas of the Permanent Works and areas of land occupied by the Contractor within the Site as may be necessary to implement his obligations under the Contract, to the satisfaction of the Project Manager. Where any temporary fence has to be erected alongside a public road, footpath, etc., it shall be of the type required by and shall be erected to the satisfaction of the Government authority concerned.

(b) Lighting –The Contractor shall provide sufficient lighting in all places where work is in progress:

(i) Safe working conditions are provided both for the Contractor's personnel, sub-contractor's personnel and for personnel of the Project Manager;

(ii) The Works can be constructed in complete compliance with the Contract; and

(iii) A complete inspection of all Works in progress can be made by the Project Manager.

(c) Unless otherwise directed, the minimum service luminance on ground or working surfaces to be provided for the various operations or work areas shall be as tabulated below:

Operation or Area	Design Value (Lux)	Minimum Measured Value (Lux)
Earthworks and Excavation	50	20
Bridges	20	10
Access and haul where Cross traffic or other hazardous conditions exist	20	10
Concrete placing	100	50
Maintenance shops and auxiliary buildings	300	200

(d) The Contractor shall supply a suitable instrument to the Project Manager for measuring the intensity of illumination. The instrument shall comply with BS 667.

(e) Illumination for areas or operations not listed in the above table shall conform to the requirements of the Lighting Guide, Building and Civil Engineering, Site Illuminating Engineering Society, London.

(f) All mobile equipment or plant used during night operations, as and when approved by the Project Manager, shall be equipped with sufficient lights and reflectors to ensure safe working conditions.

(g) Not less than fourteen (14) days before the start of night operations, the Contractor shall submit his proposals for lighting in the areas in which he proposes to work at night to the Project Manager. The Contractor shall modify the proposals if required by the Project Manager, and shall not begin operations at night until the proposals for lighting (in an amended form if required) have been approved.

(h) Approval of the Contractor's proposals for lighting shall not relieve the Contractor of any of his liabilities or obligations under the Contract.

(i) Work in the vicinity of electrical equipment – in the interest of safety and security, the Contractor shall complete the erection of any safety fencing around electrical and mechanical apparatus by the time that the said apparatus is connected to any electricity supply.

(j) Explosives – in the use, handling and storage of explosives, the Contractor shall comply with the guidelines given in **Section 5**, Excavation and Miscellaneous Earthworks of this Specification and with all statutory regulations of Pakistan. The Contractor's attention is drawn to the fact that, depending on the nature of work in progress, the Project Manager may require the Contractor to discontinue the handling or use of explosives during the approach and progress of severe thunderstorms in which case all persons shall be removed form danger areas to a place of safety during such periods.

(k) Safety Instructions – the Contractor shall at his own cost supply and issue to his employees and those of his subcontractors and the staff of the Project Manager printed booklets, of pocket-size, on the scale of one per person, in English and in other languages used by his employees at Site, instructions based on good practice. Within sixty (60) days of the Project Manager's written order to commence the Works at Site, proof copies of the booklet shall be submitted for approval before printing and amendments shall be made to the booklet to his entire satisfaction. The Contractor shall issue the booklet immediately after printing as required by this Clause and ensure that all employees are fully conversant with the instructions. Safety instructions shall deal with all safety including:

(i) Protective clothing, headgear and footwear;

(ii) Use of lifting equipment;

(iii) Use of drilling equipment;

(iv) Contract with and use of electrical equipment;

(v) Use and storage of explosives;

(vi) Compressed air;

(vii) Welding;

(viii) Routine for accidents or fires; and

(ix) Watchmen, warning notices and barriers.

The Contractor shall allow for 20 booklets for the use of the Project Manager.

(l) The Contractor shall provide for the Project Manager and Project Manager's supervisory staff the protective clothing, headgear and footwear necessary for the proper discharge of their duties on Site.

(m) Accident Reports – the Contractor shall promptly report to the Project Manager in the form to be prescribed, all accidents involving death or serious injury to staff or workmen, and furnish monthly reports of all accidents to staff or workmen involving loss of time, giving such information as may be prescribed by the Project Manager.

(n) (i) The Contractor shall provide all necessary signs for the works. These shall include, but not be limited to:

use of sirens before blasting and a all-clear indication

standard road signs;

warning signs;

danger signs;

control signs;

safety signs; and

direction signs.

(ii) Wording on all signs shall be in English and Urdu and other approved languages. The size, colour, lettering and location of all signs will be subject to approval and attention shall be paid to international signs.

(iii) The Contractor shall maintain all signs placed by him as well as those placed by the Employer.

(iv) If the Project Manager considers that the system of signs provided by the Contractor is inadequate to ensure safety, or unsatisfactory in other respects, the Contractor shall add to, amend, or otherwise change the system to the satisfaction of the Project Manager.

(v) The Contractor shall at his own cost make suitable replacement as directed by the Project Manager in case of loss or damage to any signs provided by the Contractor under this Sub-Clause.

(vi) The Contractor shall at his own cost adopt such measures as the Project Manager may consider reasonable and necessary to minimize nuisance from dust, noise or other disturbance created while or in carrying out the Works.

The cost of provision of safety measures and safety officer will be deemed to be included in the various rates of the priced Bill of Quantities. Separate payment will not be made for

complying with the provisions of this Clause (Clause 1-1.11 including subclauses) unless included in the Bill of Quantities as such.

1-1.12 Hours and Days of Working

Contractor is not permitted to work during the night or on locally recognized days of rest. However, in special cases, he may be allowed to work during the night or on locally recognized days of rest with prior permission of the Project Manager.

Before commencement of work on the Contract, the Contractor shall notify the Project Manager, in writing, of the hours and of the number of shifts that he proposes to work and shall give at least 48 hours notice to the Project Manager of any changes to such hours of working and / or number of shifts that may be necessary during the currency of the Contract.

If any part of the Works is located within a security controlled area, the following will aplly in the security controlled area:

a. No persons will be permitted to enter or leave the security controlled Works area between 1900 hours on one day and 0700 hours on the following day.

b. No restrictions will be imposed on the movement of personnel within the security controlled Works area at any time of the day or night.

1-1.13 Resources Reports

During the course of construction, the Contractor shall submit on the first day of each week a detailed list by trade classification of manpower employed during the report period and a list of all major items of Constructional Plant on Site to the Project Manager.

1-1.14 Temporary Works

The Employer will allocate to the Contractor free of cost an area of land at the Site within which the Contractor shall accommodate his work force and set up all services and facilities required for the construction of the Work on Site.

Unless otherwise provided in the drawings, the Contractor shall submit to the Project Manager for his approval 2 copies of all working or shop drawings produced by him including al drawings, made by his approved sub-contractors for all temporary works. Such submission shall be made at least two weeks before the temporary work is scheduled to commence. Notwithstanding the approval by the Project Manager the Contractor is solely responsible for the adequacy and safety of his work and for any necessary modification or addition whenever found necessary by the Project Manager.

The Contractor’s proposals for the details of erection and construction of all Temporary Works shall be in accordance with the proposals submitted with the Bid and approved in the Letter of Acceptance or with such modifications as approved from time to time.

Temporary Works shall include but not be limited to the work covered in **Sub-Clauses 1-1.15 to 1-1.27**, both inclusive, of this Specification, Contractor's offices and accommodation, building, temporary fences, sanitary facilities, fixed construction facilities including but not limited to workshops, compressed air stations, electric power, water supply, telecommunications and construction and maintenance of access roads required for the execution of the Works and clean-up of the Site on completion.

The Contractor shall submit for approval drawings and full particulars of all Temporary Works, which he intends to construct at least thirty (30) days before he desires to commence constructing such works. Approval of any such proposals from the Contractor shall not relieve the Contractor of any of his responsibility for the sufficiency of the Temporary Works for their intended purpose. The Contractor shall also obtain any necessary approval from local statutory or other Government authorities before commencing construction. Such work shall not be started without prior approval.

Construction facilities on which interim payments have been made shall be maintained in good order and shall not be demolished, removed from the Site or otherwise disposed of without prior approval.

No house, office, store, workshop or other habitable building will be permitted underneath or within 3 m of the nearest point in plan of the uninsulated overhead conductor of low or medium voltage of an electricity supply main.

On completion of the Works, all Temporary Works whether existing or constructed by the Contractor, unless otherwise specified or directed shall be removed from the Site. The Contractor shall make safe all areas affected by Temporary Works and reinstate natural drainage. The Contractor shall finish, reinstate, clean up and relinquish full or parts of the site at the end of the Maintenance Period or such earlier times as directed by the Project Manager. Buildings and facilities removed from the Site will remain the Contractor’s property.

Separate or additional payment will not be made for Temporary Works and complying with the provisions of this Sub-Clause and **Sub-Clauses 1-1.15 to 1-1.27** unless included in Bill of Quantities as such.

1-1.15 Temporary Access and Haul Roads

1-1.15.1 General

The Contractor shall design, construct and maintain all temporary access and haul roads (including associated drainage and stream crossing facilities) to the various working sites, designated borrow & disposal areas and quarry sites as required for the Works.

The temporary access and haul roads may be constructed at times to suit the Contractor’s construction except where the requirements of **Sub-Clause 1-1.6** of this Specification apply.

The Contractor shall submit for approval drawings, design and full particulars of all temporary access roads, which he intends to construct at least thirty (30) days before he desires to commence constructing such temporary access roads. Approval of any such proposals by the Project Manager shall not relieve the Contractor of any of his responsibility under this Contract.

1-1.15.2 Heavy Construction Traffic

The Contractor's heavy construction traffic or tracked equipment shall not traverse any public roads or bridges, unless the Contractor has made arrangements with the Authorities concerned and the approval of the Project Manager to such arrangements has been obtained.

1-1.15.3 Maintenance of Roads

The Contractor shall be wholly responsible for the maintenance of all temporary access and haul roads constructed by him or as specified in this Contract.
In maintaining these roads the Contractor shall:

(a) Keep clear and in good working order at all times all road structures, bridges, culverts, drains and other waterways;

(b) Patch potholes with approved materials, keep the road surface in good repair and perform any grading and necessary resurfacing;

(c) Maintain all fender posts, guide posts, guard posts, fencing, signs, signposts and other roadside structures;

(d) Take reasonable and necessary measures to minimize nuisance from dust created while or in carrying out the Works.

1-1.15.4 Use of Roads by Others

During the period of the Contract, the Employer may be engaged on other works in the vicinity of the Works covered by the Technical Specifications, and the Contractor shall allow the Project Manager or persons authorized by the Project Manager free use of all temporary access and haul roads.

The cost for maintenance of roads will be deemed to be included in the various rates of the priced Bill of Quantities. Separate payment will not be made for complying with the requirements of this Sub-Clause unless included in the Bill of Quantities as such.

1-1.16 Electric Power

The Contractor shall make his own arrangements for the supply and distribution of electricity to provide for power and light for the Contractor's Site office, camp accommodation and camp amenities, workshops, stores, offices, including the Project Managers Project Site Office, laboratories and all other facilities necessary for the execution of the Works.

The power supply shall be three-phase, four-wire, 50 Hz, 415 V (ph-ph) for power and 240 V (ph-N) for lighting and small power and shall comply with the regulations of local power supply authorities. Facilities shall be provided to permit the isolation of individual supply points while maintaining supply to the remainder of the system. Unless otherwise provided, the Contractor shall install a meter at the Project Site Office and site laboratory.

Not less than sixty (60) days prior to the installation for supply and distribution of electricity as required under this Sub-Clause, the Contractor shall submit in full detail his proposals and drawings for approval.

Unless otherwise directed, on the completion of the Works, the Contractor shall remove from the Site the installation for electricity supply provided by him and the electrical distribution systems in and amongst the Contractor camps, offices, stores, workshops and other areas.

The cost for supply and maintenance of electrical power will be deemed to be included in the various rates of the priced Bill of Quantities. Separate payment will not be made for complying with the requirements of this Sub-Clause unless included in the Bill of Quantities as such.

1-1.17 Telecommunications

The Contractor shall make his own arrangements for the required telecommunication services.

The Contractor shall provide and operate a communications system for the purpose of intercommunication within the Site area.

The cost for providing and maintaining the telecommunication system will be deemed to be included in the various rates of the priced Bill of Quantities. Separate payment will not be made for complying with the requirements.

1-1.18 Water Supply

The Contractor shall make his own arrangements for the supply of adequate safe drinking water. The Contractor shall comply with all rules and regulations made by the authorities having jurisdiction, and by the Project Manager, regarding the taking of water from the canals in the area or from groundwater resources.

The water from any source should be tested for impurities contents and approved by the Project Manager. Any additional cost incurred will not be paid but will be deemed to be included in the various rates of the priced Bill of Quantities.

The Contractor shall be responsible for the supply and reticulation of all water for his own use and to the Project Manager's residential camp, Project Site Office and Field Offices. Water supplied for domestic use shall be potable.

The Contractor's methods of storage of water for construction purposes shall be in accordance with the proposals approved by the Project Manager.

The cost for provision and maintenance of water supply system will be deemed to be included in the various rates of the priced Bill of Quantities. Separate payment will not be made for complying with the requirements of this Sub-Clause unless included in the Bill of Quantities as such.

1-1.19 Sewerage

The Contractor shall provide and install an approved treatment process for disposal of sewage from all offices, camps and other buildings for Project Manager and contractor and their staff constructed by the completion of this Contract.

The Contractor shall construct, operate and maintain at the site temporary toilet facilities complete with adequate water borne water closets, urinals and hand-basins, septic tanks, absorption trenches or other sewerage disposal installations, for all site personnel.

The temporary toilet facilities shall meet the requirements of the Government health authority. The location of these facilities and their construction shall be as approved.

Sewage from temporary facilities shall be disposed of in a hygienic manner as approved.

The cost for provision and maintenance of sewerage system will be deemed to be included in the various rates of the priced Bill of Quantities. Separate payment will not be made for complying with the requirements of this Sub-Clause unless included in the Bill of Quantities as such.

1-1.20 Garbage Disposal

The Contractor shall undertake the collection of and disposal of all garbage from within the area of both the Permanent and Temporary Works including from the Project Manager's residential camp Project Site Office. Garbage collections shall be made at least twice each week and shall continue until completion of the Works.

Garbage shall be disposed of in a properly constructed incinerator followed by burial of the residue in an approved location. The Contractor shall submit the proposed design and layout of garbage disposal facilities for approval.

The cost for provision and maintenance of garbage disposal will be deemed to be included in the various rates of the priced Bill of Quantities. Separate payment will not be made for complying with the requirements of this Sub-Clause unless included in the Bill of Quantities as such.

1-1.21 Fire Prevention

The Contractor shall provide and maintain adequate fire-fighting equipment and take adequate fire precaution measures for the safety of all personnel, temporary and permanent works, and shall take action to prevent damage to or destruction by fire of trees, shrubs or grasses.

The cost for provision and maintenance of fire fighting system will be deemed to be included in the various rates of the priced Bill of Quantities. Separate payment will not be made for complying with the requirements of this Sub-Clause unless included in the Bill of Quantities as such.

1-1.22 First Aid and Medical Facilities

1-1.22.1 General

The Contractor shall in all respects be fully responsible for ensuring necessary first-aid services to his employees and employees of his subcontractors and Project Manager's staff, including transport for injured personnel to hospital or other appropriate accommodation as and when required.

1.1.22.2 Staff

To enable the fulfillment of his obligations under this Clause, the Contractor shall engage qualified resident first-aid staff, provide and maintain an Ambulance to move serious patients or victims of an accident to nearby Hospital.

Separate payment will not be made for first-aid and medical facilities provided by the Contractor for his employees and the employees of his subcontractors but will be deemed to be included in the various rates of the priced Bill of Quantities unless included in the Bill of Quantities as such. The facility shall be also available for the use of Project Manager's staff.

1-1.23 Living Facilities, Camp Amenities and Recreation Facilities

1-1.23.1 Location of Construction Camp

The Contractor shall be responsible to arrange the land on rent or on lease the land to be used for the construction of quarters for his own staff and camps for workmen and for other camp amenities for his employees.

1-1.23.2 Contractor's Staff Quarters and Camps

The Contractor shall ensure that his allocated areas are at all times kept in a clean and sanitary condition, and shall provide and maintain sanitary conveniences for the use of persons employed on the Works to the extent and in the manner and at such places as shall be approved by the Project Manager and by any local or other Government authority concerned, and all employees of the Contractor and his subcontractors shall be obliged to use these conveniences. Any employee found violating this requirement shall be liable to

immediate termination of employment and to the refusal of further employment on the Works.

1-1.23.3 Camp Amenities

a) The Contractor may be permitted to lease areas within his labour camp or quarters area for his staff, or space in buildings constructed by him in these areas, for conducting such business or services as may be necessary for the convenience of his labour or staff. The Contractor may recoup from leases such rent as necessary to cover the costs of administering the provision of these businesses or services. Patronage of such businesses or employment of such services by the Contractor's employees shall be optional.

b) All concessions or leases shall require a submission to the Project Manager and the approval of the Employer. No concessions or leases shall be granted for the operation of games of chance or gambling in any form. They shall contain provisions making them subject to termination upon both completion of the Works and in the case of the business or service, being conducted in such a manner as to infringe the terms of this Sub-Clause.

c) The charges for all goods and services at camp shops, canteens and the like shall be fair and reasonable and not in excess of the charges for similar goods and services in the area.

1-1.23.4 Recreation Facilities

a) The Contractor shall provide construct and maintain in an approved area, recreation facilities for sports such as soccer, volley ball and tennis etc. These facilities shall be available for the use of the Contractor and the Project Manager's staff, and respective dependents.

b) The Contractor may also at his expense, construct any additional service facilities required in the recreation area and shall ensure that the standard is at least equal to other township buildings.

c) The Contractor shall ensure the recreation area and service facilities are at all times kept in a clean and tidy condition.

d) Separate payment will not be made for complying with requirements of above mentioned Sub-Clause.

1-1.23.5 Security Fencing

The Contractor shall erect and maintain and keep in good repair this security fence and shall make good any damage, at his own costs, before vacating the site on the completion of the Contract.

The cost for provision and maintenance of security fencing system will be deemed to be included in the various rates of the priced Bill of Quantities. Separate payment will not be made for complying with requirements of above mentioned Sub-Clause unless included in the Bill of Quantities as such.

1-1.23.6 Removal of Buildings and Facilities

The Contractor, upon completion of the works, shall dismantle and remove all buildings complete including the facilities as stated in this Sub-Clause and temporary structures erected by him as part of his construction camp, and fill in all excavated areas as directed, remove all refuse, debris and other objectionable materials and leave the camp area in a clean and rightly condition to the satisfaction of the Project Manager.

The cost for removal of buildings will be deemed to be included in the various rates of the priced Bill of Quantities. Separate payment will not be made for complying with the requirements of this Sub-Clause, unless included in the Bill of Quantities as such.

1-1.24 Contractor's Offices, Stores and Workshops

1-1.24.1 General

a) The Contractor shall provide and maintain such offices, stores, workshops and adequately fenced store and delivery compounds as are necessary for the execution of the Works, including all necessary services for water supply, drainage, lighting, roads, paths, parking places, sewerage and garbage disposal.

b) On the completion of the Works, all buildings and facilities provided by the Contractor in accordance with the provisions of this Clause shall remain the property of the Contractor and shall be removed from the Site.

The cost for provision and maintenance of offices, stores, and workshops will be deemed to be included in the various rates of the priced Bill of Quantities. Separate payment will not be made for complying with the requirements of this Sub-Clause but will be deemed to be included in the various rates of the priced Bill of Quantities.

1-1.25 Flood Prevention

The Contractor shall plan his work in such a manner to ensure no flooding or ponding of water outside the construction area will occur.

Separate payment will not be made for the provision of flood prevention measures and the cost of this work shall be deemed to be included in the various rates and lump sum prices in the priced Bill of Quantities.

1-1.26 Security

1-1.26.1 General

(a) The Employer will specify overall security requirements for the project and the Contractor shall conform to such requirements and be responsible for such action of his personnel in respect of such requirements.

(b) The project site may be located within a Security Controlled Area and the Contractor shall conform with all requirements established by the Police/Defense Department for this area.

(c) The entry of personnel, food stuff, clothing and other items into the Security Controlled Area will be regulated by the Police Department or as directed by the Project Manager.

(d) The Contractor shall obtain Police Permits to enter the Security Controlled Area for all personnel employed on the project including personnel of his subcontractors and all other persons he requires to visit the Site. Application for permits shall be lodged with the Police Department not less than fourteen (14) days prior to the date of proposed entry to the area. Applications shall include all personnel information as required by the Police Department.

(e) Personnel holding a permit will be permitted to enter or leave the site between 0700 hours and 1900 hours. Personnel will not be permitted to enter or leave the Site after 1900 hours or before 0700 hours. Personnel will be permitted to remain and work within the Site during the restricted period.

1-1.26.2 Identification

(a) All Contractor's employees, representatives, and subcontractor's employees shall wear identification badges provided by the Contractor. Badges shall identify the Contractor, show an employee number, and shall be worn at all times while at the Site.

(b) All vehicles used by the Contractor shall be clearly marked with the Contractor's name, and name of project.

1-1.26.3 Site Security

The Contractor shall be responsible for the security of the works for the duration of the Contract and shall provide and maintain continuously an adequate security force to fulfill these obligations. The duties of the Contractor's security force shall include, but not be limited to, maintenance of order on the Site, provision of all lighting, fencing, guards, flagmen, and all other measures necessary for the protection of the Works within the township and elsewhere on the Site, all material delivered to the Site, the public, and all persons employed in connection with the Works, continuously throughout working and non-working periods, including nights, days of rest and holidays, for the duration of the Contract.

1-1.26.4 Camp Security

Each entrance in the security fence surrounding camp area shall be continuously manned by the Contractor's security personnel who shall control the movement of personnel and goods into and out of the enclosed area and shall prohibit persons leaving the area between night hours except those authorized personnel employed during the night shift on the construction work.

Separate payment will not be made for complying with the requirements of this Sub-Clause but will be deemed to be included in the various rates of the priced Bill of Quantities.

1-1.27 Provision of Residential cum Office Accommodation for Project Manager's Staff

1-1.27.1 General

The Contractor shall design, construct or hire, maintain and insure until completion of the Works, the buildings (Residential cum Office Accommodation and Testing Laboratory) of of temporary nature which shall consist of the facilities complete with fixtures and equipment for sole use by the Project Manager's staff as follows.

Resident Engineer	1 No.
AREs/Site Engineers	2 Nos.
Material Engineer	1 No.
Supervisors	2 Nos.
Surveyors	2 Nos.
Laboratory Technician	2 No.
Survey Helpers	2 No.

The space requirements are as follows.

(i) The Residential cum office accommodation shall measure not less than One Thousand (1500) square feet (143 square meters), furnished with tables, chairs, etc. in accordance with Appendix 1-1 or as required by the Project Manager.

(iii) Testing Laboratory not less than 800sqft (76 sq m) or as required by the Project Manager, with tables, guest chairs, and lockable filing cabinets and Laboratory Equipments in accordance with Appendix 1-2 or as required by the Project Manager.

1-1.27.2 Construction

The buildings shall be new and of single story construction and shall conform with the Local Government Act and Ordinances and requirements of this specification. Building materials and surface finishes used shall be appropriate for this class of work.

The roofs and external walls shall have effective thermal insulation and all ceiling and internal partitions shall be effectively soundproofed. The floors shall be fitted with a heavy duty vinyl covering.

The buildings will be located on site as approved by the Project Manager after consideration of the proposal by the Contractor and the Contractor shall construct drains, temporary roads, parking areas and paths as directed. Earthworks and drainage for the buildings, roads and parking areas shall be carried out to an approved standard. Car parks shall be constructed at the Project Site Office with space for twelve cars; five of these spaces shall be covered. The area surrounding the Project Site Office, laboratory shall be surrounded with chain link fencing not less than 1.8 meters high and lockable gates along with guards shall be provided at entry / exit points.

The Contractor shall submit the specifications and full construction drawings for the Residential cum Office accommodation and laboratory building. The construction of the Residential cum Office accommodation and laboratory building shall be in accordance

with the layout as approved by the Project Manager. The Contractor shall not commence any construction or fabrication work on the buildings or services until approval has been given by the Project Manager.

The design, construction and supply of the Residential cum Office accommodation and laboratory buildings shall include all necessary electrical installations, including switchboards and meters in accordance with the provisions of the related local unless and incase they are silent, the Regulations for Electrical Equipment of Buildings as issued by the Institution of Electrical Engineer's G.B. The artificial lighting provided in the building shall be with the provisions of IES Code for Interim Lighting (Illuminating Engineering Society London).

1-1.27.3 Services

(a) The Project Site Office, laboratory and residential houses shall be connected to the Contractor's distribution system for power and light.

(b) Communication services shall be installed in each of the room provided in the Project Site Office as required by Sub-Clause 1-1.17 of this Specification.

(c) Washroom with approved sanitary fittings shall be provided at the Project site Office.

(d) The Contractor shall install and maintain an approved sewerage installation for the Project Site Office and residential houses.

(e) The Contractor shall provide and maintain a suitable water supply to all plumbing connections in the Project Site Office and residential houses and laboratory. The water supply for sinks and water cooler shall be potable water. The installation shall include such supply and storage tanks as are necessary to maintain an adequate supply of suitable water and electric water heaters storage type of 150 and 50-liter capacity for the Project Site Office.

(f) The Residential cum office accommodation and Testing Laboratory buildings shall be air-conditioned or as instructed by the Project Manager.

The Contractor shall pay for all drinking water, potable water supply, electricity, gas and telephone charges consumed in the Residential cum office accommodation and laboratory buildings. The Contractor shall include the cost of maintenance of the Residential cum office accommodation and laboratory buildings.

1-1.27.4 Fittings and Fixtures

The required number and approximate location of electrical, plumbing and other hardware items shall be as shown on the Drawings or as directed. Unless otherwise shown on the Drawings or approved, all water supply pipes shall be copper tubes in accordance with BS 2871 Part 1 and all fittings shall be copper or brass, chromium plated as appropriate or as approved by the Project Manager. The design for the Residential cum office accommodation and laboratory buildings houses shall provide for:

(a) Wall mirrors to be fitted above all hand basins;

(b) Air-conditioners and ceiling fans for each room of rating as shown on the Drawing or as directed;

(c) Venetian blinds to be fitted to all office windows;

(d) Fridge and Water cooler for to be located at a place directed by the Project Manager, connected to a potable water supply and capable of supplying hot and cold water at rate of not less than 25 liters per hour when room and inlet water temperature are both 40^{o} C;

(e) Furniture for each bedroom, drawing and dining rooms.

(f) Insect screens to be fitted to external doors and windows and

(g) 'Deadlock' type latches to be fitted to all external doors.

1-1.27.5 Furniture and Office Equipment

(a) The Contractor shall furnish and equip the Residential cum office accommodation and Laboratory buildings in accordance with Appendix 1.1 and 1.2 or as approved by the Project Manager.

1-1.27.6 Project Manager's Testing Laboratory

(a) The Contractor shall design, construct or hire on Site for the duration of the contract a laboratory in a temporary building for the exclusive use of the Project Manager for testing soils, aggregate, concrete and bituminous materials. The laboratory shall be fully equipped with all utilities, furniture, apparatus and fittings appropriate to such use and in full compliance with the Project Manager's instructions & as per site requirement (Appendix 1-2).

(b) The Laboratory shall be located adjacent to the Residential cum office accommodation building or elsewhere if required by the Project Manager, and shall consist of a hall and two offices with storage, lavatory and washing facilities. The total area of the laboratory building shall be 600 sq ft. The hall shall be divided into soil and aggregates section, and concrete section.

(c) Outside the laboratory water tanks shall be constructed for curing concrete samples, of a size and location approved by the Project Manager.

(d) The laboratory shall be provided with electricity and telephone and shall be fully air-conditioned. It shall have a regular and dependable supply of water, gas and electricity available throughout 24 hours of each day.

(e) All rooms shall be provided with exhaust fans, located particularly over fume cupboards and the like.

(f) The water supply shall be maintained by an elevated or pressure tank of adequate capacity.

(g) The Contractor shall provide qualified materials technicians and qualified laboratory helpers as deemed necessary by the Project Manager to assist in operating the laboratory. All costs necessary for the provision and upkeep of these personnel shall be the responsibility of the Contractor and shall be considered included in the payment herein specified for providing and maintaining the Project Manager's Laboratory.

(h) The equipment, fixtures and furniture of Project Manager's laboratory shall remain the property of the Client unless otherwise decided by the Client.

(i) It shall be the responsibility of the Contractor to take samples as required by the Project Manager and to provide all necessary transport, labour, tools, containers, wrappings and so forth for uplifting and dispatching samples to the Project Manager's Laboratory.

(j) The Contractor shall maintain, and shall repair and replace the laboratory equipments in the event of loss or damage of these equipments during the duration of the Contract. This work is part of maintenance and the cost shall be included in the price of maintenance of the project office laboratory and no additional payment shall be made by the Employer.

1-1.27.7 Maintenance and Cleaning

(a) The Contractor shall maintain the Residential cum office accommodation and laboratory buildings and Testing Laboratory with all the fittings, equipments, and associated facilities provided in accordance with the provisions of this Clause and its Appendices in good order and condition including any replacement due to loss or damage until completion of the Works. Maintenance shall include the repair and making good of all faults and defects that become apparent in the buildings surface drainage, roads and paths including cleaning, electrical, plumbing, water supply and sewerage services appurtenant to the buildings and all items in the buildings provided in accordance with the provisions of this Sub-Clause and its Appendices.

(b) Maintenance shall also include the provision of expendable items such as electric light tubes and bulbs or repainting including repainting required by manifestly poor workmanship or materials in the initial supply.

(c) The Contractor shall carry out regular daily cleaning of the Residential cum office accommodation and laboratory buildings and arrange disposal of waste from buildings. The cost shall be included in the maintenance of the Residential cum office accommodation and laboratory buildings and no additional payment shall be made by the Employer.

Separate payment will not be made for complying with the requirements of this Sub-Clause unless included in the Bill of Quantities as such.

1-1.27.8 Insurances

The Contractor shall insure the Project Site Office, laboratory, residential houses and all associated facilities in accordance with the provisions of **Clause 13** of the Conditions of Contract.

No additional payment shall be made by the Employer in this regard.

1-1.27.9 Handing over of Buildings and Facilities

The Contractor, upon completion of the works, shall handover the Buildings including Residential cum office accommodation and laboratory buildings (if constructed) to the Employer including all the facilities provided as per the provisions of this Sub-Clause and its appendices restored to its original condition at no extra cost.

The office furniture, equipment and fixtures provided in all buildings (Project site office, Testing Laboratory and Residential houses) shall be the property of the Employer upon completion of works.

On completion of the works, all the temporary buildings constructed by the Contractor, unless otherwise specified or directed shall be removed from the site. The Contractor shall make safe all areas affected by the buildings and reinstate / reverse natural drainage. The Contractor shall finish, reinstate, cleanup the site at the end of the completion period or such earlier times as directed.

Separate payment will not be made for complying with the requirements of this Sub-Clause and will be deemed to be included in the various rates of the priced Bill of Quantities unless included in the Bill of Quantities as such.

1-1.27.10 Payment

Payment for provision and or construction of Residential cum office accommodation and laboratory buildings and supply and maintenance of equipment and furniture for project manager site office, residence and laboratory shall be made on provisional sum basis.

Payment for the provision and or construction of Testing Laboratory, supply and maintenance / calibration of laboratory equipment/ apparatus for project manager site office, shall be made on provisional sum basis.

The rates for payment of buildings shall include but not limited to :

(i) design of buildings and related facilities.

(ii) construct to completion in all respect with doors and windows and include the surrounding surface drain, excavation and backfill, setting out, brickwork, painting, etc as detailed in the Contract Drawings and Specifications.

(iii) all internal electrical wiring and fittings.

(iv) all water storage tanks and internal plumbing work for water supply.

(v) all sanitary fittings including septic tank, manholes and pipeworks terminating at the septic tank.

(vi) Provision of all furniture and equipment required for each type of building.

1-1.27.11 Maintenance

Payment for the maintenance of Residential cum office accommodation and laboratory buildings will be made at the monthly rate as approved by the Project Manager which shall be deemed to include all costs incurred in maintaining the project site office, testing laboratory and field offices, the services, facilities and furniture to the satisfaction of the Project Manager.

1-1.28 Existing Public Utilities and Other Services

1-1.28.1 Location, Protection and Repair of Damage

The Contractor shall be responsible for locating the position of all services, including mains, overhead and underground cables, pipes, canals, sewers and drains, and where necessary shall adopt such methods of excavation as may be required by the appropriate Authorities or Owners to ensure that no damage is caused to them.

All services which are encountered in the course of the Works even though they may not be in the line of excavation but near to it shall be adequately supported, slung up, strutted or otherwise protected form injury to the satisfaction of the persons or Authority in whom they may be vested.

The Contractor shall make good, at his own expense, any damage done to existing services to the complete satisfaction of and in accordance with the instruction of the appropriate Authority or Owner concerned, and shall keep the Employer indemnified at all times from all claims, costs and expenses which may be brought against or incurred by the Employer for or on account of any damage (whether permanent, temporary or recurring) to the said services.

In the event of the Owner or responsible Authority electing to repair such damage the Contractor shall pay the cost of his or their so doing the work. Should the Contractor fail to pay the cost of the said work within a reasonable period of the account being presented the Employer reserves the right to settle the account and deduct the sum paid by him from moneys due or which may become due to the Contractor. This shall in no case relieve the responsibilities of the Contractor under this Clause.

Separate payment will not be made for complying with the requirements of this Sub-Clause unless included in the Bill of Quantities as such.

1-1.28.2 Diversion / Relocation of Public Utilities and Services

The diversion / relocation of any public utilities or services within or outside the Works area to permit the construction of the Works or to suit the Contractor's method or sequence of work shall be the responsibility of the Contractor. Where a service is required to be interrupted or relocated the Contractor shall notify and arrange with the appropriate Authority or Owner for all permanent and temporary diversions so required. The Contractor shall keep the Project Manager fully informed of his negotiations and no final arrangements shall be made without the approval of the Project Manager.

In planning his work for the diversion / relocation of Public utilities or services the Contractor shall make proper allowance for the time necessary to obtain the Project Manager's approval for the work and for the appropriate Authorities or Owners to authorize the work, obtain the necessary materials and carry out the work. The Contractor shall not be entitled to any extension of time because of his making insufficient allowances for the time taken to obtain approvals and complete the work.

Due allowance shall be made by the Contractor for the effect on the phasing of the Works of alterations to existing public and private mains and services necessitated by the Works. The Contractor must ensure that such existing mains and services are not interrupted without the written consent of the appropriate Authority or the Owner of the services concerned.

The Contractor shall ensure that his program for the whole of the Works executed under the Contract is compatible with the requirements of the Service Authorities and the specifications and the Conditions of Contract. During the execution of the Works, he shall coordinate all services diversion operations with the remainder of the Works in close liaison with the Service Authorities and shall make such adjustments to his program as are from time to time necessary to accommodate the actual progress achieved with the temporary and permanent diversions undertaken.

Separate payment will not be made for complying with the requirements of this Sub-Clause unless included in the Bill of Quantities as such.

1-1.28.3 Relocation of Privately Owned Services

If any privately Owned Services for water, electricity, drainage sewerage or telephones, passing through the site will be affected by the Works, the Contractor shall provide an approved equivalent alternative service in full working order to the satisfaction of the owner of the service and the Project Manager, before the cutting of the existing service.

Separate payment will not be made for complying with the requirements of this Sub-Clause and all costs shall be deemed to be included in the various rates and lump sums tendered in the priced Bill of Quantities.

1-1.29 Traffic Safety and Control (Traffic Safety Measures)

The Contractor shall provide, erect and maintain such traffic signs, lamps barriers and traffic control signals and such other measures as may be necessitated by the construction of the Works in accordance with this Specification and in the local traffic safety rules. Where the circumstances of any particular case are not covered by the recommendations the Contractor shall submit proposals for dealing with such situations to the Project Manager for approval. Compliance with this Clause shall not relieve the Contractor of any of his other obligations and liabilities under the Contract and under the relevant provision of the Road Traffic Ordinance.

The Contractor shall, after consultation with any statutory or other authority concerned, submit to the Project Manager for his approval a program based on such consultation showing the scheme of traffic management he proposed for carrying out the Works before commencing any work which affects the use of public highway or road and then furnish such further details and information as necessitated by the Works or as the Project Manager may require.

The Contractor shall not commence any work which affects the public road until all traffic safety measures necessitated by the work are fully operational.

The traffic signs, lamps, barriers and traffic control signals shall be in accordance with the requirements of the Traffic Signs (Size, Color and Type) Rules current at the date of the execution of the work and the local traffic safety rules.

Traffic signs and road danger lamps shall comply with the provisions of Section 12, Road Work, except that the flashing rate for flashing lamps shall be within the range 120-150 flashes per minute.

The minimum luminous intensity of the lamps shall be 0.5 candelas for steady lamps, 1.0 candela for ripple lamps at their peak, and 1.5 candelas for flashing lamps at their peak.

The Contractor shall keep clean and legible at all times signs, lamps, barriers and traffic control signals and he shall position, re-position, cover or remove them as necessitated by the progress of Works.

Separate payment will not be made for complying with the requirements of this Sub-Clause unless included in the Bill of Quantities as such.

1-1.30 Transport for Project Manager's Staff

The Contractor shall within thirty (30) days of the Project Manager's order to commence work, provide and maintain at all times transport with competent drivers for the exclusive use of the Project Manager and his staff. The transport is to be sited at locations approved by the Project Manager.

All vehicles shall be registered, air conditioned, comprehensively insured and equipped with tracker facility and of the following types.

Two (2) Nos. 4 Wheel Drive vehicles (Revo / Vigo or Equivalent) of the capacity not less than 2800 cc. The vehicle should be in good running condition (not used for more than 2 years) and as approved by Project Manager. Replacement vehicles shall be provided when normal vehicles are not available such as during periods of servicing, maintenance or repair for more then 24 hours.

Two (2) Nos. of motorcycles of the capacity not less than 100 cc, Honda / Yamaha or equivalent of latest model. Replacement motorcycles shall be provided when normal motorcycles are not available such as during periods of servicing, maintenance or repairs for more than 24 hours.

The Contractor shall also provide drivers (including shift drivers as required) all fuel oil and necessary service maintenance throughout construction period and extended period thereof.

The failure on part of the Contractor to provide these facilities, shall entitle the employer to hire all required such facilities and recover the spent charges from the monthly payment of the Contractor.

1-30.1 Measurement and Payment

Refer to Part 4 – Measurement and Payment of this Section.

1-1.31 Survey Equipment for the Project Manager

The Contractor shall provide and maintain during the period of the Contract for the exclusive use of the Project Manager for any purpose in connection with the Contract surveying equipment in accordance with the following:

1 No.	Total Station with tripod
1 No.	RTK for establishing the BMs on rental basis
1 No	Quick Stand with Prism
4 No.	Single prism target system complete with tilting prism holder with target, tribrach adapter, optical plummet tribrach, prism soft bay and telescopic aluminium tripod.
1 No.	Precise Levels (Automatic type), with tripod, magnification 34X
2 Nos.	Levelling Staff with graduations in metric units
2 Nos.	Steel measuring tapes 100 m long
3 Nos.	Steel measuring tapes 20m long
3 Nos.	Hand tapes 3 m (lockable in pocket)
4 Nos.	Measuring rods(4m)
18 Nos.	Ranging rods with tripods
6 Nos.	Club hammer 2 kg
6 Nos.	Sledge hammer 4 kg
3 Nos.	Survey Umbrellas
3 Nos.	Aluminium Straight Edges,3.0m long
3 Nos.	Aluminium Straight Edges,5.0m long
3 Nos.	Spirit Levels, 30 cm long.
	Sufficient numbers of templates, straightedges, canvas bags, pegs, and other equipment as and when required by Project Manager

The contractor shall make available required numbers of helpers as and when required by the Project Manager Representative. After completion of the project all the equipment will be property of the Employer.

The equipment shall be maintained by the Contractor and kept in good working order and correct adjustment during the period of the Contract.

All equipment shall be suitable for working in metric units.

The Contractor shall make suitable replacement as directed by the Project Manager in case of any loss or damage to the equipment provide by Contractor under this Clause. No

extra payment shall be made for such replacements that shall be deemed to be covered under maintenance of Survey Equipments.

Upon completion of the Contract or at such time as it is no longer required by the Project Manager for the Works the surveying equipment provided under this Clause shall remain the property of the Employer.

Separate payment will not be made for complying with the requirements of this Sub-Clause unless included in the Bill of Quantities as such.

1-1.32 Assistance to Project Manager

1-1.32.1 Provision of Labour

The Contractor shall provide at all times during the period of the Contract, for the exclusive use of the Project Manager, such sub professional staff / labour, either continuously or from time to time, as may be required by the Project Manager in carrying out his duties in connection with the Contract, namely:

(i) ACAD Draftsman;
(ii) Quantity Surveyor;
(iii) Lab Technicians for carrying out tests as embankment cum concrete Laboratory Assistance.
(iv) Labour;

- as watchmen over the Project Site Office and equipment.
- In checking the setting out
- In measuring the works
- In carrying out text

Payment for provision of labour / manpower for Assistance to Project Manager will be made at the applicable rate per month tendered in the priced Bill of Quantities.

1-1.33 Contractor's Duty Staff

At least one responsible senior representative of the Contractor shall be immediately available at all times and he shall be on the Site during normal working hours. The representative shall be reasonably proficient in English as required in relevant Clauses of the Special Conditions of Contract. To such representative shall be delegated full authority to confer with the Project Manager's Representative or his deputy and to take all steps and to issue all those instructions which may be required in an emergency to ensure the safety of all personnel of the Works and of all the Employer's and other property on the Site and in the immediate vicinity thereof.

The Project Manager may from time to time at his discretion after taking into consideration all the prevailing conditions allow some relaxation of this Clause but such relaxation shall be made only with the Project Manager's written permission and subject to any special conditions which the Project Manager may then require.

Separate payment will not be made for complying with the requirements of this Sub-Clause unless included in the Bill of Quantities as such.

1-1.34 Photographic Records

1-1.34.1 Colour Photographs & Slides

The Contractor shall procure a digital camera approved by the Project Managers to take colour progress photographs and slides under the direction of the Project Manager of the works before during and after construction viewed form the same position. The number of photographs taken each month for the Project Manager's selection shall not be less than 36.

The Contractor shall provide the Project Manager, within seven (7) days of the following month proof copies of the photographs taken which shall be 120mm by 90mm in size, together with the colour negatives.

The date the photograph was taken, the description and the negative number shall be recorded on the reverse side of each print.

After selection by the Project Manager, one copy of each of the photographs selected shall be supplied to the Project Manager together with their negatives in an approved album provided by the Contractor.

In addition, during the construction of the Works, the Contractor shall provide the Project Manager with colour photographs for record purposes taken under the direction of the Project Manager. These record photographs shall be supplied as two (2) prints, each not less than 290mm by 200mm in size together with the colour negative. The reverse of each print shall be inscribed with the signatures of the Contractor and Project Manager, or their authorized representatives for the purposes of attestation and will be retained by the Employer. Additional prints similarly attested may be retained by the Contractor. The date, caption, description and negative number shall also be recorded on the reverse side of each print. Negatives and prints shall not be retouched. The copyright of all photographs shall belong to the Employer.

1-1.34.2 Video Film

(a) The Contractor shall produce an edited and narrated video film in colour of not less than 90 minutes duration, showing all the major phases in the construction of the Project. The film shall be edited by a specialist experienced in the production of documentary video films. On completion of the project, two sets of the so completed video films shall be provided to the Employer and one to the Project Manager. Also video compact disc shall be provided to the Employer.

(b) The Contractor shall within thirty (30) days of the Project Manager's written order to commence work, submit for approval the name of the specialist proposed to carry out the work and details of his previous experience.

(c) The copyright of the video-film shall belong to the Employer.

1-1.34.3 Payment

No separate payment will be made for the color photographs and Video film as these will be basically the part of progress reports.

1-1.35 Provisional Sum

Each provisional sum shall only be used in whole or in part in accordance with the Project Manager's instructions and the contract price shall be adjusted accordingly. The total sum paid to the contractor shall include only such amounts, for the work, supplies or services to which the Provisional sum relates as the Project Manager shall have instructed. For each Provisional Sum the Project Manger may instruct:

a. Work to be executed (including Plant, Materials or services to be supplied by the Contractors, and / or
b. Plant, Materials or services ot be purchased by the contractor, from a sub-contractor or other wise and for which these shall be included in the contract price.
c. The actual amount paid or due to be paid by the contractor, and
d. A sum of overhead charges and profit, calculated as a percentage of these actual amounts by applying the relevant percentage rate (if any) stated in the appropriate schedule. If there is no such rate, the percentage rate shall be applied as 10 percent.

The contractor shall, when required by the Project Manager, produce quotations, invoices, vouchers, and accounts or receipts in substantiation.

1-1.36 Amenities to be preserved

The Contractor shall cause the least possible interference with existing amenities whether natural or man-made. No trees shall be felled except on the instructions of the Project Manager, and clearance of the Site shall be kept to the minimum necessary in the Work and Temporary Works.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTION

Not Used

PART 4 MEASUREMENT AND PAYMENT

1-4.1 Performance Security

1-4.1.1 Payment

No payment shall be made for the cost of Performance Security acceptably provided according to the Conditions of Contract.

1-4.2 Insurances

1-4.2.1 Measurement

The costs of providing and maintaining the insurances in accordance with the Conditions of Contract will be reimbursed by the Employer. Provisional sum has been allocated in BoQs for this purpose.

1-4.2.2 Payment

Payment for cost of Insurances will be made on provisional sum basis. The payment shall include all costs of complying with the requirements of the Conditions of Contract. The Employer shall not pay any additional amount for contractor's compliance with the related requirements of Conditions of Contract.

1-4.3 Mobilization and Demobilization

The Employer shall not pay any amount on account of Contractor's Mobilization and Demobilization. The costs of mobilization and demobilization shall be deemed to be included in the related items of the Bill of Quantities.

1-4.4 Residential cum Office Accommodation and Laboratory Buildings

Measurement for payment for the provision / construction of Residential cum Office Accommodation for Project Manager' staff in accordance with the specifications shall be made on provisional sum basis if shown in BoQs.

Measurement for payment for the provision of furnishing and equipment for Residential cum Office Accommodation for Project Manager's staff in accordance with Appendix 1-1 of the specifications shall be made on provisional sum basis.

Measurement for payment for the Provision of utilities, service, repairs and maintenance costs for the Residential cum Office Accommodation for Project Manager's staff in accordance with Appendix 1-1 of the specifications shall be made on provisional sum basis.

Measurement for payment for providing of messing facilities for the staff of Project Manager shall be made on provisional sum basis.

Measurement for payment for the provision of Lab Equipment and Furniture & Fixtures in accordance with Appendix 1-2 of the specifications shall be made on provisional sum basis.

Measurement for payment for maintenance of Testing Laboratory and Lab Equipment in accordance with the specifications shall be made on provisional sum basis.

1-4.5 Provide, Maintain and Operate Transport for Project Manager's Staff

Measurement for payment for provisions of vehicles and motorcycles for Project Manager's staff shall be on a monthly hire charge basis as approved by the Project Manager. The monthly rates shall be deemed to include for each vehicle the fixed costs, depreciation, comprehensive insurance, licenses and the provision of full time competent drivers.

Measurement for payment for operation and maintenance of vehicles and motorcycles for Project Manager's staff will be made at the monthly rates as approved by the Project Manager, which shall include the cost of fuel and oil, road tax, maintenance cost, repair and service charges and all other related costs.

1-4.6 Operatives for Project Manager

Measurement and payment for assistance (Lab Technician) to the Project Manager shall be made on monthly basis as approved by the Project Manager. The Contractor shall provide the assistance when required by the Project Manager. Provisional Sum has been allocated in BoQs Item A2 for this purpose.

1-4.7 Photographic Records

No separate payment will be made for the color photographs/ video as these will be basically the part of progress reports.

Appendix 1-1

PROJECT MANAGER OFFICE CUM ACCOMODATION

ITEM NR.	ITEM	NUMBERS REQUIRED
1.	Table	
1.1	1500 L x 915W x 750 H, Double pedestal with wooden work top & 6 mm glass and three lockable drawers.	1 Nr.
1.2	1200L x 914W x 750H, Single Pedestal with three lockable drawers.	8 Nr.
2.	Chairs:	
2.1	Executive swivel chair with 5 prong legs 660W x 450D x 500H.	1 Nr.
2.2	Upholstered armchairs with 5 prong legs.	8 Nr.
2.3	Guest Chairs	16 Nr.
2.4	Settee set (3+2+1 with coffee and side table)	1 Set
3.	Steel Cabinets:	
3.1	4 drawers file.	12 Nr.
4.	Notice / Display Boards	
4.1	Pin boards (1200 x 2400)	2 Nr.
4.2	White magnetic boards (1200 x 2400)	1 Nr.
5.	Glass fronted bookcase 1200L x 900H x 300W-	1 Nr.
6.	Waste paper basket	12 Nr.
7.	Hole Punchers:	
7.1	Heavy duty hole puncher	1 Nr.
7.2	Office hole puncher	9 Nr.
8.	Stapler:	
8.1	Heavy duty stapler	1Nr.
8.2	Office Stapler	9 Nrs.
9.	First Aid Kit	2
10.	Kitchen Requirements	
10.1	Electric Kettle	3 Nr.
10.2	Tea Set for 18 persons	1 Nr.
10.3	Refrigerator (large)	1 Nr.
11.	Digital camera (high resolution with 64GB memory card)	1 Nr.
12.	Air-Conditioners	5 Nr.
	ACCOMMODATION	
1	Beds (4' x 6') with Side Tables	9 Nr
2	Almirah (4' x 6')	9 Nr
3	Fans	9 Nrs
4	Air Conditioner	5 Nr
6	Guests Chairs	12 No

7	Centre Table	5 Nr

CONSUMABLE STORES FOR PROJECT MANAGER'S STAFF RESIDENTIAL CUM OFFICE ACCOMMODATION

Provide each of the offices with an adequate supply of all necessary consumable stores, as requested by the Project Manager, including the items scheduled here.

- Office Stationery and consumables
- Soap, toilet rolls and hand towels
- Washing-up liquid, dish cloth
- Torchlights and batteries
- Replacements for first aid boxes
- Toilet brushes, brooms, mop
- Polythene bags 760 mm x 510 mm
- Refill for Stapler

List of Protection Clothing to be provided and to be replaced when damaged

- 15 nos. safety helmets
- 15 pairs Safety boots

Appendix 1-2

TESTING LABORATORY
FURNITURE AND EQUIPMENTS

Furniture		
ITEM NR.	**ITEM**	**NUMBERS REQUIRED**
1.	Steel desk (1200L x 914W x 750H with lockable drawers)	5 Nr.
2.	Swivel type padded desk chairs	5 Nr.
3.	Work tables	7 Nr.
5.	Chairs	6 Nr.
6.	Stool	6 Nr.
7.	Timber bench 3m x 0.6m	4 Nr.
8.	4 drawers file steel cabinets	7 Nr.
10.	Pin boards (1200 x 2400)	2 Nr.
11.	Dustbin	6 Nr.
12.	Wheel-barrow	2 Nr.
13.	Electric table fan	5 Nr.
14.	Wash Basin	4 Nr.
15.	Electronic calculators	6Nr.
16.	Air conditioners (cooling and heating)	3 Nr.
17.	Electric water coolers	1 Nr.
18.	Desk lamps, fluorescent, 20 watts	5 Nr.
19.	Standard size staplers	3 Nr.
20.	Heavy duty stapler	1 Nr.
21.	Paper cutters	2 Nr.
22.	Paper hole punches	2 Nr.
23.	Pencil sharpeners	2 Nr.
24.	Fire extinguishers	4 Nr.

LABORATORY APPRATUS / EQUIPMENT			
EQUIPMENT DESCRIPTION	**SOIL TEST / MODEL NO.**	**UNIT**	**QUANTITY**
Laboratory oven, capacity 240 liter	L-158	Each	1
Laboratory oven, capacity 50 liter	L-6	Each	1
Hot plate, maximum temperature 350 ^{o}C	L-236	Each	1
Gas burner, two flames	-	Each	1
Bunsen burner with tripod	LT-105	Each	1

Heavy duty straight spring scale	LT-911	Each	1
Heavy duty balance, 20 kg	L-500	Each	1
Triple beam balance, 2,610 grams	L-415	Each	2
Triple beam balance, 311 grams	L-817	Each	1
Platform balance 115 kg	L-855M	Each	1
Electronic precision balance	L-600	Each	1
Wall clock	-	Each	1
Stop watch	LT-475	Each	1
Vernier caliper	LT-100	Each	1
Thermometer, general, 0 ^{o}c – 200 ^{o}c	G-201A	Each	2
Maximum – minimum thermometer	W-27	Each	1
Sampling tools, complete set	-	Each	1
Tongs	G-120	Each	2
Desicator	G-61	Each	1
Beaker, pyrex, 250 ml	G-5	Each	2
Beaker, pyrex, 600 ml	G-8	Each	2
Beaker, pyrex, 1,000 ml	G-9	Each	2
Funnel, 250 ml	-	Each	2
Funnel, 500 ml	-	Each	2
Volumetric flask, 100 ml	G-40	Each	2
Volumetric flask with stopper, 250 ml	G-26	Each	2
Volumetric flask with stopper, 500 ml	G-27	Each	2
Volumetric bottle flask, 250 ml	G-41	Each	2
Volumetric bottle flask, 500 ml	G-42	Each	2
Wash bottle, 100 ml	-	Each	2
Wash bottle, 250 ml	-	Each	2
Wash bottle, 500 ml	-	Each	2
Specific gravity bottles	G-341	Each	1
Graduated cylinder, 100 ml	G-18	Each	2
Graduated cylinder, 250 ml	G-19	Each	2
Graduated cylinder, 1,000 ml	G-21	Each	2
Reagent bottle stoppered, 2 litre	-	Each	2
Aluminum cans with cover, 2” diameter	LT-20	L.S.	As required
Aluminum cans with cover, 3” diameter	LT-30	L.S.	As required
Scoop	CN-502	Each	2
Brush, fine	-	Each	1
Wire brush, coarse	CL-316	Each	1
Wire brush, fine	CL-315	Each	1

Bucket, 12 litre	-	Each	2
Trolley	-	Each	1
Shovel, large	DR-26	Each	1
Pickaxe	-	Each	1
Sample splitter, coarse	CL-287	Each	1
Sample splitter, fine	CL-280	Each	1
Sieve shaker for 8” diameter sieve, motorized	CL-305	Each	1
Sieve shaker for 12” / 18” diameter sieve, motorized	CL-309	Each	1
Tine pan / tray, 12” x 12” x 2”	[Local make]	Each	4
Tine pan / tray, 16” x 16” x 3”	[Local make]	Each	4
Tine pan / tray, 24” x 16” x 3”	[Local make]	Each	4
Tine pan / tray, 20” x 16” x 4”	[Local make]	Each	4
Mortar porcelain, 200 mm diameter with rubber covered pestle	CL-281	Each	1
COARSE AND FINE AGGREGATES SIEVE ANALYSIS			
Sieve set 8” diameter:			
3/4 inch	CBC-8075	Each	3
1/2 inch	CBC-8050	Each	2
3/8 inch	CBC-8037	Each	2
No. 4 (4.74 mm)	CB-84	Each	2
No. 8 (2.36 mm)	CB-88	Each	2
No. 10 (2.00 mm)	CB-810	Each	3
No. 16 (1.18 mm)	CB-816	Each	2
No. 30 (0.60 mm)	CB-830	Each	2
No. 40 (0.425 mm)	CB-840	Each	3
No. 50 (0.300 mm)	CB-850	Each	2
No. 80 (0.180 mm)	CB-880	Each	1
No. 100 (0.150 mm)	CB-8100	Each	2
No. 200 (0.075 mm)	CB-8200	Each	3
Wet washing No. 200	CL-385	Each	3
Sieve set 12” diameter:			
3 inch (75 mm)	CW-18300	Each	2
2 1/2 inch (63 mm)	CW-18250	Each	2
2 inch (50 mm)	CW-18200	Each	2
1 1/2 inch (38 mm)	CW-18150	Each	2
1 inch (25 mm)	CW-18100	Each	2
3/4 inch (19 mm)	CW-18075	Each	2
1/2 inch (12.5 mm)	CW-18050	Each	2

3/8 inch (9.5 mm)	CW-18037	Each	2
No. 4 (4.74 mm)	CW-184	Each	2
Sieve set 18" diameter:			
3 inch (75 mm)	CW-18300	Each	2
2 1/2 inch (63 mm)	CW-18250	Each	2
2 inch (50 mm)	CW-18200	Each	2
1 1/2 inch (38 mm)	CW-18150	Each	2
1 inch (25 mm)	CW-18100	Each	2
3/4 inch (19 mm)	CW-18075	Each	2
1/2 inch (12.5 mm)	CW-18050	Each	2
3/8 inch (9.5 mm)	CW-18037	Each	2
No. 4 (4.75 mm)	CW-184	Each	2
Pan	CW-8500	Each	2
Cover	CW-8506	Each	2
ATTERBERG LIMITS			
Liquid limit test set with all accessories	CL-209	Each	1
Plastic limit test set with all accessories	CL-251	Each	1
HYDROMETER ANALYSIS			
Mechanical stirrer, 10,000 revolution per minute	CL-272A	Each	1
Dispersion cup	CL-274	Each	1
Mixing paddle	CL-275	Each	1
Hydrometer jar bath	CL-268	Each	1
Hydrometer jar	CL-271	Each	6
Hydrometer, 0.995 – 1.038	CL-277A	Each	1
Hydrometer, 1.000 – 1.050	CL-270A	Each	1
Dispersion agent, sodium hexa-meta-phosphate	CL-288A	L.S.	As required
SAND EQUIVALENT			
Apparatus complete	CL-230	Set	1
COARSE AND FINE AGGREGATE UNIT WEIGHT			
Density basket, brass	G-340	Each	1
Sand absorption cone and tamper	G-325	Each	1
Pycnometers	G-335	Each	2
Specific gravity bottle	G-341	Each	1
Specific gravity bottle	G-342	Each	1
Specific gravity bottle	G-343	Each	1
ABRASION			
Los Angeles abrasion machine with	M-600	Each	1

abrasion charges set			
COARSE AND FINE AGGREGATE SOUNDNESS			
Distilled water	-	L.S.	As required
Sodium Sulphate solution	-	L.S.	As required
ORGANIC MATTER IMPURITIES			
Graduated testing bottle	CT-96	Each	4
Colour standards	CT-97	Each	1
Burette	-	Each	2
Pipette	G-33	Each	2
Chemicals	CT-34	kg	As required
Chemicals	CT-98	kg	As required
MODIFIED COMPACTION			
Straight edge	CN-838	Each	1
Scoop	CN-502	Each	1
Scoop	CN-502A	Each	1
Mixing spoons	CN-995	Each	1
Sample ejector	CN-803	Each	1
Modified compaction hammer, 10 lbs	CN-416	Each	2
Modified compaction mould, 6” diameter	CN-404	Each	2
Modified compaction mould, 4” diameter	CN-405	Each	2
Preparation knife	P-89	Each	1
Wooden hammer	-	Each	1
Spatula	P-85	Each	1
Mixing tray, 24” x 24” x 3”	-	Each	As required
FIELD DENSITY			
Sand cone bottle	CN-992	Each	2
Density plate	CN-994	Each	2
Plastic jug for sand	-	Each	2
Replacement jug	CN-1003	Each	2
Spoon	CN-995	Each	2
Plastic bags	-	Each	As required
Chisel, 12”	CN-998	L.S.	2
Hammer, 2.5 lbs	-	Each	2
Field balance	L-770B	Each	2
Sieve No. 30 (0.60 mm)	CB-830	Each	2
BITUMEN			
Say bolt viscometer	AP-110	Set	-
Bacon sampler	AP-256	Each	-

Bitumen penetration test, penetrometer	AP-140	Set	1
Cleveland flash point tester	AP-243	Set	-
CONCRETE AND CEMENT			
Compressive strength machine, heavy duty, 250,000 lbs	CT-755		1
Pipe and cable locator	R-210	Each	1
Steel scale	-	Each	2
Curing tank with temperature control	-	Each	1
Cement mould brush	CT-68B	Each	2
Concrete vibrator	CT-106	Each	1
Concrete tray	CT-58	Each	As required
Air meter complete	-	Set	1
Cylinder mould, heavy duty, 6" diameter	CT-35	Each	9
Cylinder capping apparatus	CT-53	Each	1
Concrete capping compound	-	Kg	As required
Laboratory warming pot	L-114	Each	1
Slump test cone	CT-69	Set	2
Tamper	CT-22	Each	1
Vibrating table	CT-164	Each	1
Concrete micrometer	CT-29	Each	1
Schmidt concrete test hammer	CT-320	Each	1
Vicat apparatus set	CT-1	Set	1
Steel straight edge	-	Each	2
Hand gloves, rubber	-	Pair	As required
Trowel triangular blade	CT-67	Each	2
Cement cube mould	CT-60	Each	2

CONSUMABLE STORES FOR TESTING LABORATORY

Provide the testing laboratory with adequate consumable stores necessary for material testing to be carried out during the construction period and any extended period thereof including the items scheduled here:

- Office stationery and consumables
- Filter paper No. 5.11 cm
- Dry natural sand all passing 600 µm and retained 300 µm supplied in 50 kg bags in 1000 kg lots.

- 30 litres drums with taps for clean Methylene Chloride
- Trichloroethylene in 46 gals. lots (each drum contains 46 gals.)
- Polythene bags 760 mm x 510 mm
- First Aid boxes

CHAPTER 2 - QUALITY CONTROL

PART 1 GENERAL

2-1.1 Scope

The Contractor shall institute a Quality Assurance System to demonstrate compliance with the requirement of the Contract. The requirements of this Section of the Specifications apply to, and are a component part of, each section of the Specifications.

2-1.2 References

The publications listed below form a part of this Specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM*)*	
• ASTM D 3740	• (2001) Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
• ASTM E 329	• (2002) Agencies Engaged in the Testing and/or Inspection of Materials Used in Construction
U.S. ARMY CORPS OF ENGINEERS (USACE)	
• ER 1110-1-12	• (1993) Quality Management

2-1.3 Submittals

The followings shall be submitted for Project Manager's review and approval in accordance with **Clause 1-1.4 - Submittal Procedures** and in sufficient detail to show full compliance with the Specification:

SD-01 Preconstruction Submittals

Contractor's Quality Assurance Plan

SD-06 Test Reports

Contractor shall submit the following items in accordance with the **Sub-Clause 2-1.6 – Records**, of this section:

- Quality Control Data
- Quality Control Coordinating Actions
- Quality Control Training
- Inspection Records
- Letters of Authority or Delegation
- Field Tests
- Factory Tests

SD-07 Certificates

a. Contractor shall submit a detailed written statement describing procedures that will be implemented to achieve quality on the project according to the **Sub-Clause 2-1.5.1- Quality Assurance (QA) Plan** of this Section.

b. Contractor shall submit the following in accordance with the **Sub-Clause 2-1.7.1- Qualifications of this Section**:

(i) Contractor's Quality Representative Qualifications

(ii) Special Certifications

2-1.4 General Requirements

The Contractor is responsible for quality control and shall establish and maintain an effective quality control system in compliance with the Conditions of Contract **Clause 32 - 36 Quality Control**. The quality control system shall consist of plans, procedures, and organization necessary to produce an end product which complies with the contract requirements. The system shall cover all construction, design and construction operations, both onsite and offsite, and shall be keyed to the proposed construction sequence. The Contractor's site project superintendent (Engineer) will be held responsible for the quality of work on the job and is subject to removal by the Project Manager for non-compliance with the quality requirements specified in the Contract. The site project superintendent in this context shall be the highest level manager responsible for the overall construction activities at the site, including quality and production. The site project superintendent shall maintain a physical presence at the site at all times, except as otherwise acceptable to the Project Manager, and shall be responsible for all construction and construction related activities at the site.

2-1.5 Quality Control Plan

The Contractor shall furnish for review by the Project Manager, not later than 60 days after receipt of notice to proceed, the Contractor's Quality Assurance (QA) Plan and a Design Quality control (DQC) Plan proposed to implement the requirements of the **Conditions of Contract Clause 32 to 36**.

The QA plan shall identify personnel, procedures, control, instructions, tests, records, and forms to be used. The Employer will consider an interim plan for the first 90 days of operation. Design and construction will be permitted to begin only after acceptance of the QA Plan and DQC Plan or acceptance of interim plans applicable to the particular feature of work to be started. Work outside of the features of work included in an accepted interim plan will not be permitted to begin until acceptance of a QA Plan and or DQC plan other interim plan containing the additional features of work to be started.

2-1.5.1 Quality Assurance (QA) Plan

The QA plan shall address the following:

(a) Description of the authority, responsibilities and coordinating procedures, of on-site/off-site quality assurance personnel, including those QA personnel not under direct control of the Contractor.

(b) Plan shall list personnel designated by the Contractor to accomplish the work required by the contract.

(c) QA plan shall also contain an appendix with a copy of each form, report format, or similar record to be used in the QA program.

(d) Contractor's organization that handles construction contract activities.

(e) Contractor's operational plan for accomplishing and reviewing work controls, fabrication controls, certifications, and documentation of quality control operations, inspections, and test records, including those for subcontractors. These provisions shall include the methods to be used during the procurement cycle (order to delivery) for those materials or equipment that require source inspections, shop fabrications, or similar operations located separately from the work site.

(f) Description of on-site personnel training.

(g) Certification(s) of personnel, procedures, processes, and equipment.

(h) Nondestructive testing requirements.

(i) Identification of independent certifying and testing laboratories.

2-1.5.2 Design Quality Control (DQC) Plan

The following requirements apply to the Design Quality Control (DQC) plan for the works, which are to be designed by the Contractor.

(a) The Contractor's shall maintain a Design Quality Control (DQC) Plan as an effective quality control program which will assure that all services required by this Contract are performed and provided in a manner that meets professional engineering quality standards. The Contractor shall correct errors and deficiencies in the design documents prior to submitting them to the Project Manager for review and approval.

(b) The Contractor shall include the design schedule in the master project schedule, showing the sequence of events involved in carrying out the project design tasks within the specific contract period. This should be at a detailed level of scheduling sufficient to identify all major design tasks, including those that control the flow of work. The schedule shall include review and correction periods associated with each item. This should be a forward planning as well as a project monitoring tool. If the schedule is changed, the Contractor shall submit a revised schedule reflecting the change within 7 calendar days. The Contractor shall include in the DQC Plan the discipline-specific checklists to be used during the design and quality control of each submittal. These completed checklists shall be submitted at each design phase as part of the project documentation.

(c) The DQC Plan shall be implemented by a Design Quality Control Manager who has the responsibility of being cognizant of and assuring that all documents on the project have been coordinated. This individual shall be a person who has verifiable engineering design experience and is a registered professional engineer. The

Contractor shall notify the Project Manager, in writing, of the name of the individual, and the name of an alternate person assigned to the position.

The Project Manager will notify the Contractor in writing of the acceptance of the DQC Plan. After acceptance, any changes proposed by the Contractor are subject to the acceptance of the Project Manager.

2-1.6 Records

Records shall include all quality control data; factory tests or manufacturer's certifications, quality control coordinating actions; records of quality control training/certifications as well as routine hydrostatic, electrical continuity, grounding, welding, line cleaning, field tests and similar tests. Quality records shall be available for examination by the Project Manager.

Legible copies of the test and inspection records shall be furnished to the Project Manager. Records shall cover work placement traceable to the contract schedule, Specifications and drawings, and shall be verified by the Contractor.

Contractor shall submit for approval, the narrative description of an inspection system which provides for compliance with the quality requirements and technical criteria of the Contract within 30 calendar days after notice to proceed.

Contractor shall submit a monthly performance report that summarizes the quality operations. This report shall identify inspections made, tests performed, non-conformances, corrective actions taken, status of plans/procedures being developed, and status of open items/problems in work.

Contractor shall submit Letters of Authority or Delegation outlining the authority and responsibilities of quality control personnel along with a copy of the letter of delegation to the Project Manager that defines delegated duties and responsibilities.

In-process inspection records and control away from the job site may be used as evidence of quality of materials/work and may reduce further inspection or testing after delivery to the job site.

2-1.7 Quality Assurance

2-1.7.1 Qualifications

Contractor's Quality Representative’s qualifications shall be submitted to the Project Manager for approval.

When approval or certification of special processes, operating personnel, and special equipment or procedures is required by the Specifications, the Contractor shall obtain necessary approvals or special certifications prior to starting the work.

2-1.7.2 Quality Control Requirements

Contractor shall provide a quality control program encompassing: selection of construction materials and sources; suppliers; subcontractors; on-site and off-site fabrication of Contractor-furnished assemblies; on-site and off-site assembly; erection; work procedures; workmanship; inspection; and testing.

Contractor's program shall provide document systems ensuring that quality provisions of contract schedule, Specifications, and drawings have been performed.

(a) Management and Organization

Contractor shall designate an individual as Quality Program Manager within the on-site organization whose sole responsibility shall be the day-to-day on-site management and direction of the Quality Program.

The Quality Program Manager shall report to the Contractor's management and shall have the necessary authority to discharge contractual responsibilities.

(b) CQC Personnel

The Contractor shall also provide specialized personnel to assist the Quality Program Manager for the following areas: civil, structural, electrical, mechanical, environmental, materials technician, engineering geology, submittals clerk. These individuals may be employees of the Contractor or Subcontractor; be responsible to the Quality Programme Manager; be physically present at the construction site during work on their areas of responsibility; have the necessary education and/or experience in accordance with the experience matrix listed herein. These individuals may perform other duties but must be allowed sufficient time to perform their assigned quality control duties as described in the Quality Control Plan.

Experience Matrix

	Area	**Qualifications**
•	Civil	Graduate Civil Engineer with 5 years' experience in the type of work being performed on this project or technician with 10 yrs related experience
•	Structural	Graduate Structural Engineer with 5 yrs experience or person with 5 yrs related experience
•	Mechanical	Graduate Mechanical Engineer with 2 yrs experience or person with 5 yrs related experience
•	Electrical	Graduate Electrical Engineer with 2 yrs related experience or person with 5 yrs related experience
•	Engineering Geologist	Graduate Engineering Geologist with 2 yrs experience or person with 5 yrs related experience
•	Environmental	Graduate Environmental Engineer with 3 yrs experience

•	Concrete, Pavements and Soils	Materials Technician with 10 yrs experience for the appropriate area
•	Design Quality Control Manager	Registered Professional Engineer
•	Submittals	Submittal Clerk with 1 yr experience

(c) Identification and Data Retrieval

Contractor shall have an identification and data retrieval system.

Referencing the Contract Number; Contract Specification Number; Contract Drawing Number; Submittal Document Number; Contract Change Number; and the Contractor's Drawing Number System shall identify records, drawings, submittals, and equipment.

(d) Procurement

Contractor shall be responsible for controlling procurement sources and those of his subcontractors to ensure that each purchase meets quality requirements.

(e) Receiving Inspection System

Contractor shall maintain a site receiving inspection system that ensures procured materials and equipment are inspected and tested.

Receiving inspection records shall accompany each procurement delivery to the construction site. Records of site receiving inspections shall be maintained by the Contractor.

Records shall show defects, discrepancies, dispositions, and waivers.

(f) Nonconforming Articles and Material Control

The Contractor shall control non-conformances discovered by the Contractor, subcontractors, suppliers or Project Manager quality representatives to prevent their use and to correct deficient operations.

(i) Contractor shall prepare a "non-conformance" report for each instance comprising:

(1) A unique and traceable number.

(2) Identification of the non-conforming article or material.

(3) A description of the non-conformance and the applicable requirement.

(4) Cause or reason for the non-conformance.

(5) Remedial actions taken or recommended.

(6) Disposition of the nonconforming article or material.

(ii) The Contractor shall identify and mark each nonconforming article for removal from the work area.

(iii) The Contractor shall monitor and correct deficient operations.

(g) Fabrication Process and Work Control

Contractor's procedures and controls shall ensure compliance with requirements in contract Specifications and drawings.

Contractor shall establish in-process inspections, to ensure compliance with quality requirements.

Special processes may include, but are not limited to, plating, anodizing, nondestructive testing, welding, and soldering.

(h) Quality Control Records

Quality control records shall be maintained at a central on-site location. Maintenance of quality control records shall not relieve the Contractor from submitting samples, test data, detail drawings, material certificates, or other information required by each section in the specification.

Contractor shall ensure each record is identified and traceable to specific requirements in the Specifications and drawings.

(i) Drawings and Change Control

Drawing-control system shall be maintained to provide revised drawings and ensure continuous removal of obsolete drawings from work areas. Changes involving interface with other work areas, or affecting materials controlled by others shall be controlled by the Contractor. This system shall be integrated with the document requirements of the contract.

Drawing changes shall be clearly annotated. Implemented changes shall be clearly identified and associated drawings shall be revised accordingly. Drawings that have been approved, or approved as noted, by the Project Manager shall be used for fabrication and inspection.

2-1.7.3 Quality Inspections

(a) Project Manager’s Inspections

Work performed under this Contract will be subject to inspection by the Project Manager.

When the Project Manager determines that inspected work needs to be corrected, the Project Manager will be allowed 24 hours to complete re-inspection of the corrected work.

The Project Manager shall also be notified in writing before backfilling or encasing any utility so that work may be inspected. Failure to notify the Project Manager before

backfilling or encasement occurs shall require the work be uncovered at no additional cost to the Employer.

Contractor's program is subject to continuous evaluation, review, and verification by the Project Manager. Contractor will be notified in writing of any noncompliance and will be given 15 calendar days to correct identified deficiencies.

(b) Contractor's Quality Inspections

The contractor shall implement an inspection system. Documentation shall indicate quality control through records of inspections, tests, and procedures.

Contractor's quality assurance system shall include the following:

(i) Single Contractor's representative responsible for on-site communication and operation of the inspection program.

(ii) Purchasing control system documenting project procurement to drawings, Specifications, and approved submittals.

(iii) Receiving inspection system documenting inspections for each procurement.

(iv) Documentation for handling and disposing of nonconforming components and materials.

(v) Inspection records for each specific section of the Specification and drawings.

(vi) Identification of test(s) to be performed, test procedures, records, and independent organizations used.

(vii) Documenting and maintaining certification or re-certification of procedures.

(viii) Calibration of gages, tools, measuring instruments, and independent laboratories used.

The contractor shall establish a system of scheduled or random audits to ensure task completion.

2-1.7.4 Field Services

(a) Responsibility for Inspection and Testing

The contractor shall be responsible for all inspections and tests, and the accompanying documentation for each inspection and test. Contractor shall establish his own laboratory at site or may utilize independent inspection and testing laboratories or services as approved by the Project Manager. Contractor shall also be responsible for tests of construction materials utilizing the services of an approved independent testing laboratory.

(b) Inspection and Test Records

The Contractor shall provide on-site records of each inspection and test performed throughout the life of the contract. Records shall include, but not be limited to, factual evidence that the required inspections or tests have been performed, including type and number of inspections or tests involved, identification of operators and inspectors, result of

inspections or tests, nature of defects, causes for rejection, proposed remedial action, and corrective actions taken.

Inspection records, test procedures, test results, and associated forms be verified by and provided to the Project Manager. Final test data shall have a cover letter/sheet clearly marked with the system name, date, and the words "Final Test Data".

2-1.8 Handling and Storage

The Contractor shall provide controls, procedures and documentation with each shipment that meets requirements of each section of the Specifications.

The Contractor shall include documentation with each shipment. The data shall consist of documentation required by the Contract along with Specifications required to identify, store, preserve, operate, and maintain the items shipped.

2-1.9 Sequencing and Scheduling

The Contractor shall notify the Project Manager at least 24 hours prior to scheduled inspections and tests.

Contractor shall provide 24 hour notice to the Project Manager of the date when any contract work will begin at the site. When Contractor suspends work for 7 calendar days or longer prior to completion; the Project Manager shall be notified. Work shall not resume without notification of the Project Manager.

The Project Manager shall be notified at least 24 hours in advance of backfilling or encasing any underground utility.

2-1.10 Tests

2-1.10.1 Testing Procedure

The Contractor shall perform specified or required tests to verify that control measures are adequate to provide a product which conforms to contract requirements. Upon request, the Contractor shall furnish to the Project Manager duplicate samples of test specimens for possible testing by the Employer. Testing includes operation and/or acceptance tests when specified. The tests shall be conducted at the project site laboratory or any other laboratory approved by the Project Manager. The Contractor shall perform the following activities and record and provide the following data:

(a) Verify that testing procedures comply with contract requirements.

(b) Verify that facilities and testing equipment are available and comply with testing standards.

(c) Check test instrument calibration data against certified standards.

(d) Verify that recording forms and test identification control number system, including all of the test documentation requirements, have been prepared.

(e) Results of all tests taken, both passing and failing tests, shall be recorded on the CQC report for the date taken. Specification paragraph reference, location where tests were taken, and the sequential control number identifying the test shall be given. If approved by the Project Manager, actual test reports may be submitted later with a reference to the test number and date taken. An information copy of tests performed by an offsite or commercial test facility shall be provided directly to the Project Manager. Failure to submit timely test reports as stated may result in nonpayment for related work performed and disapproval of the test facility for this Contract.

2-1.10.2 Testing Laboratories

(a) Capability Check

The Employer reserves the right to check laboratory equipment in the proposed laboratory for compliance with the standards set forth in the contract Specifications and to check the laboratory technician's testing procedures and techniques. Laboratories utilized for testing soils, concrete, asphalt, and steel shall meet criteria detailed in ASTM D 3740 and ASTM E 329.

(b) Onsite Laboratory

The Employer reserves the right to utilize the Contractor's control testing laboratory and equipment to make assurance tests, and to check the Contractor's testing procedures, techniques, and test results at no additional cost to the Employer.

2-1.10.3 Furnishing or Transportation of Samples for Testing

Costs incidental to the transportation of samples or materials shall be borne by the Contractor. Samples of materials for test verification and acceptance testing by the Employer shall be delivered to the laboratory approved by the Project Manager located in Pakistan.

2-1.11 Completion Inspection

2-1.11.1 Pre-Final Inspection

The Project Manager will perform the pre-final inspection to verify that the project works are complete and ready to be occupied. A Pre-Final Punch List may be developed as a result of this inspection. The Contractor's Quality Program Manager shall ensure that all items on this list have been corrected before notifying the Project Manager, so that a Final inspection with the Employer can be scheduled. Any items noted on the Pre-Final inspection shall be corrected in a timely manner. These inspections and any deficiency corrections required by this paragraph shall be accomplished within the time stated for completion of the entire work or any particular increment of the work if the project is divided into increments by separate completion dates.

2-1.11.2 Final Acceptance Inspection

The Contractor's Quality Control Inspection personnel, plus the superintendent or other primary management person, and the Project Manager's Representative shall be in

attendance at the final acceptance inspection. Additional Employer personnel including, may also be in attendance. The final acceptance inspection will be formally scheduled by the Project Manager based upon results of the Pre-Final inspection. Notice shall be given to the Project Manager at least 14 days prior to the final acceptance inspection and shall include the Contractor's assurance that all specific items previously identified to the Contractor as being unacceptable, along with all remaining work performed under the contract, will be complete and acceptable by the date scheduled for the final acceptance inspection.

2-1.12 Documentation

The Contractor shall maintain current records providing factual evidence that required quality control activities and/or tests have been performed. These records shall include the work of subcontractors and suppliers and shall be on an acceptable form that includes, as a minimum, the following information:

(a) Contractor/subcontractor and their area of responsibility.

(b) Operating plant/equipment with hours worked, idle, or down for repair.

(c) Work performed each day, giving location, description, and by whom. When Network Analysis (NAS) is used, identify each phase of work performed each day by NAS activity number.

(d) Test and/or control activities performed with results and references to Specifications/drawings requirements. The control phase shall be identified (Preparatory, Initial, and Follow-up). List of deficiencies noted, along with corrective action.

(e) Quantity of materials received at the site with statement as to acceptability, storage, and reference to Specifications/drawings requirements.

(f) Submittals and deliverables reviewed, with contract reference, by whom, and action taken.

(g) Offsite surveillance activities, including actions taken.

(h) Job safety evaluations stating what was checked, results, and instructions or corrective actions.

(i) Instructions given/received and conflicts in plans and/or Specifications.

(j) Contractor's verification statement.

These records shall indicate a description of trades working on the project; the number of personnel working; weather conditions encountered; and any delays encountered. These records shall cover both conforming and deficient features and shall include a statement that equipment and materials incorporated in the work and workmanship comply with the contract. The original and one copy of these records in report form shall be furnished to the Project Manager daily within 48 hours after the date covered by the report, except that reports need not be submitted for days on which no work is performed. As a minimum, one report shall be prepared and submitted for every 7 days of no work and on the last day of a no work period. All calendar days shall be accounted for throughout the life of the contract. The first report following a day of no work shall be for that day only. Reports shall

be signed and dated by the Quality Program Manager. The report from the Quality Program Manager shall include copies of test reports and copies of reports prepared by all subordinate quality control personnel.

2-1.13 Notification of Noncompliance

The Project Manager will notify the Contractor of any detected noncompliance with the foregoing requirements. The Contractor shall take immediate corrective action after receipt of such notice. Such not

ice, when delivered to the Contractor at the work site, shall be deemed sufficient for the purpose of notification. If the Contractor fails or refuses to comply promptly, the Project Manager may issue an order stopping all or part of the work until satisfactory corrective action has been taken. No part of the time lost due to such stop orders shall be made the subject of claim for extension of time or for excess costs or damages by the Contractor.

PART 2 PRODUCTS

Not Used

PART 3 EXECUTIONS

Not Used

PART 4 MEASUREMENT AND PAYMENT

2-4.1 Payment

No separate payment will be made for compliance of requirements of this Section. All costs associated with Quality Control are deemed to be covered in the rates tendered for the Bill of Quantities and as such indirectly included in the Contract Price.

CHAPTER 3 - ENVIRONMENTAL AND SOCIAL PROTECTION

PART 1 GENERAL

The World Bank approved ESMP shall be the part of this Specification / Contract Documents for implementation.

The Contractor shall possess environmental and social expertise in the application of World Bank requirements and Pakistani laws and policies related to environmental assessment, protecting labour rights and occupational health and safety.

3-1.1 References

The documents listed below form a part of this specification to the extent refined:

World Bank (OD/OP 04)

Pakistan Land Acquisition Act

The Environmental Protection Agency, Government of Pakistan

The Environment Management Plan of the project is available with the Employer.

3-1.2 Definitions

3-1.2.1 Environmental Pollution and Damage

Environmental pollution and damage is the presence of chemical, physical, or biological elements or agents which adversely affect human health or welfare; unfavorably alter ecological balances of importance to human life; affect other species of importance to humankind; or degrade the environment aesthetically, culturally and/or historically.

3-1.2.2 Environmental Protection

Environmental protection is the prevention/control of pollution and habitat disruption that may occur to the environment during construction. The control of environmental pollution and damage requires consideration of land, water, and air; biological and cultural resources; and includes management of visual aesthetics; noise; solid, chemical, gaseous, and liquid waste; radiant energy and radioactive material as well as other pollutants.

3-1.2.3 Contractor Generated Hazardous Waste

Contractor generated hazardous waste means materials that, if abandoned or disposed of, may meet the definition of a hazardous waste. These waste streams would typically consist of materials brought on site by the Contractor to execute work, but are not fully consumed during the course of construction. Examples include, but are not limited to, excess paint thinners (i.e. methyl ethyl ketone, toluene etc.), waste thinners, excess paints, excess solvents, waste solvents, and excess pesticides, and contaminated pesticide equipment rinse water.

3-1.3 General Requirements

The Contractor shall minimize environmental pollution and damage that may occur as the result of construction operations. The environmental resources within the project boundaries and those affected outside the limits of permanent work shall be protected during the entire duration of this contract. The Contractor shall comply with all applicable environmental laws and regulations of Government. The Contractor shall be responsible for any delays resulting from failure to comply with environmental laws and regulations.

3-1.4 Subcontractors

The Contractor shall ensure compliance with this section by subcontractors.

3-1.5 Submittals

The following shall be submitted in accordance with Sub-Clause 1-1.4 Submittals Procedures:

SD-01 Preconstruction Submittals

Environmental Protection Plan

3-1.6 Environmental Protection Plan

Prior to commencing construction activities or delivery of materials to the site, the Contractor shall submit an Environmental Protection Plan for review and approval by the Project Manager. The purpose of the Environmental Protection Plan is to present a comprehensive overview of known or potential environmental issues which the Contractor must address during construction. Issues of concern shall be defined within the Environmental Protection Plan as outlined in this section. The Contractor shall address each topic at a level of detail commensurate with the environmental issue and required construction task. Topics or issues which are not identified in this section, but which the Contractor considers necessary, shall be identified and discussed after those items formally identified in this section. Prior to submittal of the Environmental Protection Plan, the Contractor shall meet with the Project Manager for the purpose of discussing the implementation of the initial Environmental Protection Plan; possible subsequent additions and revisions to the plan including any reporting requirements; and methods for administration of the Contractor's Environmental Plans. The Environmental Protection Plan shall be current and maintained on site by the Contractor.

3-1.6.1 Compliance

No requirement in this Section shall be construed as relieving the Contractor of any applicable Environmental protection laws and regulations of the Government. During Construction, the Contractor shall be responsible for identifying, implementing, and submitting for approval any additional requirements to be included in the Environmental Protection Plan.

3-1.6.2 Contents

The Environmental Protection Plan shall include, but shall not be limited to, the following:

(a) Name(s) of person(s) within the Contractor's organization who is (are) responsible for ensuring adherence to the Environmental Protection Plan.

(b) Name(s) and qualifications of person(s) responsible for manifesting hazardous waste to be removed from the site, if applicable.

© Name(s) and qualifications of person(s) responsible for training the Contractor's environmental protection personnel.

(d) Description of the Contractor's environmental protection personnel training program.

(e) An erosion and sediment control plan which identifies the type and location of the erosion and sediment controls to be provided. The plan shall include monitoring and reporting requirements to ensure that the control measures are in compliance with the erosion and sediment control plan, laws and regulations of the Government.

(f) Drawings showing locations of proposed temporary excavations or embankments for haul roads, stream crossings, material storage areas, structures, sanitary facilities, and stockpiles of excess or spoil materials including methods to control runoff and to contain materials on the site.

(g) Traffic control plans include measures to reduce erosion of temporary roadbeds by construction traffic, especially during wet weather. Plan shall include measures to minimize the amount of mud transported onto paved public roads by vehicles or runoff.

(h) Work area plan showing the proposed activity in each portion of the area and identifying the areas of limited use or non-use. Plan should include measures for marking the limits of use areas including methods for protection of features to be preserved within authorized work areas.

(i) Drawing showing the location of borrow areas.

(j) The Spill Control Plan shall include the procedures, instructions, and reports to be used in the event of an unforeseen spill of a substance regulated under laws and regulations of the Government. The Spill Control Plan shall include as a minimum:

(1) The name of the individual who will report any spills or releases of hazardous substances and who will follow up with complete documentation. This individual shall immediately notify the Project Manager and the local fire department in addition to the legally required reporting channels if a reportable quantity is released to the environment. The plan shall contain a list of the required reporting channels and telephone numbers.

(2) The name and qualifications of the individual who will be responsible for implementing and supervising the containment and cleanup.

(3) Training requirements for Contractor's personnel and methods of accomplishing the training.

(4) A list of materials and equipment to be immediately available at the job site, tailored to cleanup work of the potential hazard(s) identified.

(5) The names and locations of suppliers of containment materials and locations of additional fuel oil recovery, cleanup, restoration, and material-placement equipment available in case of an unforeseen spill emergency.

(6) The methods and procedures to be used for expeditious contaminant cleanup.

(a) A non-hazardous solid waste disposal plan identifying methods and locations for solid waste disposal including clearing debris. The plan shall include schedules for disposal. The Contractor shall identify any subcontractors responsible for the transportation and disposal of solid waste. Licenses or permits shall be submitted for solid waste disposal sites that are not a commercial operating facility. Evidence of the disposal facility's acceptance of the solid waste shall be attached to this plan during the construction. The Contractor shall attach a copy of each of the Non-hazardous Solid Waste Diversion Reports to the disposal plan. The report shall be submitted on the first working day after the first quarter that non-hazardous solid waste has been disposed and/or diverted and shall be for the previous quarter (e.g. the first working day of January, April, July, and October). The report shall indicate the total amount of waste generated and total amount of waste diverted in cubic meters or tons along with the percent that was diverted.

(b) A recycling and solid waste minimization plan with a list of measures to reduce consumption of energy and natural resources. The plan shall detail the Contractor's actions to comply with and to participate in Government sponsored recycling programs to reduce the volume of solid waste at the source.

(c) An air pollution control plan detailing provisions to ensure that dust, debris, materials, trash, etc., do not become airborne and travel off the project site.

(d) A contaminant prevention plan that: identifies potentially hazardous substances to be used on the job site; identifies the intended actions to prevent introduction of such materials into the air, water, or ground; and details provisions for compliance with Government laws and regulations for storage and handling of these materials. As new hazardous materials are brought on site or removed from the site, the plan shall be updated.

(e) A wastewater management plan that identifies the methods and procedures for management and/or discharge of waste waters which are directly derived from construction activities, such as concrete curing water, clean-up water, dewatering of ground water, disinfections water, hydrostatic test water, and water used in flushing of lines. If a settling/retention pond is required, the plan shall include the design of the pond including drawings, removal plan, and testing requirements for possible pollutants. If land application will be the method of disposal for the wastewater, the plan shall include a sketch showing the location for land application along with a description of the pretreatment methods to be implemented. If surface discharge will be the method of disposal, a copy of the permit and associated documents shall be included as an attachment prior to discharging the wastewater. If disposal is to a sanitary sewer, the plan shall include documentation that the Wastewater Treatment Plant Operator has approved the flow rate, volume, and type of discharge.

(f) A historical, archaeological, cultural resources biological resources and wet lands plan that defines procedures for identifying and protecting historical, archaeological, cultural resources, biological resources and wetlands known to be on the project site: and/or identifies procedures to be followed if historical archaeological, cultural resources, biological resources and wetlands not previously known to be on site or in the area are discovered during construction. The plan shall include methods to assure the protection of known or discovered resources and shall identify lines of communication between Contractor personnel and the Project Manager.

(g) A pesticide treatment plan shall be included and updated, as information becomes available. The plan shall include sequence of treatment, dates, times, locations, pesticide trade name, authorized uses, chemical composition, formulation, original and applied concentration, application rates of active ingredient (i.e. pounds of active ingredient applied), equipment used for application and calibration of equipment. The Contractor is responsible for the Government regulations on pest management record keeping and reporting requirements.

3-1.6.3 Appendix

Copies of all environmental permits permit application packages, approvals to construct, notifications, certifications, reports, and termination documents shall be attached, as an appendix, to the Environmental Protection Plan.

3-1.7 Protection Features

Prior to start of any onsite construction activities, the Contractor and the Project Manager shall make a joint condition survey. Immediately following the survey, the Contractor shall prepare a brief report including a plan describing the features requiring protection under the provisions of the Contract Clauses, which are not specifically identified on the drawings as environmental features requiring protection along with the condition of trees, shrubs and grassed areas immediately adjacent to the site of work and adjacent to the Contractor's assigned storage area and access route(s), as applicable. This survey report shall be signed by both the Contractor and the Project Manager upon mutual agreement as to its accuracy and completeness. The Contractor shall protect those environmental features included in the survey report and any indicated on the drawings, regardless of interference which their preservation may cause to the Contractor's work under the Contract.

3-1.8 Environmental Assessment of Contract Deviations

Any deviations, requested by the Contractor, from the drawings, plans and specifications which may have an environmental impact will be subject to approval by the Project Manager and may require an extended review, processing, and approval time. The Project Manager reserves the right to disapprove alternate methods, even if they are more cost effective, if the Project Manager determines that the proposed alternate method will have an adverse environmental impact.

3-1.9 Notification

The Project Manager will notify the Contractor in writing of any observed noncompliance with the Government environmental laws or regulations, permits, and other elements of the Contractor's Environmental Protection plan. The Contractor shall, after receipt of such notice, inform the Project Manager of the proposed corrective action and take such action when approved by the Project Manager. The Project Manager may issue an order stopping all or part of the work until satisfactory corrective action has been taken. No time extensions shall be granted or equitable adjustments allowed to the Contractor for any such suspensions. This is in addition to any other actions the Project Manager may take under the Contract.

PART 2 PRODUCTS

(NOT USED)

PART 3 EXECUTION

The Contractor shall be responsible for obtaining and complying with all environmental permits and commitments required by the Government environmental laws and regulations.

3-3.2 Land Resources

The Contractor shall confine all activities to areas defined by the drawings and specifications. Prior to the beginning of any construction, the Contractor shall identify any land resources to be preserved within the work area. Except in areas indicated on the drawings or specified to be cleared, the Contractor shall not remove, cut, deface, injure, or destroy land resources including trees, shrubs, vines, grasses, topsoil, and land forms without approval. No ropes, cables, or guys shall be fastened to or attached to any trees for anchorage unless specifically authorized. The Contractor shall provide effective protection for land and vegetation resources at all times as defined in the following Sub-Clauses. Stone, soil, or other materials displaced into uncleared areas shall be removed by the Contractor.

3-3.2.1 Work Area Limits

Prior to commencing construction activities, the Contractor shall mark the areas that need not be disturbed under this contract. Isolated areas within the general work area which are not to be disturbed shall be marked or fenced. Monuments and markers shall be protected before construction operations commence. Where construction operations are to be conducted during darkness, any markers shall be visible in the dark. The Contractor's personnel shall be knowledgeable of the purpose for marking and/or protecting particular objects.

3-3.2.2 Landscape

Trees, shrubs, vines, grasses, land forms and other landscape features indicated and defined on the drawings to be preserved shall be clearly identified by marking, fencing, or wrapping with boards, or any other approved techniques. The Contractor shall restore

landscape features damaged or destroyed during construction operations outside the limits of the approved work area.

3-3.2.3 Erosion and Sediment Controls

The Contractor shall be responsible for providing erosion and sediment control measures in accordance with Government laws and regulations. The erosion and sediment controls selected and maintained by the Contractor shall be such that water quality standards are not violated as a result of the Contractor's construction activities. The area of bare soil exposed at any one time by construction operations should be kept to a minimum. The Contractor shall construct or install temporary and permanent erosion and sediment control best management practices which may include, but not be limited to, vegetation cover, stream bank stabilization, slope stabilization, silt fences, construction of terraces, interceptor channels, sediment traps, inlet and outfall protection, diversion channels, and sedimentation basins. Any temporary measures shall be removed after the area has been stabilized.

3-3.2.4 Contractor Facilities and Work Areas

The Contractor's field offices, staging areas, stockpile storage, and temporary buildings shall be placed in areas designated on the drawings or as directed by the Project Manager. Temporary movement or relocation of Contractor facilities shall be made only when approved. Erosion and sediment controls shall be provided for on-site borrow and spoil areas to prevent sediment from entering nearby waters. Temporary excavation and embankments for plant and/or work areas shall be controlled to protect adjacent areas.

3-3.3 Water Resources

The Contractor shall monitor construction activities to prevent pollution of surface and ground waters. Toxic or hazardous chemicals shall not be applied to soil or vegetation unless otherwise indicated. All water areas affected by construction activities shall be monitored by the Contractor. For construction activities immediately adjacent to impaired surface waters, the Contractor shall be capable of quantifying sediment or pollutant loading to that surface water when required by concerned Government Agencies.

3-3.3.1 Cofferdams, Diversions, and Dewatering Operations

Construction operations for dewatering and removal of cofferdams shall be controlled at all times to maintain compliance with existing Government Water Quality standards and designated uses of the surface water body.

3-3.3.2 Stream Crossings

Stream crossings shall allow movement of materials or equipment without violating water pollution control standards of the Government.

3-3.4 Air Resources

Equipment operation, activities, or processes performed by the Contractor shall be in accordance with all air emission and performance laws and standards of the Government. The Contractor shall provide temporary ventilation system for working inside the grouting and inspection gallery until the permanent ventilation system is installed and commissioned.

3-3.4.1 Particulates

Dust particles; aerosols and gaseous by-products from construction activities; and processing and preparation of materials, such as from asphaltic batch plants; shall be controlled at all times, including weekends, holidays and hours when work is not in progress. The Contractor shall maintain excavations, stockpiles, haul roads, permanent and temporary access roads, plant sites, spoil areas, borrow areas, and other work areas within or outside the project boundaries free from particulates which would cause the air pollution standards of the Government to be exceeded or which would cause a hazard or a nuisance. Sprinkling, chemical treatment of an approved type, baghouse, scrubbers, electrostatic precipitators or other methods will be permitted to control particulates in the work area. Sprinkling, to be efficient, must be repeated to keep the disturbed area damp at all times. The Contractor must have sufficient, competent equipment available to accomplish these tasks. Particulate control shall be performed as the work proceeds and whenever a particulate nuisance or hazard occurs. The Contractor shall comply with all the Government Visibility Regulations.

3-3.4.2 Odors

Odors from construction activities shall be controlled at all times. The odors shall not cause a health hazard and shall be in compliance with Government regulations and/or ordinances.

3-3.4.3 Sound Intrusions

The Contractor shall keep construction activities under surveillance and control to minimize environment damage by noise. The Contractor shall comply with the provisions of the Government, rules.

3-3.4.4 Burning

Burning will not be allowed on the project site unless specified in other sections of the specifications or authorized in writing by the Project Manager. The specific time, location, and manner of burning shall be subject to approval. Fires shall be confined to a closed vessel, guarded at all times, and shall be under constant surveillance until contents have burned out or have been extinguished. Burning shall completely reduce the materials to ashes.

3-3.5 Chemical Materials Management and Waste Disposal

Disposal of wastes shall be as directed below, unless otherwise specified in other sections and/or shown on the drawings.

3-3.5.1 Solid Wastes

Solid wastes (excluding clearing debris) shall be placed in containers which are emptied on a regular schedule. Handling, storage, and disposal shall be conducted to prevent contamination. Segregation measures shall be employed so that no hazardous or toxic waste will become co-mingled with solid waste.

3-3.5.2 Chemicals and Chemical Wastes

Chemicals shall be dispensed ensuring no spillage to the ground or water. Periodic inspections of dispensing areas to identify leakage and initiate corrective action shall be performed and documented. This documentation will be periodically reviewed by the Government. Chemical waste shall be collected in corrosion resistant, compatible containers. Collection drums shall be monitored and removed to a staging or storage area when contents are within 150 mm of the top. Wastes shall be classified, managed, stored, and disposed of in accordance with the Government laws and regulations.

3-3.5.3 Contractor Generated Hazardous Wastes/Excess Hazardous Materials

Hazardous waste is defined by applicable regulations of the Government. The Contractor shall take sufficient measures to prevent spillage of hazardous and toxic materials during dispensing. The Contractor shall segregate hazardous waste from other materials and wastes, shall protect it from the weather by placing it in a safe covered location, and shall take precautionary measures such as berming or other appropriate measures against accidental spillage. The Contractor shall be responsible for storage, describing, packaging, labeling, marking, and placarding of hazardous waste and hazardous material in accordance with the Government laws and regulations. The Contractor shall dispose of hazardous waste in compliance with the Government laws and regulations. Spills of hazardous or toxic materials shall be immediately reported to the Project Manager Cleanup and cleanup costs due to spills shall be the Contractor's responsibility.

3-3.5.4 Fuel and Lubricants

Storage, fueling and lubrication of equipment and motor vehicles shall be conducted in a manner that affords the maximum protection against spill and evaporation. Fuel, lubricants and oil shall be managed and stored in accordance with all Government laws and regulations. Used lubricants and used oil to be discarded shall be stored in marked corrosion-resistant containers and recycled or disposed in accordance with the Government laws and regulations.

3-3.5.5 Waste Water

Disposal of waste water shall be as specified below.

(a) Waste water from construction activities, such as onsite material processing, concrete curing, foundation and concrete clean-up, water used in concrete trucks, forms, etc. shall not be allowed to enter water ways or to be discharged prior to being treated to remove pollutants. The Contractor shall dispose of the construction related waste water in accordance with all the Government laws and regulations or by collecting and placing it in a retention pond, where suspended material can be settled out and/or the water can evaporate to separate pollutants from the water. The site for the retention pond shall be coordinated and approved by the Project Manager. The residue left in the pond prior to completion of the project shall be removed, tested, and disposed of from project site in accordance with the Government laws and regulations. The area shall be backfilled to the original grade, top-soiled and seeded/sodded.

(b) For discharge of groundwater, the Contractor shall obtain a Government permit specific for pumping and discharging ground water prior to surface discharging. Land application shall be in accordance with all Government laws and regulations for pumping and land applying ground water.

3-3.6 Recycling and Waste Minimization

The Contractor shall participate in the Government sponsored Recycling Programs. The Contractor is further encouraged to minimize solid waste generation throughout the duration of the project.

3-3.7 Non-Hazardous Solid Waste Diversion Report

The Contractor shall maintain an inventory of non-hazardous solid waste diversion and disposal of construction and demolition debris. The Contractor shall submit a report to the Project Manager on the first working day after each fiscal year quarter, starting the first quarter that non-hazardous solid waste has been generated. The following shall be included in the report:

(a) Construction and Demolition (C&D) Debris Disposed in cubic meters.

(b) Construction and Demolition (C&D) Debris Recycled in cubic meters.

(c) Total C&D Debris Generated in cubic meters.

3-3.8 Historical, Archaeological, and Cultural Resources

If during excavation or other construction activities any previously unidentified or unanticipated historical, archaeological, and cultural resources are discovered or found, all activities that may damage or alter such resources shall be temporarily suspended. Resources covered by this paragraph include but are not limited to: any human skeletal remains or burials; artifacts; shell, midden, bone, charcoal, or other deposits; rock or coral alignments, pavings, wall, or other constructed features; and any indication of agricultural or other human activities. Upon such discovery or find, the Contractor shall immediately notify the Project Manager so that the appropriate authorities may be notified and a determination made as to their significance and what, if any, special disposition of the finds should be made. The Contractor shall cease all activities that may result in impact to or the destruction of these resources. The Contractor shall secure the area and prevent

employees or other persons from trespassing on, removing, or otherwise disturbing such resources.

3-3.9 Biological Resources

The Contractor shall minimize interference with, disturbance to, and damage to fish, wildlife, and plants including their habitat. The Contractor shall be responsible for the protection of threatened and endangered animal and plant species including their habitat in accordance with Government laws and regulations.

3-3.10 Integrated Pest Management

In order to minimize impacts to existing fauna and flora, the Contractor, through the Project Manager, shall coordinate with the concerned government agency to give opportunity to their representative to be present at all meetings concerning treatment measures for pest or disease control and during application of the pesticide.

3-3.10.1 Pesticide Delivery and Storage

Pesticides shall be delivered to the site in the original, unopened containers bearing legible labels and the manufacturer's registered uses. Pesticides shall be stored according to manufacturer's instructions and stored under lock and key when unattended.

3-3.10.2 Qualifications

For the application of pesticides, the Contractor shall use the services of a subcontractor whose principal business is pest control. The subcontractor shall be licensed and certified in the Governorate where the work is to be performed.

3-3.10.3 Pesticide Handling Requirements

The Contractor shall formulate, treat with, and dispose of pesticides and associated containers in accordance with label directions and shall use the clothing and personal protective equipment specified on the labeling for use during all phases of the application. Material Safety Data Sheets (MSDS) shall be available for all pesticide products.

3-3.10.4 Application

Pesticides shall be applied by a Government Certified Pesticide Applicator in accordance with the Government restrictions and recommendation. The Certified Applicator shall wear clothing and personal protective equipment as specified on the pesticide label. Water used for formulating shall only come from locations designated by the Project Manager. The Contractor shall not allow the equipment to overflow. Prior to application of pesticide, all equipment shall be inspected for leaks, clogging, wear, or damage and shall be repaired prior to being used.

3-3.11 Previously Used Equipment

The Contractor shall clean all previously used construction equipment prior to bringing it onto the project site. The Contractor shall ensure that the equipment is free from soil residuals, egg deposits from plant pests, noxious weeds, and plant seeds.

3-3.12 Maintenance of Pollution Facilities

The Contractor shall maintain permanent and temporary pollution control facilities and devices for the duration of the contract or for that length of time construction activities create the particular pollutant.

3-3.13 Military Munitions

In the event the Contractor discovers or uncovers military ammunitions as defined the Contractor shall immediately stop work in that area and immediately inform the Project Manager.

3-3.14 Training of Contractor's Personnel

The Contractor's personnel shall be trained in all phases of environmental protection and pollution control. The Contractor shall conduct environmental protection/pollution control meetings for all Contractor personnel prior to commencing construction activities. Additional meetings shall be conducted for new personnel and when site conditions change. The training and meeting agenda shall include: methods of detecting and avoiding pollution; familiarization with statutory and contractual pollution standards; installation and care of devices, vegetative covers, and instruments required for monitoring purposes to ensure adequate and continuous environmental protection / pollution control; anticipated hazardous or toxic chemicals or wastes, and other regulated contaminants; recognition and protection of archaeological sites, artifacts, wetlands, and endangered species and their habitat that are known to be in the area.

3-3.15 Post Construction Cleanup

The Contractor shall clean up all areas used for construction in accordance with the provisions of the Contract. The Contractor shall, unless otherwise instructed in writing by the Project Manager, obliterate all signs of temporary construction facilities such as haul roads, work area, structures, foundations of temporary structures, stockpiles of excess or waste materials, and other vestiges of construction prior to final acceptance of the work. The disturbed area shall be graded, filled and the entire area seeded unless otherwise indicated.

PART 4 MEASUREMENTS AND PAYMENT

3-4.1 Payment

No separate payment will be made for work covered under this section. The Contractor shall be responsible for payment of fees associated with environmental permits, application, and/or notices obtained by the Contractor. (The Contractor shall be

responsible for payment of all fines / fees for violation or non-compliance with the Government laws and regulations).

All costs associated with this section shall be deemed covered in the rates quoted in the Bill of Quantities & included in the Contract Price.

CHAPTER 4 - DIVERSION AND CARE OF WATER

PART 1 GENERAL

4-1.1 Scope

This Section covers the technical requirements for the planning, design, testing, construction, maintenance and removal of the **Temporary Works** required for the diversion and care of water during the period of construction of the Permanent Works.

4-1.2 Reference

EM 1110-2-2300 (1994) Earth and Rockfill Dams-General Design and Construction Considerations - U.S. Army Crops of Engineers (USACE)

Earth Manual - United States Bureau of Reclamation - USBR

4-1.3 Definitions

The following terms shall have the meanings hereby assigned to them:

Flood Protection:	Provision of temporary works to protect the site from perennial and flood flows.
Diversion of Canal Flows:	The Contractor shall maintain irrigation water supplies to the scheme throughout the contract period.
Maintenance of Irrigation Water supplies:	The Contractor shall maintain irrigation water supplies to the scheme throughout the contract period.

4-1.4 Submittals

The following shall be submitted for Project Manager's review and approval in accordance with **Sub-Clause 1-1.4 - Submittal Procedures**.

SD-01 Preconstruction Submittals

- Proposal on Diversion and Care of water.

SD-02 Shop Drawings

- Drawings of Diversion Scheme

SD-05 Design Data

- Construction of diversion channels and appurtenant system for the diversion and care of water.

4-1.4.1 Initial Submission

The Contractor shall submit his proposed Diversion Scheme for the approval of the Project Manager within 30 days of the Project Manager's notice to commence work. This submission shall include all information necessary to understand fully the Contractor's Diversion Scheme and its interrelationship with the Contractor's Construction Schedule. The submission shall include the following:

- Descriptions and drawings of the various stages of the Diversion Scheme.

- Outline designs and construction methods of all the features of the Diversion Scheme.
- Descriptions of the methods, including the layout and capacity, of the drainage and dewatering systems proposed for the construction of all parts of the Permanent Works.
- Proposed outline specifications for any elements of the Temporary Works not covered by these Technical Specifications, or for which the Contractor wishes to propose alternative specifications.
- Description of any aspects of the Contractor's Diversion Scheme which may differ from that submitted with his Tender, giving the reasons for such differences.

After reviewing the initial submission, the Project Manager may require the Contractor to submit further information or amended proposals until, in the Project Manager's opinion, the proposals are satisfactory. The Project Manager will then approve the Contractor's Diversion Scheme.

4.1.4.2 Detailed Submissions

Within 28 days after approval of the Contractor's Diversion Scheme, the Contractor shall submit for the approval of the Project Manager detailed designs of all the features forming part of the scheme, together with full technical specifications for any matters covered by Sub-Clause 4-1.4.1 hereof.

4-1.5 Measures Included

In accordance with the Specifications contained in this Section and or as directed, the Contractor shall:

- Divert and control the flows from the river / canals/ nullahs / hill torrent so that irrigation water supplies are not affected, and
- Care for all surface water and groundwater from any source, as may be required, so that all the construction work can be performed in areas free from water.

The Contractor shall design, furnish, construct, operate, maintain, and remove the necessary facilities as may be required for diversion, for dewatering the construction areas, for caring for all surface water and groundwater from any source, and for general protection of the Works.

The design of all Temporary Works for the diversion and care of water shall be carried out by the Contractor and shall conform to accept and safe engineering practice. The Contractor shall include with his submissions copies of all design calculations relating thereto.

The Contractor's proposals for diversion and care of water shall not require any change to the location, dimensions, design or details of any part of the Permanent Works, unless approved by the Project Manager pursuant to Sub-Clause 4-3.5.

4-1.6 Works used for diversion

With the approval of the Project Manager, the Contractor may use parts of the Permanent Works, such as the sluices section where downstream stilling basin and downstream protection works have been completed to divert Nullah flows.

4-1.7 Data Supplied to Contractor

The limited hydrological data, its analysis for Remodeling of Hairdin Drainages and Allied Structures is available with the Employer for Contractor's review. The Employer does not guarantee the reliability or accuracy of these data and will not be responsible for any deductions, conclusions or interpretations, which may be made by the Contractor from these data.

4-1.8 Project Manager's Diversion Proposal

Not Used.

4-1.8.2 Schedule of Construction and Diversion Scheme

Not Used.

4-1.9 Contractor's Diversion Scheme

4-1.9.1 General Requirements

The Contractor shall plan, design, construct, operate, maintain and remove, when required, all parts of his scheme for controlling and diverting the river / nullahs / tributaries/ hill torrents and for taking care of surface and ground water throughout the construction period.

The Contractor's Diversion Scheme shall be suitable and sufficient for the intended purpose and shall meet the specific design criteria given hereunder.

4-1.9.2 Criteria

The Contractor's Diversion Scheme shall be based on the general guidelines on design of diversion works as provided in USACE – EM 1110-2-2300: "Concrete Weirs– General Design and Construction Considerations", or any other criteria approved by the Project Manager.

The Contractor shall carry out sufficient surveys as may be needed to establish the required extent of the diversion channel and demonstrate to the satisfaction of the Project Manager that the channel will perform as intended.

4-1.9.3 Use of Permanent Works

The proposed use of any part of the Permanent Works as part of the Contractor's Diversion Scheme shall be such that the Permanent Works are not subjected to any greater loads or any other more adverse conditions, such as erosion, than would occur after that part of the Permanent Works has been put into service during impounding or after completion of the construction.

4-1.10 Contractor's acknowledgement and responsibility

The Contractor shall be solely and fully responsible for the diversion and care of water throughout the period of construction and for any damage to persons and property, as provided in **Clauses 13 of the Conditions of Contract**.

The Contractor shall be responsible for any damage or detriment to the Permanent Works which may result from any overtopping, breach, breakdown or other failure of his measures for the diversion and care of water, and shall make good such damage to the satisfaction of the Project Manager, at no additional cost to the Employer.

PART 2 PRODUCTS

4-2.1 Materials

The materials used for all diversion features shall conform to the requirements of the appropriate sections of these Specifications.

PART 3 EXECUTION

4-3.1 General

In addition to the specific requirements of this Section, the construction of all Temporary Works for the diversion and care of water shall conform to the requirements of the appropriate sections of these Specifications.

4-3.2 Closure of Diversion Channels

No diversion channel shall be closed unless the Project Manager is satisfied that its closure can be undertaken without detriment to the safe conveyance of water through and/or past the site of the Permanent Works, and that those parts of the arrangements for the diversion and care of the water remaining after its closure will meet the requirements of this Section of the Specifications. Nor shall it be closed until the Project Manager is satisfied that the Contractor has made adequate preparations and secured sufficient resources for the proper and timely execution of any subsequent parts of the Diversion Scheme as the Project Manager may consider necessary to allow the safe discharge of Nullah flows.

Closure of a diversion channel shall not be commenced without the written permission of the Project Manager.

4-3.3 Incorporation in Permanent Works

Subject to the approval of the Project Manager, any suitable part of the Temporary Works which is located within the limits of Permanent Works may be incorporated therein, provided that its construction standard has been shown to meet the specified requirements, and the construction details are compatible with the design of the Permanent Works.

Subject to the approval of the Project Manager, parts of the Permanent Works may be constructed with additional features required to enable them to function as part of the diversion arrangements. Such features may be retained within the Permanent Works, subject to the approval of the Project Manager, provided that their construction standard has been shown to meet the specified requirements and the construction details are compatible with the design of the Permanent Works.

4-3.4 Dewatering

4-3.4.1 General

Except where otherwise specified, shown on the Drawings or approved by the Project Manager, the Contractor shall maintain all foundations and other Permanent Works areas well drained and free of water of any origin, including groundwater, seepage, precipitation, runoff or from construction uses.

Except where otherwise approved by the Project Manager, the Contractor shall drain, dewater and keep dry all areas of construction that are below the Nullah or the groundwater elevation, and shall ensure that all excavated surfaces are maintained in a safe and stable condition.

All embankments whether Permanent Works or Temporary Works, shall be placed in the dry, with the exception of such parts of the Contractor's Diversion Scheme as are designed to be placed in water and have received the Project Manager's approval for that method of placing.

The work to be performed by the Contractor in connection with dewatering shall include, but not necessarily be limited to, the following:

- The supply, installation, operation, maintenance and subsequent removal of all pumps, pumping stations, pipework and other equipment, including sufficient standby equipment, for the dewatering of the works areas and maintaining those areas free of water as required. Should deep well pumps be deployed, they shall be placed at least 30 m beyond the limits of any completed Permanent Works, except flexible aprons.
- The construction, maintenance and subsequent removal of any temporary sumps, lagoons, chambers, flumes, cofferdams, protective bunds or dykes and the like. All temporary sumps and lagoons shall be placed at least 20 m beyond the limits of any Permanent Works.
- The construction, maintenance and subsequent backfilling of such temporary drains or ditches as are required to efficiently carry all water to sumps or other collection or disposal locations.
- The supply, installation, maintenance, operation and subsequent removal of dewatering wells and/or well points.

Subject to the Project Manager's approval, which shall not be unreasonably withheld, the Contractor may deploy any other appropriate part of the Permanent Works as part of his drainage and dewatering arrangements.

4-3.4.2 Groundwater Pressure Relief

The Contractor shall evaluate all groundwater information and take whatever measures are necessary to ensure the stability of all structures and ground surfaces during construction. The measures needed may depend on the precise sequence of such matters as excavation, construction and the installation of permanent drainage wells and blankets.

The Contractor's dewatering arrangements may require the drilling of drainage wells from the ground surface, together with the installation of piezometers to monitor groundwater levels and the performance of the dewatering arrangements.

If, in the opinion of the Project Manager, the foundation is damaged due to any inadequacy or failure of the Contractor's system for groundwater pressure relief, then the Contractor shall take all corrective measures necessary, as directed by the Project Manager, at no additional cost to the Employer.

4-3.4.3 Excavations for Concrete Structures

At all excavations where concrete is to be placed, the water level within and adjacent to the excavation shall be maintained a minimum of 300 mm below the finished excavation for at least 24 hours after the completion of the structure to an elevation above the natural water-table, or for such additional time as the Project Manager may require to preclude injury to the foundation or structure.

4-3.5 Maintenance of Temporary Works

The Contractor shall maintain all Temporary Works required for the diversion and care of water, shall carry out any repairs promptly and shall ensure that each part of the Temporary Works functions properly throughout the period during which it is required.

4-3.6 Removal of Temporary Works

Subject to the requirements for the diversion and care of water shall be removed promptly after they have served their intended purpose. The Project Manager may, however, permit the removal of certain Temporary Works to be delayed, if he is satisfied that this will cause no detriment to the Permanent Works or to the safe conveyance of water through and/or past the site of the Permanent Works, and that the Contractor has made adequate provision for their subsequent timely removal.

Removal of all Temporary Works for the diversion and care of water shall be carried out in a workmanlike manner and to the approval of the Project Manager, leaving a clean appearance to the remaining surfaces, and so as not to interfere with the proper completion or future functioning of the Project. Waste material shall be properly disposed of, to the approval of the Project Manager.

The site of any diversion channel shall be backfilled and reinstated to such levels and in such a manner as the Project Manager may direct, having regard to the subsequent construction of Permanent Works on or near the site of the diversion channel and the safe conveyance of water through and/or past the Works.

4-3.7 Reinstatement

Any surfaces which are affected by erosion or deposition due to the flow of water shall be reinstated in such a manner and at such a time as the Project Manager may direct, having regard to the construction, safety, stability and proper functioning of the Permanent Works.

PART 4 MEASUREMENT AND PAYMENT

4-4.1 General

No measurement or payment shall be made for diversion, drainage, dewatering or care of water, except as specified herein and included in the Bill of Quantities.

The lump sum price included in the priced Bill of Quantities shall be deemed to cover all costs of diverting the flows, including arrangement of land for diversion channels, conveying and maintaining flows through and/or past the site of the Permanent Works, keeping each part of the Works protected against inundation, well drained and properly dewatered during construction; and of constructing, maintaining, operating and removing all Temporary Works in connection therewith. Any costs resulting from accidental inundation of any working areas, whether due to breakdown, failure or overtopping of the Temporary Works, shall be to the account of the Contractor.

The lump sum price shall be deemed to include all measures for the diversion and care of water including temporary arrangement of land for diversion channels, dewatering of foundations, required for the proper completion of the Permanent Works, whether or not they are specifically mentioned in the Contract.

The lump sum price shall be deemed to take account of any effects of the measures for the diversion and care of water on any surfaces, including such effects as erosion and deposition due to the flow of water. The lump sum price shall be deemed to include all costs resulting from the reinstatement of such surfaces.

Progress payments for diversion and care of water shall be made according to such schedule as the Project Manager approves as reasonable, having regard to the construction schedule of each feature of the Works.

4-4.2 Diversion and Care of Water

4-4.2.1 Measurement

Diversion and care of water will be measured on the basis of break down of the Lump sum Price showing cost of all items for water control works of listed in the Water Control Plan proposed by him and submitted with the Tender.

4-4.2.2 Payment

Payment will be made as per the breakdown of the lump sum price tendered and submitted by the Contractor as stated under Measurement.

The lump sum price shall be deemed to cover all costs of diversion and controlling water including arrangement for land acquisition for diversion channel, maintaining all work areas free of water regardless of source; constructing, maintaining, breaching, and removing cofferdams, reinstatement of surfaces due to sediment deposition / erosion and all other work related to the item.

Payment shall include all costs of designing and furnishing all sumps, ditches, pumps, motors, pipes, valves, etc., for care of water and performing all pumping and drainage operations including the furnishing of all power and energy etc. necessary to comply with

the requirements under the Sub-Clause. The Employer shall not pay any additional amount in full compliance to the requirements of this Sub-Clause.

4-4.3 Incorporation in Permanent Works

Any parts of the Temporary Works which become incorporated within the Permanent Works shall, at the time of incorporation, be measured for payment to such limits and under such bill items as would have applied to the relevant part of the Permanent Works, as if that part of the Temporary Works had not previously existed.

CHAPTER 5 – EXCAVATION AND MISCELLANEOUS EARTHWORK

PART 1 GENERAL

5-1.1 Scope

This section covers the requirements for clearing, stripping, and excavation for foundations, borrows areas, quarries and for other works of this project and construction of miscellaneous earthworks other than that covered under Section 7, Embankment Construction.

5-1.2 References

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM C 117	(1995) Standard Test Method for Materials Finer than 75-micrometer (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 131	(2001) Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	(2001) Sieve Analysis of Fine and Coarse Aggregates
ASTM C 33	(2003) Concrete Aggregates.
ASTM C 88	(1999a) Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM D 1140	(2000) Amount of Material in Soils Finer than the No. 200 (75-micrometer) Sieve
ASTM D 1556	(2000) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 1557	(2002) Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/cu. ft. (2,700 kN-m/cu.m.))
ASTM D 2167	(1994; R 2001) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D 2434	(1968; R 2000) Permeability of Granular Soils (Constant Head)
ASTM D 2487	(2000) Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D 2922	(2001) Standard Test Methods for Density of Soil and
Soil-Aggregate in Place by	(Shallow Depth)

Nuclear Methods	
ASTM D 2937	(2000e1) Density of Soil in Place by the Drive-Cylinder Method
ASTM D 3017	(2001) Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)
ASTM D 3282	(1993; R 1997) Standard Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes
ASTM D 3740	(1994) Standard Practice for Evaluation of Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used In Engineering Design and Construction
ASTM D 422	(1963; R 2002) Particle-Size Analysis of Soils
ASTM D 4318	(2000) Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D 698	(2000a) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO T 2	2000) Standard Specification for Sampling of Aggregates
AASHTO M 145	(1991; R 1995) Recommended Practice for Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes
AASHTO T 180	(1997) Standard Method of Test for Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop
AASHTO T 87	(1986; Rev 1993) Standard Method for the Dry Preparation of Disturbed Soil and Soil Aggregate Samples for Test

U.S. ARMY CORPS OF ENGINEERS (USACE)

EM 385-1-1 (2003) Safety -- Safety and Health Requirements

U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)

29 CFR 1926 (2001) Safety and Health Regulations for Construction

5-1.3 Definitions

5-1.3.1 Satisfactory Materials

Satisfactory materials for road fill shall mean AASHTO M 145, (ASTM D 3282) Soil Classification Groups A-1, A-2-4, A-2-5, and A-3.

Satisfactory materials for grading shall be comprised of stones less than 200 mm, except for fill material for pavements and roads which shall be comprised of stones less than 75 mm in any dimension.

5-1.3.2 Unsatisfactory Materials

Unsatisfactory soil materials for road fill shall mean AASHTO M 145, Soil Classification Groups A-2-6, A-2-7, A-4, A-5, A-6, and A-7, peat and other highly organic soil, and soil materials of any classification that have a moisture content at the time of compaction beyond the range of 1 percentage point below and 3 percentage points above the optimum moisture content of the soil material as determined by moisture-density relations test.

For other fills, the materials, which do not comply with the requirements for satisfactory materials, are unsatisfactory. Unsatisfactory materials also include man-made fills; trash; refuse; backfills from previous construction; and material classified as satisfactory which contains root and other organic matter or frozen material. The Project Manager shall be notified of any contaminated materials.

5-1.3.3 Cohesionless and Cohesive Materials

Cohesionless materials include materials classified in ASTM D 2487 as GW, GP, SW, and SP. Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. Materials classified as GM and SM will be identified as cohesionless only when the fines are non-plastic. Testing required for classifying materials shall be in accordance with ASTM D 4318, ASTM C 136, ASTM D 422, and ASTM D 1140.

5-1.3.4 Hard/Unyielding Materials

Weathered rock, dense consolidated deposits, or conglomerate materials, not included in the definition of "rock", with stones greater than 100 mm in any dimension or as defined by the pipe manufacturer, whichever is smaller. These materials usually require the use of heavy excavation equipment, ripper teeth, or jack hammers for removal.

5-1.3.5 Rock

Solid homogeneous interlocking crystalline material with firmly cemented, laminated, or foliated masses or conglomerate deposits, neither of which can be removed without systematic drilling and blasting, drilling and the use of expansion jacks or feather wedges,

or the use of backhoe-mounted pneumatic hole punchers or rock breakers; also large boulders, buried masonry, or concrete other than pavement exceeding 0.4 cubic meter in volume. Removal of hard material will not be considered rock excavation because of intermittent drilling and blasting that is performed merely to increase production.

5-1.3.6 Unstable Material

Unstable material is defined as any material that is too wet to properly support the utility pipe, conduit, or appurtenant structure.

5-1.3.7 Select Granular Material

Select granular material is defined as any material classified as GW, GP, SW, and SP by ASTM D 2487 where indicated. Coefficient of permeability shall be a minimum of 0.01 mm per second when tested in accordance with ASTM D 2434.

5-1.3.8 Initial Backfill Material

Initial backfill is defined as select granular material or satisfactory materials free from rocks 75 mm or larger in any dimension or free from rocks of such size as recommended by the pipe manufacturer, whichever is smaller. When the pipe is coated or wrapped for corrosion protection, the initial backfill material shall be free of stones larger than 75 mm in any dimension or as recommended by the pipe manufacturer, whichever is smaller.

5-1.3.9 Expansive Soils

Expansive soils are defined as soils that have a plasticity index equal to or greater than 25 percent when tested in accordance with ASTM D 4318.

5-1.3.10 Trees

The line of demarcation between brush and trees, for the purpose of distinguishing clearing requirements, is that trees, as used, will be considered as that woody growth not falling within the limits of brush as defined below.

5-1.3.11 Brush

Brush is that growth, which is less than 50 mm in diameter, measured 150 mm from the ground on the uphill side and is less than 2 m in height measured from the ground on the uphill side.

5-1.3.12 Structures to be removed

The term "structures to be removed" shall include buildings or portions thereof, walls, silos, storm or root cellars, cisterns, wells, windmills, pit silos, water towers, etc. Structures shall be removed or filled to the ground surface.

5-1.4 Submittals

The following shall be submitted for Project Managers review and approval in accordance with **Clause 1-1.4 - Submittal Procedures**:

SD-01 Preconstruction Submittals

Shoring

Blasting

Submit 15 days prior to starting work.

SD-03 Product Data

Utilization of Excavated Materials

Rock Excavation,

Opening of any Excavation or Borrow Pit or Quarry

Procedure and location for disposal of unused satisfactory material and quarry. Proposed source of borrow material. Notification of encountering rock in the project. Advance notice on the opening of excavation or borrow areas.

SD-06 Test Reports

Testing

Borrow Site and Quarry Testing

Within 24 hours of conclusion of physical tests, copies of test results, including calibration curves and results of calibration tests. Results of testing at the borrow site.

SD-07 Certificates

Testing

Qualifications of the commercial testing laboratory or Contractor's testing facilities.

SD-01 Preconstruction Submittals

Construction Equipment List shall be submitted

Contractor shall record Existing Conditions prior to starting work in accordance with the **Clause 5-1.7 - Existing Conditions** of this section.

SD-06 Test Reports

Test Reports shall be submitted for Soil Test results within 7 calendar days. Test reports shall be submitted according to Sub-Clause 5-1.5.3 - Quality Control Testing during Construction of this section.

SD-07 Certificates

Certificates of Compliance for Proposed Soil Materials shall be submitted according to **Sub-Clause 5-1.5.2 - Tests for Proposed Soil Materials** of this section.

Certificates of Compliance for Compost shall be submitted indicating grade and compliance with state and local regulations.

5-1.5 Sampling and Testing

5-1.5.1 Soil Test and Inspection Service

Soil survey for satisfactory soil materials and samples of soil materials shall be furnished by the Contractor. A certified soil-testing service approved by the Project Manager shall

be provided by the Contractor. Testing shall include soil survey for satisfactory soil materials; sampling and testing soil materials proposed for use in the work, and field-testing facilities for quality control during construction period.

Testing agencies shall conform to the requirements of ASTM D 3740.

5-1.5.2 Tests for Proposed Soil Materials

Materials shall be approved by the Project Manager prior to start of work.

Soil materials proposed for use in the work shall be tested as follows:

Table 5-1

Material	***Requirement***	***Test Method***	***Number of Tests***
Satisfactory soil materials	Sampling	AASHTO T 2	Three from each source of materials to determine conformance to Definition of satisfactory soil materials; additional tests whenever there is any apparent change
	Preparation of samples	AASHTO T 87	
	Sieve analysis is of fine and coarse aggregates	ASTM C 136	
	Amount of material passing 75 micrometer sieve	ASTM C 117	
	Liquid Limit	ASTM D 4318	
	Plastic limit and plasticity index	ASTM D 4318	
	Mechanical analysis	ASTM D 4318	
	Moisture density relations	ASTM D 1557, Method D	As required to determine moisture-density requirement of materials from each source.
	Los Angeles abrasion of coarse aggregates	ASTM C 131	One for each soil material from each source if called for in reference specification
	Magnesium sulfate soundness test	ASTM C 88	

5-1.5.3 Quality Control Testing During Construction

Soil materials shall be tested during construction as follows:

Table 5-2

Material	***Requirement***	***Test Method***	***Number of Tests***
Soil materials Specified	Sieve analysis is of fine and coarse aggregates	ASTM C 136	One daily for each soil material from each source; additional test whenever there is any apparent change
	Amount of material passing 75 micrometer sieve	ASTM C 117	
Soil materials prior to compaction	Moisture density relations of soil	ASTM D 1557, Method D	One for each subgrade soil material except under backfill for structures; One for each backfill and fill material from each source
Soil Material-in-place after compaction	Density of Soil-in-place	ASTM D 1556 Sand Cone Method or ASTM D 2922, Nuclear Method (when Approved by Project Manager)	At least three daily for each subgrade soil material except under backfill for structures, and for each layer and backfill and fill material; additional test whenever there is any change in moisture conditions

5-1.5.4 Test Reports

No soil material shall be used until test reports have been reviewed and approved by the Project Manager.

5-1.5.5 Evaluation of Test Results

Results of density of soil-in-place tests shall be considered satisfactory if the average of any group of four consecutive density tests which may be selected is in each instance equal to or greater than the specified density, and if not more than one density test in five has a value more than 2 percentage points below the specified density.

5-1.6 Construction Equipment List

Construction Equipment List of all major equipment to be used shall be submitted.

5-1.7 Existing Conditions

Existing Conditions shall be recorded, in the presence of the Project Manager, and shall include all structures and other facilities adjacent to areas of alteration or removal. Such records shall contain the location of existing utilities, the elevation of the top of foundation

walls, the location and extent of cracks and other damage, and a description of surface conditions that exist prior to the start of work. Copies of the record shall be submitted and the conditions prior to starting work shall be verified.

5-1.8 Subsurface Data

Subsurface soil data is not available with client for contractor's review. The contractor has to carry out the geotechnical investigations to determine subsurface information; however, variations may exist in the subsurface between boring locations.

5-1.9 Clearing

Areas to be cleared shall include, but not be restricted to:

(i) Borrow areas and quarries,

(ii) Surfaces of stockpiles,

(iii) Disposal areas outside the canal area,

(iv) Areas to be backfilled, and

(v) Areas to be occupied by the permanent and temporary construction

5-1.9.1 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.

Uprooting of Vegetation

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.

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.

5-1.10 Classification of Excavation

Excavation specified shall be done on a classified basis, in accordance with the following designations and classifications.

5-1.10.1 Common Excavation

Common excavation shall include the satisfactory removal and disposal of all materials not classified as rock excavation.

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.

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.

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.

5-1.10.2 Rock Excavation

Rock excavation shall include blasting, excavating, grading, and disposing of material classified as rock and shall include the satisfactory removal and disposal of boulders 1/2 cubic meter or more in volume; solid rock; rock material that is in ledges, bedded deposits, and unstratified masses, which cannot be removed without systematic drilling and blasting; firmly cemented conglomerate deposits possessing the characteristics of solid rock impossible to remove without systematic drilling and blasting; and hard materials (see Definitions). The removal of any concrete or masonry structures, except pavements, exceeding 1/2 cubic meter in volume that may be encountered in the work shall be included in this classification. If at any time during excavation, including excavation from borrow areas, the Contractor encounters material that may be classified as rock excavation, such material shall be uncovered and the Project Manager notified by the Contractor. The Contractor shall not proceed with the excavation of this material until the

Project Manager has classified the materials as common excavation or rock excavation and has taken cross sections as required. Failure on the part of the Contractor to uncover such material, notify the Project Manager, and allow ample time for classification and cross sectioning of the undisturbed surface of such material will cause the forfeiture of the Contractor's right of claim to any classification or volume of material to be paid for other than that allowed by the Project Manager for the areas of work in which such deposits occur.

5-1.10.3 Blasting

Blasting shall be performed in accordance with EM 385-1-1 and in conformance with Government safety regulations. The Contractor shall submit a Blasting Plan, prepared and sealed by a registered professional Project Manager that includes calculations for overpressure and debris hazard. Blasting mats shall be provided and non-electric blasting caps shall be used. The Contractor shall obtain written approval prior to performing any blasting and shall notify the Project Manager 24 hours prior to blasting. The plan shall contain provisions for storing, handling and transporting explosives as well as for the blasting operations. The Contractor shall be responsible for damage caused by blasting operations.

PART 2 PRODUCTS

5-2.1 Backfill and Fill Materials

Materials for backfill and fill shall be free of clay clods, rock or gravel larger than 50 millimeter in any dimension, debris, waste, and other deleterious matter and shall be satisfactory soil materials as follows:

Table 5-3

Area Classification	Backfill or Fill Materials
In excavations, unless otherwise specified	Excavated or borrow material that has been sampled, Tested, and approved as "Satisfactory Soil Material"
Against face of structures where footing drains from top of porous fill for footing drains to indicated elevation, and from face of structure a distance equal to three footing drain diameters.	Filtering material
Against surfaces having applied waterproofing for a distance of at least 150 millimeter from surface	Sand
In foundation sub-drain trenches over porous fill drain pipe.	Filtering material
Under grassed areas	Excavated or borrow material that has been sampled, tested, and approved as

	"Satisfactory Soil Material"
Under walks, steps, and paved areas	Subbase material or excavated or borrow material that has been sampled, tested, and approved as "Satisfactory Soil Material"
Under building slabs and under culverts	Granular fill and sand bedding
Underdrainage of structures	Filtering material

5-2.1.1 Satisfactory Materials

The satisfactory materials for backfill are as defined in Sub-Clause 5-1.3.1 – Satisfactory Materials.

5-2.1.2 Unsatisfactory Materials

The unsatisfactory materials for backfill are as defined in Sub-Clause 5-1.3.2 – Unsatisfactory Materials.

5-2.2 Cohesionless Materials

Cohesionless soil materials include gravels, gravel-sand mixtures, sands, and gravelly-sands. Moisture-density relations of compacted cohesionless soils, when plotted on graphs, will show straight lines or reverse-shaped moisture density curves.

5-2.3 Cohesive Materials

Cohesive soil materials include clayey and silty gravels, sand-clay mixtures, gravel-silt mixtures, clayey and silty sands, sand-silt mixtures, clays, silts, and very fine sands. Moisture-density relations of compacted cohesive soils, when plotted on graphs, will show normal moisture-density curves.

5-2.4 Subbase Material

Subbase material shall be a naturally or artificially graded mixture of natural or crushed gravel, crushed stone, or sand.

5-2.5 Granular Fill

Granular fill shall be a washed, uniformly graded mixture of crushed stone or crushed or uncrushed gravel, with 100 percent passing 37.5 millimeter sieve and not more than 5 percent passing 4.75 millimeter sieve.

5-2.6 Filtering Material

Unless otherwise specified or shown on drawings, the filtering material shall conform to ASTM C 33 and shall be a uniformly graded mixture of natural or crushed gravel, crushed stone, and natural sand, with 100 percent passing 9.5-millimeter sieve and 2 to 10 percent passing a 150-micrometer sieve. The gradation limits of filtering material for Underdrainage of structures shall be as shown on drawings.

5-2.7 Sand

Sand shall be natural sand.

PART 3 EXECUTION

5-3.1 Clearing

5-3.1.1 Clearing Requirements

All trees, stumps and brush shall be removed. Unless otherwise directed trees shall not be cut down outside areas specified in **Clause 5-1.9** - Clearing and, where directed, trees shall be protected carefully from damage by the Contractor's operations.

Felling of trees shall be restricted to the minimum practicable for the execution of the Works and the limits shall be as directed.

5-3.1.2 Equipment

A tree-crushing machine may be used at the option of the Contractor in all clearing operations.

5-3.1.3 Disposal of Material

(a) General

The material cleared from the areas shall be completely removed by transporting from Client’s property or burned within the cleared areas unless otherwise approved by the Project Manager. All timber from which saw logs, posts, ties or cordwood can be produced will become the property of the Contractor and in the interest of conservation it is required that the Contractor make a reasonable effort to dispose of material for these purposes. The Contractor may cut timber into convenient lengths at the site but approval must be secured prior to the operation of saw mills within the Project area. In no case shall cleared material be thrown into or left in the creeks or Nullah. After the felling operation has been completed, the timber to be burned must be decked for burning within 10 days. All felled timber shall be completely removed. The cutting of branches and debris remaining after clean-up, to reduce their length in order to avoid removal, will not be permitted.

(b) Burning

The material cleared may be burned within the contract area, and at any time within the contract period provided such burning does not interfere with inhabitants of the area by drastic changes in their accustomed environment, such as addition to air pollution or danger of fire. However, the specific time, location and manner of burning shall be subject to approval from the viewpoints of air pollution, governing fire laws and safety. In the interest of conservation, the Contractor may, should he desire to do so, make available to the general public without charge, the material scheduled for burning. No burning operations shall be conducted within 30 m of any standing timber or flammable growth. The burning operations shall be subject to all public law governing such operations and the Contractor will be responsible for any damage to life and/or property resulting from fires that are started by his employees or as a result of his operations.

The Contractor shall furnish at the site adequate fire fighting equipment, such as back tanks, flaps, shovels, rakes, etc., to properly equip his personnel for fighting fires. Fires shall be guarded at all times and shall be under constant surveillance until they have burned out or have been extinguished. All burning shall be so thorough that the materials will be reduced to ashes, except that occasional charred pieces of logs or branches not exceeding 100 mm in diameter and/or 2.5 m in length will be permitted to remain. Upon approval, charred material will be buried after it is determined that it could not be disposed of by methods used in the normal burning operation. All material disposed of in such manner shall be at approved locations and shall be covered within a minimum of 450 mm of earth.

(c) Burial

In certain cases, such as along drainage channels in remote areas, cleared material may be disposed of by burial in areas designated for disposal of excess excavation or spoil. When this option is used, care will be taken to insure that all such cleared material will be buried under not less than 450 mm of earth. Approval will be obtained for each area selected for debris disposal for burial prior to beginning such operations. Burial is not allowed in excavated borrow area. Areas to be used for permanent roadways, levees or embankments will not be used for disposal of material from clearing operations. Areas for disposal of cleared materials by burial will not be located within 92 m of public road crossings or of project areas to be regularly visited by the public.

(d) Removal from Site

Except as otherwise provided, the Contractor will be permitted to remove felled and trimmed timber from the site of the work. The Contractor will be allowed to stockpile salvaged timber above elevation 137.5m at approved locations, unless otherwise approved by the Project Manager. The Employer will assume no responsibility for the protection and safekeeping of such material. All stockpiled timber must be removed from Employer lands before final acceptance of the work will be made.

5-3.1.4 Debris

Combustible debris shall be burned in accordance with **Sub-Clause 5-3.1.3 - Disposal of Material**. Noncombustible debris in excess of that disposed of as set forth in **Sub-Clause 5-1.3.12** - Structures to be removed shall be disposed of at such locations as may be designated by the Project Manager. Debris shall include trash of all kinds.

5-3.1.5 Marketable Materials

Any of the cleared materials, which the Contractor considers marketable, shall become Employer's property and shall be removed from the construction site.

5-3.2 Stripping of Topsoil

Where indicated or directed, topsoil shall be stripped to a depth of 150 mm. Stripping more than 150 mm shall be considered as excavation. Topsoil shall be spread on areas

already graded and prepared for topsoil, or transported and deposited in stockpiles convenient to areas that are to receive application of the topsoil later, or at locations indicated or specified. Topsoil shall be kept separate from other excavated materials, brush, litter, objectionable weeds, roots, stones larger than 50 mm in diameter, and other materials that would interfere with planting and maintenance operations. Any surplus of topsoil from excavations and grading shall be removed from the site.

5-3.3 General Excavation

The Contractor shall perform excavation of every type of material encountered within the limits of the project to the lines, grades, and elevations indicated and as specified. Grading shall be in conformity with the typical sections shown and the tolerances specified in Clause

5-3.17 Finishing

Satisfactory excavated materials shall be transported to and placed in fill or embankment within the limits of the work. Unsatisfactory materials encountered within the limits of the work shall be excavated below grade and replaced with satisfactory materials as directed. Such excavated material and the satisfactory material ordered as replacement shall be included in excavation. Surplus satisfactory excavated material not required for fill or embankment shall be disposed of in areas approved for surplus material storage or designated waste areas. Unsatisfactory excavated material shall be disposed of in designated waste or spoil areas. During construction, excavation and fill shall be performed in a manner and sequence that will provide proper drainage at all times. Material required for fill or embankment in excess of that produced by excavation within the grading limits shall be excavated from the borrow areas indicated or from other approved areas selected by the Contractor as specified.

5-3.3.1 Ditches, Gutters, and Channel Changes

Excavation of ditches, gutters, and channel changes shall be accomplished by cutting accurately to the cross sections, grades, and elevations shown. Ditches and gutters shall not be excavated below grades shown. Excessive open ditch or gutter excavation shall be backfilled with satisfactory, thoroughly compacted, material or with suitable stone or cobble to grades shown. Material excavated shall be disposed of as shown or as directed, except that in no case shall material be deposited less than 1 meter from the edge of a ditch. The Contractor shall maintain excavations free from detrimental quantities of leaves, brush, sticks, trash, and other debris until final acceptance of the work.

5-3.3.2 Drainage Structures

Excavations shall be made to the lines, grades, and elevations shown, or as directed. Trenches and foundation pits shall be of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations as shown. Rock or other hard foundation material shall be cleaned of loose debris and cut to a firm, level, stepped, or serrated surface. Loose disintegrated rock and thin strata shall

be removed. When concrete or masonry is to be placed in an excavated area, the bottom of the excavation shall not be disturbed. Excavation to the final grade level shall not be made until just before the concrete or masonry is to be placed. Where pile foundations are to be used, the excavation of each pit shall be stopped at an elevation 300 mm above the base of the footing, as specified, before piles are driven. After the pile driving has been completed, loose and displaced material shall be removed and excavation completed, leaving a smooth, solid, undisturbed surface to receive the concrete or masonry.

5-3.3.3 Drainage

Provide for the collection and disposal of surface and subsurface water encountered during construction. Completely drain construction site during periods of construction to keep soil materials sufficiently dry. The Contractor shall establish/construct storm drainage features (ponds/basins) at the earliest stages of site development, and throughout construction grade the construction area to provide positive surface water runoff away from the construction activity and/or provide temporary ditches, swales, and other drainage features and equipment as required maintaining dry soils. When unsuitable working platforms for equipment operation and unsuitable soil support for subsequent construction features develop, remove unsuitable material and provide new soil material as specified herein. It is the responsibility of the Contractor to assess the soil and ground water conditions presented by the plans and specifications and to employ necessary measures to permit construction to proceed.

5-3.3.4 Dewatering

Groundwater flowing towards or into excavations shall be controlled to prevent sloughing of excavation slopes and walls, boils, uplift and heave in the excavation and to eliminate interference with orderly progress of construction. French drains, sumps, ditches or trenches will not be permitted within 0.9 m of the foundation of any structure, except with specific written approval, and after specific contractual provisions for restoration of the foundation area have been made. Control measures shall be taken by the time the excavation reaches the water level in order to maintain the integrity of the in situ material. While the excavation is open, the water level shall be maintained continuously, at least 0.3 m below the working level. Operate dewatering system continuously until construction work below existing water levels is complete.

5-3.3.5 Requirements of Trench Excavation for Laying of Pipes

The trench for pipe laying shall be excavated as shown on drawings. Trench walls more than 1 meter high shall be shored, cut back to a stable slope, or provided with equivalent means of protection for employees who may be exposed to moving ground or cave in. Trench walls which are cut back shall be excavated to at least the angle of repose of the soil. Special attention shall be given to slopes which may be adversely affected by weather or moisture content. The trench width below the top of pipe shall not exceed 600 mm plus pipe outside diameter (O.D.) for pipes of less than 600 mm inside diameter and

shall not exceed 900 mm plus pipe outside diameter for sizes larger than 600 mm inside diameter. Where recommended trench widths are exceeded, redesign, stronger pipe, or special installation procedures shall be utilized by the Contractor. The cost of redesign, stronger pipe, or special installation procedures shall be borne by the Contractor without any additional cost to the Employer.

(a) Bottom Preparation

The bottoms of trenches shall be accurately graded to provide uniform bearing and support for the bottom quadrant of each section of the pipe. Bell holes shall be excavated to the necessary size at each joint or coupling to eliminate point bearing. Stones of 100 millimeters or greater in any dimension, or as recommended by the pipe manufacturer, whichever is smaller, shall be removed to avoid point bearing.

(b) Excavation for Appurtenances

Excavation for manholes, catch basins, inlets, or similar structures shall be of sufficient size to permit the placement and removal of forms for the full length and width of structure footings and foundations as shown. Rock shall be cleaned of loose debris and cut to a firm surface either level, stepped, or serrated, as shown or as directed. Loose disintegrated rock and thin strata shall be removed. Removal of unstable material shall be as specified above. When concrete or masonry is to be placed in an excavated area, special care shall be taken not to disturb the bottom of the excavation. Excavation to the final grade level shall not be made until just before the concrete or masonry is to be placed.

5-3.3.6 Underground Utilities

Movement of construction machinery and equipment over pipes and utilities during construction shall be at the Contractor's risk. Report to the Project Manager immediately, any damage to utility lines or subsurface construction.

5-3.3.7 Structural Excavation

Ensure that footing subgrades have been inspected and approved by the Project Manager prior to concrete placement. Backfill and compact over excavations to 95 percent of ASTM D 698 maximum density.

5-3.4 Selection of Borrow Material

Borrow material shall be selected to meet the requirements and conditions of the particular fill or embankment for which it is to be used. Borrow material shall be obtained from the borrow areas selected by the Contractor and approved by the Project Manager. Unless otherwise provided in the contract, the Contractor shall obtain from the owners the right to procure material, pay royalties and other charges involved, and bear the expense of developing the sources, including rights-of-way for hauling. Borrow material from approved sources on Employer-controlled land may be obtained without payment of royalties. Unless specifically provided, no borrow shall be obtained within the limits of the

project site without prior written approval. Necessary clearing, grubbing, and satisfactory drainage of borrow pits and the disposal of debris thereon shall be considered related operations to the borrow excavation.

5-3.5 Opening and Drainage of Excavation and Borrow Pits

The Contractor shall notify the Project Manager sufficiently in advance of the opening of any excavation or borrow pit. Except as otherwise permitted, borrow pits and other excavation areas shall be excavated providing adequate drainage. Overburden and other spoil material shall be transported to designated spoil areas or otherwise disposed of as directed. Borrow pits shall be neatly trimmed and drained after the excavation is completed. The Contractor shall ensure that excavations of any area, operation of borrow pits, or dumping of spoil material results in minimum detrimental effects on natural environmental conditions.

Direct payment will not be made for work carried out in accordance with this Clause. The cost of all work in the borrow areas and on the stockpile shall be included in the respective rates for various zones of earth fill.

5-3.6 Quarries

5-3.6.1 General

(i) The Contractor shall operate any approved quarry in accordance with this Clause to obtain material additional to that usable material available from the required excavation, for use as:

- Rip-rap
- Drainage materials for fine and coarse filters
- Concrete aggregate
- Free draining backfill
- Road base course
- Stone Spawl or Bedding Material
- Other uses in the works.

(ii) Contractor may obtain acceptable material from Employer approved outside commercial quarries, without any additional cost to the haulage and procurement.

5-3.6.2 Method of Operation

The Contractor's proposed method of working the quarries shall be in accordance with the proposed quarry plan as approved by the Project Manager from time-to-time.

Nothing in this Clause shall relieve the Contractor from the responsibility for the adequacy and safety of the rock excavation operations.

5-3.7 Shoring

5-3.7.1 General Requirements

The Contractor shall submit a Shoring and Sheeting plan for approval 15 days prior to starting work. Submit drawings and calculations, certified by a registered professional engineer, describing the methods for shoring and sheeting of excavations. Shoring shall be furnished and installed as necessary to protect workmen, banks, adjacent paving, structures, and utilities. Shoring, bracing, and sheeting shall be removed, as excavations are backfilled, in a manner to prevent caving.

5-3.8 Grading Areas

Where indicated, work will be divided into grading areas within which satisfactory excavated material shall be placed in embankments, fills, and required backfills. The Contractor shall not haul satisfactory material excavated in one grading area to another grading area except when so directed in writing. Stockpiles of satisfactory, unsatisfactory and wasted materials shall be placed and graded as specified. Stockpiles shall be kept in a neat and well drained condition, giving due consideration to drainage at all times. The ground surface at stockpile locations shall be cleared, grubbed, and sealed by rubber-tired equipment, excavated satisfactory and unsatisfactory materials shall be separately stockpiled. Stockpiles of satisfactory materials shall be protected from contamination, which may destroy the quality and fitness of the stockpiled material. If the Contractor fails to protect the stockpiles, and any material becomes unsatisfactory, such material shall be removed and replaced with satisfactory material from approved sources.

5-3.9 Final Grade of Surfaces to Support Concrete

Excavation to final grade shall not be made until just before concrete is to be placed. Only excavation methods that will leave the foundation rock in a solid and unshattered condition shall be used. Approximately level surfaces shall be roughened, and sloped surfaces shall be cut as indicated into rough steps or benches to provide a satisfactory bond. Shales shall be protected from slaking and all surfaces shall be protected from erosion resulting from ponding or flow of water.

5-3.10 Ground Surface Preparation

5-3.10.1 General Requirements

Unsatisfactory material in surfaces to receive fill or in excavated areas shall be removed and replaced with satisfactory materials as directed by the Project Manager. The surface shall be scarified to a depth of 150 mm before the fill is started. Sloped surfaces steeper than 1 vertical to 4 horizontal shall be plowed, stepped, benched, or broken up so that the fill material will bond with the existing material. When subgrades are less than the specified density, the ground surface shall be broken up to a minimum depth of 150 mm, pulverized, and compacted to the specified density. When the subgrade is part fill and part excavation or natural ground, the excavated or natural ground portion shall be scarified to a depth of 300 mm and compacted as specified for the adjacent fill.

5-3.11 Utilization of Excavated Materials

Unsatisfactory materials removed from excavations shall be disposed of in designated waste disposal or spoil areas. Satisfactory material removed from excavations shall be used, insofar as practicable, in the construction of fills, embankments, subgrades, shoulders, bedding (as backfill), and for similar purposes. No satisfactory excavated material shall be wasted without specific written authorization. Satisfactory material authorized to be wasted shall be disposed of in designated areas approved for surplus material storage or designated waste areas as directed. Newly designated waste areas on Employer-controlled land shall be cleared and grubbed before disposal of waste material thereon. Coarse rock from excavations shall be stockpiled and used for constructing slopes or embankments adjacent to streams, or sides and bottoms of channels and for protecting against erosion. No excavated material shall be disposed of to obstruct the flow of any stream, endanger a partly finished structure, impair the efficiency or appearance of any structure, or be detrimental to the completed work in any way.

5-3.12 Backfilling and Compaction

Backfill adjacent to any and all types of structures shall be placed and compacted to at least 85 percent laboratory maximum density for cohesive materials or 85 percent laboratory maximum density for cohesionless materials to prevent wedging action or eccentric loading upon or against the structure. Ground surface on which backfill is to be placed shall be prepared as specified in **Sub-Clause 5-3.19.2 - Preparation of Ground Surface to Receive Fill**. Compaction requirements for backfill materials shall also conform to the applicable portions of Sub-clause 5-3.19.2 - Preparation of Ground Surface to Receive Fill, **Clause 5-3.14 - Embankments** and **Sub-Clause 5-3.15.3 - Compaction** shall be accomplished by sheep foot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment.

5-3.12.1 Backfill of Trench for Pipelines

Trenches shall be backfilled to the grade shown. The joints and couplings shall be left uncovered during the pressure test. The trench shall not be backfilled until all specified tests on pipeline are performed.

(a) Replacement of Unyielding Material

Unyielding material removed from the bottom of the trench shall be replaced with select granular material or initial backfill material.

(b) Replacement of Unstable Material

Unstable material removed from the bottom of the trench or excavation shall be replaced with select granular material placed in layers not exceeding 150 mm loose thickness.

(c) Bedding and Initial Backfill

Bedding shall be of the type and thickness shown. Initial backfill material shall be placed and compacted with approved tampers to a height of at least one foot above the utility

pipe or conduit. The backfill shall be brought up evenly on both sides of the pipe for the full length of the pipe. Care shall be taken to ensure thorough compaction of the fill under the haunches of the pipe. Except as specified otherwise in the individual piping section, provide bedding for buried piping in accordance with AWWA C600, Type 4, except as specified herein. Backfill to top of pipe shall be compacted to 95 percent of ASTM D 698 maximum density. Plastic piping shall have bedding to spring line of pipe. Provide materials as follows as shown on drawings:

(i) Clean, coarse-grained sand classified as SW or SP by ASTM D 2487

(ii) Clean, coarsely graded natural gravel, crushed stone or a combination thereof having a classification of GW or GP in accordance with ASTM D 2487 for bedding and backfill as indicated. Maximum particle size shall not exceed 75 mm.

(d) Final Backfill

The remainder of the trench shall be filled with satisfactory material. Backfill material shall be placed and compacted as follows:

(i) Roadways: Backfill shall be placed up to the required elevation as specified. Water flooding or jetting methods of compaction will not be permitted.

(ii) Sidewalks, Turfed or Seeded Areas and Miscellaneous Areas: Backfill shall be deposited in layers of a maximum of 300 mm loose thickness, and compacted to 85 percent maximum density for cohesive soils and 90 percent maximum density for cohesionless soils. Compaction by water flooding or jetting will not be permitted. This requirement shall also apply to all other areas not specifically designated above.

5-3.12.2 Backfill for Pipeline Appurtenances

After the manhole, catch basin, inlet, or similar structure has been constructed and the concrete has been allowed to cure for 14 days, backfill shall be placed in such a manner that the structure will not be damaged by the shock of falling earth. The backfill material shall be deposited and compacted as specified for final backfill, and shall be brought up evenly on all sides of the structure to prevent eccentric loading and excessive stress.

5-3.13 Special Requirements for Excavation and Backfill

Special requirements for both excavation and backfill relating to the specific utilities are as follows:

5-3.13.1 Water Lines

Trenches shall be of a depth to provide a minimum cover of 600 mm from the existing ground surface, or from the indicated finished grade, whichever is lower, to the top of the pipe. For fire protection yard mains or piping, an additional 500 millimeters of cover is required.

5-3.13.2 Electrical Distribution System

Direct burial cable and conduit or duct line shall have a minimum cover of 600 mm from the finished grade, unless otherwise indicated.

5-3.13.3 Sewage Absorption Trenches or Pits

Backfill material consisting of clean crushed rock or gravel having a gradation conforming to the requirements of gradation 4.75 mm for coarse aggregate in ASTM C 33.

5-3.13.4 Underdrainage Systems

Clean sand, crushed rock, or gravel meeting the following requirements:

(i) Perforated or Slotted-Wall Pipe: Backfill meeting requirements of Type I material as specified in **Table 5-4**. Place granular materials as pipe is laid and extend fit for a minimum of one pipe diameter on each side of and 450 mm above the top of the pipe. Place a layer of kraft paper on top of granular filter before continuing with the backfill.

(ii) Open Joint Pipe: Place both types of granular material specified as pipe is laid forming an aggregate filter around the pipe. Provide Type II material to envelope the pipe a minimum of one-half the pipe diameter or twice the maximum aggregate size, whichever is larger, on each side and on top of the pipe. Place Type I material next to and on top of the Type II material to provide a total fill extending at least one pipe diameter on each side of and 450 mm above the top of the pipe. Place a layer of kraft paper on top of the granular filter before continuing with the backfill.

(iii) Any Type Drain Used with Filter Fabric: Clean gravel or crushed stone or gravel conforming to ASTM C 33 coarse aggregate grading size 57, 67, or 7.

Table 5-4

ASTM D 422 Sieve Size	Type I Gradation E 11 ASTM C 33	Type II Gradation 57 ASTM C 33
	Percent Passing	Percent Passing
37.5 mm	--	100
25.0 mm	--	90 – 100
9.5 mm	100	25 – 60
4.75 mm	95 – 100	5 - 40
2.36 mm	--	0 - 20
1.18 mm	45 – 80	--
300 micrometres	10 – 30	--
150 micrometres	0 – 10	--

5-3.14 Embankments

5-3.14.1 Earth Embankments

Earth embankments shall be constructed from satisfactory materials free of organic or frozen material and rocks with any dimension greater than 75 mm. The material shall be placed in successive horizontal layers of loose material not more than 230 mm in depth or as specified in the BoQs. Each layer shall be spread uniformly on a soil surface that has

been moistened or aerated as necessary, and scarified or otherwise broken up so that the fill will bond with the surface on which it is placed. After spreading, each layer shall be plowed, disked, or otherwise broken up; moistened or aerated as necessary; thoroughly mixed; and compacted to at least 85 percent laboratory maximum density for cohesive materials or 85 percent laboratory maximum density for cohesionless materials. Compaction requirements for the upper portion of earth embankments forming subgrade for pavements shall be identical with those requirements specified in **Clause 5-3.15 - Subgrade Preparation**. Compaction shall be accomplished by sheeps foot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment.

5-3.14.2 Rock Embankments

Rock embankments shall be constructed from material classified as rock excavation, as defined above, placed in successive horizontal layers of loose material not more than 450 mm in depth or as specified in BoQ. Pieces of rock larger than 230 mm in the greatest dimension shall not be used. Each layer of material shall be spread uniformly, completely saturated, and compacted to a minimum density of 1800 kg/cubic meter. Each successive layer of material shall adequately bond to the material on which it is placed. Compaction shall be accomplished with vibratory compactors weighing at least 10 metric tons, heavy rubber-tired rollers weighing at least 20 metric tons, or steel-wheeled rollers weighing at least 12 metric tons. Rock excavation shall not be used as fill material for the construction of pavements.

5-3.15 Subgrade Preparation

5-3.15.1 Proof Rolling

Proof rolling shall be done on an exposed subgrade free of surface water (wet conditions resulting from rainfall), which would promote degradation of an otherwise acceptable subgrade. After stripping, proof roll the existing subgrade with six passes of a 13.6-meter tons, pneumatic-tired roller. Operate the roller in a systematic manner to ensure the number of passes over all areas, and at speeds between 4 to 5.5 km/hour. When proof rolling, one-half of the passes made with the roller shall be in a direction perpendicular to the other passes. Notify the Project Manager a minimum of 3 days prior to proof rolling. Proof rolling shall be performed in the presence of the Project Manager. Rutting or pumping of material shall be undercut as directed by the Project Manager and replaced with fill material. No separate payment will be made for operations of cutting and replacing of affected area.

5-3.15.2 Construction

Subgrade shall be shaped to line, grade, and cross section, and compacted as specified. This operation shall include plowing, disking, and any moistening or aerating required to obtain specified compaction. Soft or otherwise unsatisfactory material shall be removed and replaced with satisfactory excavated material or other approved material as directed. Rock encountered in the cut section shall be excavated to a depth of 150 mm below

finished grade for the subgrade. Low areas resulting from removal of unsatisfactory material or excavation of rock shall be brought up to required grade with satisfactory materials, and the entire subgrade shall be shaped to line, grade, and cross section and compacted as specified. The elevation of the finish subgrade shall not vary more than 15 mm from the established grade and cross section.

5-3.15.3 Compaction

Compaction shall be accompanied by sheep foot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment.

(a) Subgrade for Pavements

Subgrade for pavements shall be compacted to at least 95 - percentage laboratory maximum density for the depth below the surface of the pavement shown. When more than one soil classification is present in the subgrade, the top 200 mm of subgrade shall be scarified, windrowed, thoroughly blended, reshaped, and compacted.

(b) Subgrade for Shoulders

Subgrade for shoulders shall be compacted to at least 95 - percentage laboratory maximum density for the full depth of the shoulder.

5-3.16 Shoulder Construction

Shoulders shall be constructed of satisfactory excavated or borrow material or as otherwise shown or specified. Shoulders shall be constructed as soon as possible after adjacent paving is complete. The entire shoulder area shall be compacted to at least the percentage of maximum density as specified in **Clause 5-3.15 - Subgrade Preparation** above, for specific ranges of depth below the surface of the shoulder. Compaction shall be accomplished by sheep foot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment. Shoulder construction shall be done in proper sequence in such a manner that adjacent ditches will be drained effectively and that no damage of any kind is done to the adjacent completed pavement. The completed shoulders shall be true to alignment and grade and shaped to drain in conformity with the cross section shown.

5-3.17 Finishing

The surface of excavations, embankments, and subgrades shall be finished to a smooth and compact surface in accordance with the lines, grades, and cross sections or elevations shown. The degree of finish for graded areas shall be within 30 mm of the grades and elevations indicated except that the degree of finish for subgrades shall be specified in **Clause 5-3.15 - Subgrade Preparation**. Gutters and ditches shall be finished in a manner that will result in effective drainage. The surface of areas to be turfed shall be finished to smoothness suitable for the application of turfing materials. Settlement or washing that occurs in graded, topsoiled, or backfilled areas prior to acceptance of the work shall be repaired and grades re-established to the required elevations and slopes.

5-3.17.1 Subgrade and Embankments

During construction, embankments and excavations shall be kept shaped and drained. Ditches and drains along subgrade shall be maintained to drain effectively at all times. The finished subgrade shall not be disturbed by traffic or other operation and shall be protected and maintained by the Contractor in a satisfactory condition until, subbase, base, or pavement is placed. The storage or stockpiling of materials on the finished subgrade will not be permitted. No subbase, base course, or pavement shall be laid until the subgrade has been checked and approved, and in no case shall subbase, base, surfacing, pavement, or ballast be placed on a muddy, spongy, or frozen subgrade.

5-3.17.2 Grading Around Structures

Areas within 1.5 m outside of each building and structure line shall be constructed true-to-grade, shaped to drain, and shall be maintained free of trash and debris until final inspection has been completed and the work has been accepted.

5-3.18 Placing Topsoil

On areas to receive topsoil, the compacted subgrade soil shall be scarified to a 50 mm depth for bonding of topsoil with subsoil. Topsoil then shall be spread evenly to a thickness of 200 mm and graded to the elevations and slopes shown. Topsoil shall not be spread when excessively wet or dry. Material required for topsoil in excess of that produced by excavation within the grading limits shall be obtained from offsite areas.

5-3.19 Filling and Backfilling

5-3.19.1 Preparations Prior to Backfill Placement

Excavations shall be backfilled as promptly as the work permits but not until completion of the following:

- Approval of construction below finish grade
- Inspection, testing, approval, and recording location of underground utilities
- Removal of concrete formwork Removal of shoring and bracing; backfilling of voids with satisfactory soil material; temporary sheet piling driven below bottom of structures; and cutting off and removing of utilities in a manner that prevents settlement of the structure or utilities
- Removal of trash and debris
- Completion of concrete waterproofing

5-3.19.2 Preparation of Ground Surface to Receive Fill

Vegetation, debris, unsatisfactory soil materials, obstructions, and deleterious materials shall be removed from ground surface prior to the placement of fills. Sloped surfaces steeper than 1 vertical to 4 horizontal shall be plowed, stripped, or broken up in such manner that fill material will bond with the existing material.

When the ground surface has a density less than that specified for the particular area classification, the ground surface shall be broken up, pulverized, moisture-conditioned to near optimum moisture content of the soil material, and compacted to the required depth and percentage of maximum density.

5-3.19.3 Placement and Compaction

Backfill and fill materials shall be placed in layers not more than 150 millimeter in loose depth. Before compaction, each layer of backfill or fill material shall be moistened or aerated as necessary to provide the optimum moisture content of the soil material and shall then be compacted to the percentage of maximum density for each area classification as specified. Backfill or fill material shall not be placed on surfaces that are muddy, frozen, icy, or contain frost.

Backfill and fill materials adjacent to structures shall be brought up evenly around structures and shall be carried up to the indicated elevations.

Compaction adjacent to structures, within a horizontal distance from the face of the structure equal to the depth of backfill or fill material (measured from the bottom of footing or bottom of foundation or retaining wall) to final grade, shall be done with power-driven hand tampers.

5-3.20 Compaction

Degree of compaction required is expressed as a percentage of the maximum density obtained by the test procedure in AASHTO T 180, Methods B or D.

5-3.20.1 Percentage of Maximum Density Requirements

Actual density of each layer of soil material-in-place shall be not less than the following percentages of the maximum density of the same soil material determined by the moisture-density test specified.

Table 5-6

Area Classification	**Percent Maximum Density**	
	Cohesionless Soil Material	**Cohesive Soil Material**
Structures		
Each layer of back-fill material	95%	98%
Building Slabs and Steps		
Top 300 millimeter of subgrade and each layer of backfill material	98%	98%

5-3.20.2 Moisture Control

Moisture content in soil material at time of compaction shall be within limits specified.

Where the moisture content of a layer of soil material is below optimum before compaction, the required amount of water shall be uniformly applied to the surface of the layer of soil material and the layer of soil disked or otherwise mixed until uniform moisture content is reached.

Moisture of a layer of soil material that is above optimum shall be removed by drying.

5-3.21 Disposition of Surplus Material

Surplus material or other soil material not required or suitable for filling or backfilling, and brush, refuse, stumps, roots, and timber shall be removed from Employer property as directed by the Project Manager.

5-3.22 Testing

Testing shall be performed by an approved commercial testing laboratory or by the Contractor subject to approval. If the Contractor elects to establish testing facilities, no work requiring testing will be permitted until the Contractor's facilities have been inspected and approved by the Project Manager. Field in-place density shall be determined in accordance with ASTM D 1556 or ASTM D 2167 or ASTM D 2922. When ASTM D 2922 is used, the calibration curves shall be checked and adjusted using only the sand cone method as described in ASTM D 1556. ASTM D 2922 results in a wet unit weight of soil and when using this method ASTM D 3017 shall be used to determine the moisture content of the soil. The calibration curves furnished with the moisture gauges shall also be checked along with density calibration checks as described in ASTM D 3017; the calibration checks of both the density and moisture gauges shall be made at the beginning of a job on each different type of material encountered and at intervals as directed by the Project Manager. ASTM D 2937, Drive Cylinder Method shall be used only for soft, fine-grained, cohesive soils. When test results indicate, as determined by the Project Manager, that compaction is not as specified, the material shall be removed, replaced and recompacted to meet specification requirements. Tests on recompacted areas shall be performed to determine conformance with specification requirements. Inspections and test results shall be certified by a registered professional civil engineer. These certifications shall state that the tests and observations were performed by or under the direct supervision of the Project Manager and that the results are representative of the materials or conditions being certified by the tests. The following number of tests, if performed at the appropriate time, will be the minimum acceptable for each type operation.

5-3. 22.1 Fill and Backfill Material Gradation

One test per 400 cubic meters stockpiled or in-place source material. Gradation of fill and backfill material shall be determined in accordance with ASTM C 136 or ASTM D 422 or ASTM D 1140.

5-3. 22.2 In-Place Densities

Table 5-7

Material Type	Location of Material	Test Frequency
Undisturbed native soil	Structures	Two random tests in building footings and two tests on subgrade within building line
Fills and backfills	Structures (adjacent to)	One test per structure per 200 sq. m taken 300 mm below finished grade.
Subgrades		One test per lift per 250 sq. m
Embankments or borrow	Any	One test per lift per 400 cubic m placed.
Native soil subgrade other than structures and parking	Any	One test or one test per 900 sq.m whichever is greater.
Borrow	Any	One test per lift per 400 cubic m placed.

5-3. 22.3 Moisture Contents

In the stockpile, excavation, or borrow areas, a minimum of two tests per day per type of material or source of material being placed during stable weather conditions shall be performed. During unstable weather, tests shall be made as dictated by local conditions and approved by the Project Manager.

5-3. 22.4 Optimum Moisture and Laboratory Maximum Density

Tests shall be made for each type material or source of material including borrow material to determine the optimum moisture and laboratory maximum density values. One representative test per 400 cubic meters of fill and backfill, or when any change in material occurs which may affect the optimum moisture content or laboratory maximum density.

5-3. 22.5 Tolerance Tests for Subgrades

Continuous checks on the degree of finish specified in **Clause 5-3.15 - Subgrade Preparation** shall be made during construction of the subgrades.

PART 4 MEASUREMENT AND PAYMENT

5-4.1 Jungle Clearing

5-4.1.1 Measurement

Measurement for payment, of clearing of the jungle area for construction of weir, main canal, distributaries, and hydraulic structures will be made of the horizontal projection of the areas actually cleared as shown on drawings and instructed by the Project Manager. Clearing for temporary access or haul roads, construction facilities and other temporary works, quarries and borrow areas shall not be measured for payment.

Clearing and grubbing operations involving the clearance of grass for removal of rubbish shall not be measured for payment. Its cost shall be deemed to be included in the unit rate for excavation.

5-4.1.2 Payment

Payment for jungle clearing for construction of weir, main canal, distributaries and hydraulic structures measured as above will be made at the rate per square meter tendered therefor in the priced Bill of Quantities.

Payment shall include all costs associated with furnishing plant, labor, materials and equipments, and performing all operations necessary for clearing as specified.

The cost of clearing areas other than the weir, under sluice, guide bunds, canal and hydraulic structures area shall be deemed to be included in the rates tendered in the priced Bill of Quantities for the various items of the Works. No separate payment shall be made for clearing areas other than weir, canals and area of permanent structures sites.

5-4.1.3 Unit of Measure

Unit of measure: Square meter

5-4.2 Stripping of Topsoil ,

No measurement for payment shall be made for stripping of topsoil upto depth of 150 mm. However, stripping of top soil in depth greater than 150 mm when instructed by the Project Manager shall be measured and paid as excavation of the relevant material.

5-4.3 Excavation

5-4.3.1 Measurement

Measurement, for payment, of surface excavation for canals, distributaries, hydraulic structures and roads will be made of the volume of material excavated to the lines, grades and dimensions shown on the Drawings or directed and shall be taken only in the presence of the Project Manager. The Project Manager shall be notified at least 24 hours before such measurements are taken. Before commencing and immediately after completion of surface excavation, the Contractor shall take survey measurements sufficient to define the dimensions and elevations of the original and final surfaces. Measurement will be made separately for common and rock excavation as defined in **Clause 5-1.10 – Classification of Excavation**.

Also measurement will be made separately for building foundation. The measurement will not include the volume of subgrade material, or other material that is scarified or plowed and reused in-place, and will not include the volume excavated without authorization or the volume of any material used for purposes other than directed. The measurement will not include the volume of any excavation performed prior to the taking of elevations and measurements of the undisturbed grade. The measurement will not include the volume of any excavation which is required by the Contractor for working space or for shoring and supporting the excavated slopes.

5-4.3.2 Payment

Payment for the various items of surface excavation will be made at the applicable rates per cubic meter tendered therefor in the priced Bill of Quantities. These rates shall include the costs of all labour, materials, temporary construction, pumping, bailing, draining, shoring and all other work necessary to maintain the surface excavations in good order during construction and of removing such temporary construction if so directed. These rates shall also include the entire cost of clearing and stripping of Soil provided in **Clauses 5-3.1 and 5-3.2** of excavating and transporting the materials from the excavation to the point of final use, or to disposal; and, where stockpiles are used. The cost of transporting the material to the stockpiles; of re-handling and of transporting such material to the point of final use; and the entire cost of cleaning up excavated surfaces. The rates shall also include dressing and leveling of the excavated surfaces to the designed sections.

Direct payment will not be made for work carried out in accordance with this Clause. The cost of all work in the quarries including clearing, excavation, separating, selecting, processing, hauling and dumping of unsuitable materials and of soil conservation measures shall be included in the rates tendered in the Bill of Quantities for the items for which the materials form the quarries are used.

5-4.3.3 Unit of Measure

Unit of measure: Cubic Meter

5-4.4 Embankment Fill

5-4.4.1 Measurement

Measurement, for payment, of furnishing, placing and compacting embankment fill other than canal and distributaries embankments will be made of the volume of compacted material in place to the lines grades and dimensions shown on the Drawings or directed. Measurement for furnishing, placing and compacting canal and distributaries embankments shall be made as per Section 7 of these specifications. Clearing and stripping of top soil upto depth of 150 mm shall not be measured for payment.

5-4.4.2 Payment

Payment for furnishing, placing and compacting embankment fill other than canal and distributaries embankments will be made at the rate per cubic meter tendered therefor in the priced Bill of Quantities. These rates shall the costs of all labour, material, equipment for temporary constructions, clearing and stripping of top soil, preparation of foundations for embankment fill, furnishing and preparation of required test fills, providing fill materials from stockpiles or sources other than required excavation, placing and spreading of fill materials in layers of specified thickness, removal of objectionable and unsuitable materials, moistening the fill materials at the place of excavations, stockpiles or at the embankments, embankment compaction, providing machinery for compaction, testing, and all other activities and operations incidental to the furnishing, placement and compaction of the fill materials in embankments other than canal and distributaries

embankments according to the Specifications set forth or as directed by the Project Manager.

Material from required excavation used for embankment fill will be paid for both as excavation when removed from required excavation and as fill when placed. Payment will not be made for excavating materials from stockpiles or sources other than required excavation.

Payment for furnishing, placing and compacting canal and distributaries embankments shall be made as per Section 7 of these specifications

5-4.4.3 Unit of Measure

Unit of measure: Cubic Meter

5-4.5 Backfill

5-4.5.1 Measurement

Measurement, for payment, of furnishing, placing and compacting backfill will be made of the volume of material in place to the lines grades and dimensions shown on the Drawings or directed.

5-4.5.2 Payment

Payment for furnishing, placing and compacting backfill will be made at the rate per cubic meter tendered therefore in the priced Bill of Quantities. Material from required excavation or from the quarry used for backfill will be paid for both as excavation when removed and as backfill when placed. Payment will not be made for excavating materials from stockpiles or sources other than required excavation.

5-4.5.3 Unit of Measure

Unit of measure: Cubic Meter

CHAPTER 6 – PROTECTION OF SLOPES AND CHANNELS

PART 1 GENERAL

6-1.1 Scope

The Contractor shall protect, fill and cut slopes, banks and beds of channels and streams, by methods as shown on the Drawings or as directed. Excavated surfaces shall be protected where shown on Drawings or as directed.

The methods of protection are riprap and stone pitching.

The cost of furnishing and construction protection works, other than those shown on Drawings or as directed by the Project Manager, shall be deemed to include in the rates tendered in the priced Bill of Quantities for excavation for parts of the Works where such supports are used.

6-1.2 References

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM International (ASTM)	
ASTM A 370	(2003a) Mechanical Testing of Steel Products
ASTM A 428/A 428M	(2001) Weight (Mass) of Coating on Aluminum-Coated Iron or Steel Articles
ASTM A 641/A 641M	(1998) Zinc-Coated (Galvanized) Carbon Steel Wire
ASTM A 809	(2003) Standard Specification for Aluminum-Coated (Aluminized) Carbon Steel Wire
ASTM A 856/A 856M	(1998) Zinc-5% Aluminum-Mischmetal Alloy-Coated Carbon Steel Wire
ASTM A 90/A 90M	(2001) Weight (Mass) of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings
ASTM A 974	(2003)Standard Specification for Welded Wire Fabric Gabions and Gabion Mattresses (Metallic Coated or Polyvinyl Chloride (PVC) Coated)
ASTM A 975	(1997; R 2003) Double-Twisted Hexagonal Mesh Gabions and Revet Mattresses (Metallic-Coated Steel Wire or Metallic-Coated Steel Wire With Poly(Vinyl Chloride) (PVC) Coating)
ASTM B 117	(2002) Operating Salt Spray (Fog) Apparatus
ASTM C 127	(2001) Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C 136	(2001) Sieve Analysis of Fine and Coarse Aggregates
ASTM C 150	(2004) Standard Specification for Portland Cement
ASTM C 171	(2003) Standard Specification for Sheet Materials for Curing Concrete

ASTM C 172	(2004) Standard Practice for Sampling Freshly Mixed Concrete
ASTM C 231	(2003) Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 295	(2003) Petrographic Examination of Aggregates for Concrete
ASTM C 260	(2001) Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C 33	(2003) Concrete Aggregates
ASTM C 31/C 31M	(2003)a Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C 39/C 39M	(2003) Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C 309	(2003) Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 143/C 143M	(2003) Standard Test Method for Slump of Hydraulic Cement Concrete
ASTM C 494/C 494M	(2004) Standard Specification for Chemical Admixtures for Concrete
ASTM C 618	(2003) Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete
ASTM C 685/C685M	(2001) Standard Specification for Concrete Made By Volumetric Batching and Continuous Mixing
ASTM C 94/C 94M	(2004) Standard Specification for Ready-Mixed Concrete
ASTM D 1117	(2001) Standard Guide for Evaluating Nonwoven Fabrics
ASTM D 1242	(1995a) Resistance of Plastic Materials to Abrasion
ASTM D 1499	(1999) Filtered Open-Flame Carbon-Arc Type Exposures of Plastics
ASTM D 2240	(2003) Rubber Property - Durometer Hardness
ASTM D 412	(1998a; R 2002e1) Vulcanized Rubber and Thermoplastic Elastomers – Tension
ASTM D 746	(1998e1) Brittleness Temperature of Plastics and Elastomers by Impact
ASTM D 792	(2000) Density and Specific Gravity (Relative Density) of Plastics by Displacement
ASTM D 123	(2003) Textiles
ASTM D 4355	(2002) Deterioration of Geotextiles from Exposure to Light, Moisture and Heat in a Xenon-Arc Type Apparatus
ASTM D 4491	(1999) Standard Test Methods for Water Permeability of Geotextiles by Permittivity

ASTM D 4751	(1999a) Determining Apparent Opening Size of a Geotextile
ASTM D 4873	(2002) Identification, Storage, and Handling of Geosynthetic Rolls and Samples
ASTM D 4884	(1996) Strength of Sewn or Thermally Bonded Seams of Geotextiles
ASTM D 3740	(2001) Minimum Requirements for Agencies Engaged in the Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
ASTM D 3787	(2001) Test Method for Bursting Strength of Textiles-Constant-Rate-of-Traverse (CRT) Ball Burst Test
ASTM D 4791	(1999) Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D 4992	(1994; R 2001) Evaluation of Rock to be Used for Erosion Control
ASTM D 5034	(2001) Standard Test Method for Breaking Strength and Elongation of Textile Fabrics (Grab Test)
ASTM D 5312	(1992; R 1997) Evaluation of Durability of Rock for Erosion Control Under Freezing and Thawing Conditions
ASTM D 5313	(1992; R 1997) Evaluation of Durability of Rock for Erosion Control Under Wetting and Drying Conditions
ASTM D 5519	(1994; R 2001) Particle Size Analysis of Natural and Man-Made Riprap Materials
ASTM D 6473	(1999) Standard Test Method for Specific Gravity and Absorption of Rock For Erosion Control
ASTM D 75	(2003) Sampling Aggregates
ASTM E 548	(1994e1) General Criteria Used for Evaluating Laboratory Competence
ASTM G 152	(2000ae1) Operating Open Flame Carbon Arc Light Apparatus for Exposure of Nonmetallic Materials
U.S. Army Corps of Engineers (USACE)	
COE CRD-C 148	(1969) Method of Testing Stone for Expansive Breakdown on Soaking in Ethylene Glycol

6-1.3 Submittals

The following shall be submitted for Project Manager's review and approval in accordance with **Clause 1-1.4 - Submittal Procedures**:

SD-03 Product Data
Bedding Material

Submit the source for materials used in riprap and bedding.

Conveying and Placing

Submit the methods and equipment for transporting, handling, depositing, and consolidating the grout prior to first grout placement.

Admixtures
Curing Materials

Submit manufacturers' literature for the concrete admixtures and curing materials.

Batching and Mixing Equipment

Submit manufacturers' data on the concrete grout batching and mixing equipment.

Concrete Grout Mixture Proportions

Ten days prior to placement, submit the mixture proportions that will produce grout of the qualities required.

SD-04 Samples
Stone

Submit suitable stone samples prior to delivery of any such material to the worksite if stone is not from one of the stone sources listed at the end of this section.

Gabions or Mattresses
Alternative Wire Fasteners

Samples of the materials, used to fabricate the gabions or mattresses, shall be furnished to the Project Manager 60 days prior to assembly of units onsite so that testing may be prescribed by the Project Manager in accordance with either ASTM A 974 or ASTM A 975 depending on which system is being furnished by the Contractor. The Contractor shall arrange testing at approved laboratory at his own cost.

Geotextile

If requested, submit geotextile samples for testing to determine compliance with the requirements in this specification. When required, submit samples a minimum of 60 days prior to the beginning of installation of the same textile. Upon delivery of the geotextile, submit duplicate copies of the written certificate of compliance signed by a legally authorized official of the manufacturer. The certificate shall state that the geotextile shipped to the site meets the chemical requirements and exceeds the minimum average roll value listed in **Table 6-5** Minimum Physical Requirements For Drainage Geotextile. Upon request, supply quality control and quality assurance tests for the geotextile. All samples provided shall be from the same production lot as will be supplied for the contract, and shall be the full manufactured width of the geotextile by at least 3 m long, except that samples for seam strength may be a full width sample folded over and the edges stitched for a length of at least 1.5 m. Samples submitted for testing shall be identified by manufacturers lot designation. For needle punched geotextile, the manufacturer shall certify that the geotextile has been inspected using permanent on-line metal detectors and does not contain any needles.

SD-06 Test Reports
Gradation Test

Submit the gradation tests results for riprap or stone.

Evaluation Testing of Stone

Quality test on the stone in accordance with **Part 2 Sub-Clause 6-2.2.1 (a) - Evaluation Testing of Stone** shall be the responsibility of the Contractor. Prior to delivery of such material to the worksite, submit a copy of the laboratory inspection and test reports along with actions taken to correct deficiencies.

Bedding Material

Submit test reports attesting that the bedding material meet specified requirements.

Bulk Specific Gravity

At least 120 calendar days in advance of shipment of stone to the work site, submit a copy of bulk specific gravity test results for each gradation range of stone proposed to be furnished. The information shall be furnished prior to preparation of pre-production demonstration stockpiles.

Gabions or Mattresses
Alternative Wire Fasteners

For each shipment of wire gabions or mattresses delivered to the site, the Contractor shall furnish the Project Manager, in duplicate, test reports or records that have been performed during the last year on all material contained within the shipment meets the composition, physical, and manufacturing requirements stated in this specification.

SD-07 Certificates
Stone
Bedding Material

Submit certificates of compliance attesting that the materials meet specification requirements.

Laboratory

Submit a copy of the documents that validates that the laboratory proposed by the Contractor can perform the required tests. The individual tests shall be listed for which the validation covers along with the date of the inspection.

Weigh Scale Certification

Submit a copy of the certification from the regulation agency attesting to the scale's accuracy.

Certified Weight Scale Tickets

Submit a copy of each certified weight scale ticket 3 working day(s) after weighing.

Stone Fill
Filter Material

A certificate signed by a legally authorized official of the supplier of the stone fill and the supplier of the gravel bedding material that meets the quality required and gradation limits specified.

Geotextile

Submit the manufacturer's certification of the geotextile material.

6-1.4 Testing and Studies

6-1.4.1 Stone

(a) General

All stone shall be durable material as approved by the Project Manager. Selected stone from the required excavation may be used if it satisfies all requirements as to quality and dimensions. The Contractor shall show that at proposed source an adequate quantity of material is available and provide quality test data. Stone shall be of a suitable quality to ensure permanence in the structure and in the climate in which it is to be used. It shall be free from cracks, blast fractures, bedding, seams and other defects that would tend to increase its deterioration from natural causes. Inspections for cracks, fractures, seams and defects shall be made by visual examination. If, by visual examination, it is determined that 15 percent or more of the stone produced contains hairline cracks, then all stone produced by the means and measures which caused the fractures shall be rejected. A hairline crack that is defined as being detrimental shall have a minimum width of 0.1 mm and shall be continuous for one-third the dimension of at least two sides of the stone. The stone shall be clean and reasonably free from soil, quarry fines, and shall contain no refuse. The stone shall be clean and adequately free from all foreign matter. Any foreign material adhering to or combined with the stone as a result of stockpiling shall be removed prior to placement.

(b) Sources

Stone shall be furnished from the sources designated by the Contractor and accepted by the Project Manager, subject to the conditions herein stated. Satisfactory service records on other work may be acceptable. In order for stone to be acceptable on the basis of service records, stone of a similar size must have been placed in a similar thickness and exposed to weathering under similar conditions as are anticipated for this contract, and must have satisfactorily withstood such weathering for a minimum of 10 years.

(i) Selection of Source

The Contractor shall designate in writing only one source or one combination of sources from which he proposes to furnish stone. It is the Contractor's responsibility to determine that the stone source or combination of sources selected is capable of providing the

quantities and gradation needed and at the rate needed to maintain the scheduled progress of the work.

(ii) Acceptance of Materials

Acceptance of a source of stone is not to be construed as acceptance of all material from that source. The right is reserved to reject materials from certain localized areas, zones, strata, or channels, when such materials are unsuitable for stone as determined by the Project Manager. The Project Manager also reserves the right to reject individual units of produced specified materials in stockpiles at the quarry, all transfer points, and at the project construction site when such materials are determined to be unsuitable. During the contract period, both prior to and after materials are delivered to the job site, visual inspections and measurements of the stone materials may be performed by the Project Manager. If the Project Manager, during the inspections, finds that the stone quality, gradation or weights of stone being furnished are not as specified or are questionable, re-sampling and re-testing by the Contractor shall be required. Sampling of the delivered stone for testing and the manner in which the testing is to be performed shall be as directed by the Project Manager. The sampling and testing shall be performed at the Contractor's expense. Any material rejected shall be removed or disposed of as specified and at the Contractor's expense.

(c) Evaluation Testing of Stone

The tests to which the stone may be subjected will include petrographic analysis, specific gravity, unit weight, absorption, wetting and drying, freezing and thawing and such other tests as may be considered necessary to demonstrate that the stone is of a satisfactory quality which is at least equivalent to stone from the sources listed at the end of this section.

(i) Unit Weight Bulk Specific Gravity, Saturated Surface Dry (SSD) and Absorption

Stone shall weigh more than 2500 kN/m^3 have a bulk specific gravity, saturated surface dry (SSD), greater than 2.48. The stone shall have absorption less than 2 percent unless other tests and service records show that the stone is satisfactory. The method of test for unit weight bulk specific gravity (SSD) and absorption will be ASTM C 127, except the unit weight will be calculated in accordance with Note No. 5 using bulk specific gravity, saturated surface dry.

(ii) Samples

Samples of stone from the stone source shall be taken by a representative of the quarry under the supervision of the Project Manager for testing and acceptance prior to delivery of any stone from this source to the site of the work. Samples shall consist of at least three pieces of stone, roughly cubical in shape and weighing not less than 70 kg each from each unit that will be used in the production of the required stone. If the source is an undeveloped quarry, or if the operation has been dormant for more than one year such that fresh samples are not available, the Contractor shall expose fresh rock for 6 m

horizontally and for the full height of the face proposed for production, prior to the field evaluation. The Project Manager may also require documentation of subsurface exploration of an undeveloped quarry in order to determine whether or not sufficient reserves are available. The samples shall be shipped at the Contractor's expense to the laboratory approved by the Project Manager.

(iii) Tests

The tests will be conducted in accordance with applicable Corps of Engineer methods of tests given in the Handbook for Concrete and Cement or ASTM methods of tests. The cost of testing one new source will be borne by the Contractor.

(d) Random Sampling

The stone produced by each source will be sampled by the Project Manager for Quality Assurance testing on the basis of a minimum once each year or once during the production of each 25 000 tons (metric) of stone produced each year. The samples will be evaluated based upon petrographic analysis, specific gravity, unit weight, bulk specific gravity (SSD), and absorption.

(e) Drop Test

A drop test provides an immediate evaluation of the durability of very large stone during handling of the stone including placement into a structure. For comparability, the test stone(s) shall be dropped from a bucket or by other means from a height of not less than half the average diameter of the stone onto a rigid surface or second stone of comparable size. Dumping from a truck is not acceptable. The stone shall be examined carefully before as well as after the completion of the test. Failure criteria is the development of new cracks, opening of old cracks, and the loss of piece from the surface of the stone. Each stone shall be dropped a total of five times for evaluation purposes with examination after each drop. The Contractor shall provide all necessary equipment and operating personnel to help perform the testing.

6-1.4.2 Concrete Grout for Stone Protection

(a) General

Samples of aggregates shall be obtained at the point of batching in accordance with ASTM D 75. Grout shall be sampled in accordance with ASTM C 172. The slump and air content shall be determined when cylinders are molded in accordance with ASTM C 143/C 143M and ASTM C 231, respectively. Compression test specimens shall be made, cured and transported in accordance with ASTM C 31/C 31M. Compression test specimens shall be tested in accordance with ASTM C 39/C 39M. Samples for strength tests shall be taken not less than once each shift in which grout is produced. A minimum of three specimens shall be made from each sample, two shall be tested at 28 days (90 days if pozzolan is used) for acceptance and one shall be tested at 7 days for information.

(b) Concrete Grout Mixture Proportions

Concrete rout mixture proportions shall be the responsibility of the Contractor. Mixture proportions shall be submitted for review 30 days prior to being used under this contract. Mixture proportions shall include the dry weights of cementitious material(s); the specific gravities, absorptions, and saturated surface-dry weights of the fine and coarse aggregates; the quantities, types, and names of admixtures; and quantity of water per cubic meters of grout. Also, applicable test reports, such as air content, compressive strength, and unit weight of the grout, shall be submitted to verify the proportions selected will produce grout of the quality specified. The approved grout mixture proportions shall not be changed without approval. The air content shall be between 4.5 and 7.5 percent. The specified compressive strength f'c shall be 1.8 kg/mm^2 (17.64 kPa) at 28 days (90 days if pozzolan is used). The maximum water cement ratio shall be 0.70. The slump of the grout mix shall be 150 mm plus or minus 25 mm. For maximum coarse aggregate size see **Sub-Clause 6-2.6.2 - Aggregates for Concrete Grout**.

(c) Evaluation and Acceptance of Grout

The acceptance test results will be the average of the strengths of the two specimens tested at 28 days (90 days if pozzolan is used). The strength of the concrete grout will be considered satisfactory so long as the average of three consecutive acceptance test results equal or exceed the specified compressive strength f'c and no individual acceptance test result falls below the specified strength f'c by more than 350 g/mm^2. (3.43 kPa)

6-1.4.3 Testing of Gabion and Mattresses

Samples of materials used to fabricate the Gabions or Mattresses shall be tested 60 days prior to start of installation. Samples shall be tested in accordance with specification and either ASTM A 975.

Copies of all test results carried out by manufacturer or Contractor shall be furnished to the Project Manager for review and approval.

6-1.5 Construction Tolerances

The finished surface and stone layer thickness shall not deviate from the lines and grades shown by more than the tolerances listed below. Tolerances are measured perpendicular to the indicated neat lines. Extreme limits of the tolerances given shall not be continuous in any direction for more than five (5) times the nominal stone dimension nor for an area greater than 20 m^2 of the structure surface.

Table 6-1

Neat line Tolerances

Material	*Above Neat line (mm)*	*Below Neat line (mm)*
Foundation	75	50
Bedding	50	0
Riprap and other Stone Layers	100	75

The intention is that the work shall be built generally to the required elevations, slope and grade and that the outer surfaces shall be even and presents a neat appearance. Placed material not meeting these limits shall be removed or reworked as directed by the Project Manager. Payment will not be made for excess material which the Project Manager permits to remain in place.

6-1.6 Description of Gabions and Mattresses

Gabions and mattresses are wire mesh containers of variable sizes, uniformly partitioned into internal cells, interconnected with other similar units, and filled with stone at the project site to form flexible, permeable, monolithic structures. Gabions and mattresses shall be manufactured with all components mechanically connected at the production facility with the exception of the mattress lid, which is produced separately from the base. The supply to the jobsite of unassembled individual wire mesh components (panels) forming gabions and mattresses will not be permitted. Definitions of terms specific to this specification and to all materials furnished on the jobsite, with the exception of the rock to fill the baskets and the filter material, shall refer and be in compliance with ASTM A 975 for double twisted wire mesh Gabions and Revet mattresses, or with ASTM A 974 for welded wire fabric Gabions and Gabion Mattresses. For ease of reference, the term "mattress" will be used in this specification in place of Revet mattress and/or Gabion mattress, where the statement is of general nature and it is not specific to the double twisted or welded wire mesh products.

6-1.6.1 Double Twisted Wire Mesh Gabions and Mattresses

They are classified according to the wire coating, which is applied prior to manufacturing the mesh. Coating styles are as follows:

Style 1, consists of wire mesh made from wire which is zinc coated before being double twisted into mesh. Fasteners, lacing wire, and stiffeners are produced from zinc-coated wire;

Style 2, consists of wire mesh made from wire which is coated with Zn-5Al-MM before being double twisted into mesh. Fasteners, lacing wire, and stiffeners are also produced from Zn-5Al-MM coated wire;

Style 3, consists of wire mesh, lacing wire, and stiffeners as Style 1 and over coated with PVC. Fasteners shall be of stainless steel wire;

Style 4, consists of wire mesh made from wire which is aluminum-coated before being double twisted into mesh. Fasteners, lacing wire, and stiffeners are also produced from aluminum-coated wire.

Style 1 for the wire coating is normally recommended for:

(a) Permanent gabion or mattress structures, for works installed in non-aggressive or non-polluted environments, and this condition remains unaltered over time;

(b) Temporary gabion or mattress structures, for works in moderately aggressive environments, depending on the minimum design life of the structure.

Style 2 for the wire coating is normally recommended for:

(1) Permanent gabion or mattress structures, for works installed in moderately aggressive environments;

(2) Temporary gabion or mattress structures, for works in aggressive environments, depending on the minimum design life of the structure.

Style 3 for the wire coating is normally recommended for both permanent and temporary gabion structures, for works installed in aggressive or polluted environments, or when the aggressiveness of the site is moderately unpredictable or variable from low to high.

Style 4 for the wire coating is very seldom used in the gabion industry. Its life expectancy shall be adequately documented to guarantee its consistency and reliability.

The determination of the rate of aggressiveness (non-aggressive, moderately, or highly aggressive) shall be made on a project-to-project basis, due to the many variables involved and the lack of criteria of general validity. It is normally recommended for the choice to be based on all the available data and on the experience of existing gabion structures in similar environments.

6-1.6.2 Welded Wire Fabric Gabions and Mattresses

The welded wire fabric gabions and mattress shall not be used in the project.

6-1.7 Shipment, Handling, and Storage of Geotextile

Only approved geotextile rolls shall be delivered to the project site. All geotextile shall be labeled, shipped, stored, and handled in accordance with ASTM D 4873. No hooks, tongs, or other sharp instruments shall be used for handling geotextile.

PART 2 PRODUCTS

6-2.1 Bedding Material

6-2.1.1 General

Bedding material shall consist of a washed gravel or crushed stone.

6-2.1.2 Material

Bedding material shall be composed of tough, durable particles, adequately free from thin, flat and elongated pieces, and shall contain neither organic matter nor soft, friable particles in quantities considered objectionable by the Project Manager. The aggregates shall meet the quality requirements of ASTM C 33. Gradation shall conform to the gradation limit shown on drawings:

The bedding material shall be well-graded between the limits shown. At least one test shall be performed on each 1000 tons to be delivered to the project site or placed for each specified gradation in accordance with ASTM C 136. A representative sample weighting not less than 45 kg shall be removed from the bedding layer placed at locations directed by the Project Manager. All points on individual grading curves obtained from representative samples of bedding material shall lie between the boundary limits as defined by smooth curves drawn through the tabulated gradation limits plotted on gradation envelope shown in drawing. The individual gradation curves within these limits shall not exhibit abrupt changes in slope denoting either gap grading or scalping of certain sizes or other irregularities which would be detrimental to the proper functioning of the bedding layers.

6-2.2 Stone

6-2.2.1 General

(a) Evaluation Testing of Stone

The Contractor shall have evaluation tests performed on stone samples collected from the proposed source for stone. The quarry investigation shall be performed by a registered geologist or registered Engineer. The tests to which the stone shall be subjected include petrographic examination (ASTM C 295), bulk specific gravity (SSD), unit weight, absorption (ASTM C 127), resistance of stone to freezing and thawing ASTM D 5312, and if argillaceous limestone and sandstone are used, resistance to wetting and drying ASTM D 5313.

The laboratory to perform the required testing shall be validated based on compliance with ASTM E 548 and relevant paragraphs of ASTM D 3740. No work requiring testing shall be permitted until the laboratory has been inspected and validated. The inspection of the facilities shall be at the at the expense of the Contractor.

(i) Bulk Specific Gravity Range

All stone shall have a minimum bulk specific gravity, saturated surface dry (SSD), of 2.50 and a maximum bulk specific gravity of not more than 2.90 based upon water having a unit weight of 1000 kN/m^3 The method of test for bulk specific gravity (SSD) shall be ASTM C 127.

(ii) Unit Weight and Absorption

Stone shall weigh more than 2500 kN/m^3 have a bulk specific gravity, saturated surface dry greater than 2.60. The stone shall have absorption less than 1 percent unless other

tests and service records show that the stone is satisfactory. The method of test for unit weight and absorption shall be ASTM C 127, except the unit weight shall be calculated in accordance with Note No. 5 using bulk specific gravity, saturated surface dry.

(iii) Petrographic Examination

Stone shall be evaluated in accordance with ASTM C 295 which shall include information required by ASTM D 4992, paragraph 10. COE CRD-C 148 shall be used to perform Ethylene glycol tests required on rocks containing smectite as specified in ASTM D 4992 and on samples identified to contain swelling clays.

(iv) Resistance of Rock to Wetting and Drying

Stone shall have a maximum loss of 1 percent when determining the durability of stone when subject to wetting and drying in accordance with ASTM D 5313, except the surface area of one side of the sample shall be between 0.093 mm^2 and 1.486 mm^2.

(v) Samples

Samples of stone from the proposed source of stone shall be taken by a representative of the Quarry under the supervision of the Project Manager for testing and acceptance prior to delivery of any stone from this source to the site of the work. Information provided with the samples shall include the location within the quarry from which the sample was taken along with a field examination of the quarry. The field examination shall include the information outline in ASTM D 4992, paragraph 7. Samples shall consist of at least three pieces of stone, roughly cubical in shape and weighing not less than 70 kg each from each unit that shall be used in the production of the required stone. If the source is an undeveloped quarry, or if the operation has been dormant for more than one year such that fresh samples are not available, the Contractor shall expose fresh rock for 6 m horizontally and for the full height of the face proposed for production, prior to the field evaluation. The Project Manager may also require documentation of subsurface exploration of an undeveloped quarry in order to determine whether or not sufficient reserves are available. The samples shall be shipped at the Contractor's expense to a laboratory by the Project Manager to perform the required tests.

(vi) Tests

The tests shall be conducted in accordance with applicable ASTM and Corps of Engineer’s methods of tests given in the Handbook for Concrete and Cement, and shall be performed at a laboratory validated by the Project Manager. The cost of testing shall be borne by the Contractor.

(b) Quarry Operations

Quarry operations shall be conducted by the Contractor in a manner that shall produce stone conforming to the requirements specified and may involve selective quarrying, handling, processing, blending, and loading as necessary, all of which shall be as specified in Section 5, Excavation and Miscellaneous Earthworks. Blasting and handling

of rock shall be controlled by the Contractor to produce rock of the size ranges and quality specified. Techniques such as the use of proper hole diameter, hole depth, hole angle, burden and spacing distances, types and distribution of explosives. delay intervals and sequence, removal of muck piles between each shot, and special handling techniques are required as necessary to produce the specified materials. All aspects of blasting operations shall be specifically designed so that the end product is not damaged from the blasting technique and that the stone is suitable for the intended purpose.

(i) Curing Stone

The Contractor shall conduct curing operations on freshly quarried stone to allow it to release stored energy and moisture and to allow the stone to demonstrate that it will not fracture during the energy release and drying-out phase. Stones of sizes which are individually picked shall be temporarily stockpiled at the quarry site a minimum of 3 calendar days before being shipped to the project site, unless this requirement is waived by the Project Manager. Such waiver will be granted only if the stone has characteristics that make curing unnecessary.

(ii) Temporary Storage at Quarry

Storage of stone materials subsequent to shipment from the quarry and prior to permanent placement in the required work shall be subject to approval of the Project Manager. Underwater storage of stone materials is prohibited.

(c) Gradation Test

The Contractor shall perform a gradation test or tests on the riprap, stone, at the quarry in accordance with **Sub-Clause 6-3.12.5 - Gradation Tests for stone**. The sample shall be taken by the Contractor in the presence of the Project Manager. The Contractor shall notify the Project Manager not less than 3 days in advance of each test. At least one gradation tests shall be performed per 250,000 tons (metric) of each size of riprap, placed, but not less than one test shall be performed. The gradation tests shall be reported using the forms, approved by the Project Manager. The sample shall consist of not less than 25 tons (metric) of riprap, and shall be collected in a random manner which will provide a sample which accurately reflects the actual gradation arriving at the jobsite. Failure of the test on the initial sample and on an additional sample will be considered cause for rejection of the quarry and/or quarry process, and all riprap, represented by the failed tests shall be set aside and not incorporated into the work. Any additional tests required because of the failure of an initial test sample will not be considered as one of the other required tests. If collected by the truckload, each truckload shall be representative of the gradation requirements. The Project Manager may direct additional testing of the riprap, at the project site if the riprap, appears, by visual inspection, to be out of gradation. The additional tests shall be performed on in-place materials at the locations directed, or on random loads selected by the Project Manager. In-place test areas shall be not less than 3.6 m by 3.6 m and shall include the full thickness of the placed riprap, layer, without

disturbing or including the underlying material and shall meet the minimum sample size specified above. Each pit excavated for an in-place test sample shall be refilled and reworked to provide a surface void of signs of disturbance. One in-place gradation shall be performed on each 3800 cubic meters 7500 tons (metric) or portion thereof placed. If the gradation test fails, additional gradation tests will be required at the Contractor's expense to delineate the limits of unacceptable stone. The additional gradation tests shall not count as part of the minimum number of gradation tests required. The unacceptable stone shall either be reworked to bring the stone within the specified gradation or the stone shall be removed from the project site as determined by the Project Manager. The Contractor shall provide all necessary screens, scales and other equipment, and operating personnel, and shall grade the sample. Certification and test results shall represent riprap, shipped from the quarry. Certification and tests results must be received by the Project Manager at the jobsite before the riprap, is used in the work.

(d) Proportional Dimension Limitations

The maximum aspect ratio (greatest dimension: least dimension) of any piece of stone for size ranges which are not graded with a screen or grizzly, shall be not greater than 3:1 when measured across mutually perpendicular axis. Not more than 25 percent (25%) of the stones within a gradation range shall have an aspect ratio greater than 2.5:1. A maximum of 10 percent flat and elongated pieces by weight will be acceptable. A flat and elongated piece of riprap is defined as having a ratio of width to thickness or length to width greater than 3:1. ASTM D 4791 shall be used as a guide to perform the test.

(e) Riprap and Stone Stockpile

Storage of riprap and stone at the worksite is not to be confused with off-site stockpiling of riprap or stone. If the Contractor elects to provide off-site stockpiling areas, the Project Manager shall be notified by the Contractor of all such areas. The Contractor's stockpile shall be a maximum of 3.6 m high and formed by a series of layers of truckload dumps, where the rock essentially remains where it is placed. Subsequent layers shall be started 3 m from the edge of the previous layer so that the rock will not roll down the edges of the previous layers. The first layer shall be a maximum of 1.8 m high. After being stockpiled, any riprap which has become contaminated with soil or refuse shall not be put into the work unless the contaminating material has been removed from the riprap prior to placement.

(i) Worksite Stockpile

Riprap or stone delivered to the work sites, which requires temporary storage shall be placed in a container suitable for storing the riprap without waste, or a sand-clay-gravel or crushed stone pad may be constructed for the storage area and removed upon completion of the work. If the sand-clay-gravel or crushed stone pad method is used, the pad shall have a minimum thickness of at least 150 mm. The container or sand-clay-gravel or crushed stone pad method shall be subject to approval prior to delivery of the riprap. Upon completion of the work, the storage areas shall be cleaned of all storage

residues and returned to their natural condition. Temporary storage of riprap at the worksite will be allowed, provided the stockpile toe of the riprap be no closer than 20m from the closest edge of the excavation's or stream's top slope, and the amount shall not exceed 200 t unless otherwise approved.

(ii) Off-Site Stockpile

In areas where riprap is stockpiled for placement, the area shall have excess rock removed prior to completion of work. All rock and spalls greater than 75 mm in diameter shall be removed. Where rocks may have become buried due to soft ground or operation of the equipment, the rock shall be disposed of as directed or put in a disposal area. After the rock has been removed, the storage area shall be graded, dressed, and filled to return the ground surface as near as practical to the condition that existed prior to construction.

6-2.2.2 Riprap

Only quarried stone shall be used. Riprap quality shall be as specified in **Clause 6-1.4 – Testing and Studies**, **Sub-Clause 6-1.4.1 - Stone**. Stone shall be well graded and shall conform to the tables below.

Table 6-2

PERCENT LIGHTER BY WEIGHT (SSD)	**LIMITS OF STONE Weight KG**					
	RIPRAP "M40"	RIPRAP "M90"	RIPRAP “M300”	RIPRAP "M450"	RIPRAP "M900"	RIPRAP "M3400"
100	40 – 20	90 – 35	300 - 120	450 - 180	900-400	3400 -1350
50	20 – 10	40 – 20	130 – 60	200 – 90	400-200	1400 - 680
15	10 – 3	20 – 5	60 – 20	95 – 30	200-70	680 - 225

6-2.3 Placing of Riprap

The Riprap need not be compacted but shall be place d by hand to grade in a manner to insure that the larger rock fragments are uniformly distributed and the smaller rock serve to fill the spaces between the larger rock fragments in such a manner as will result in well-keyed, densely places, uniform layers of riprap of the specified thickness.

6-2.4 Materials for Gabions and Mattresses

6-2.4.1 Double Twisted Wire Mesh Gabions and Mattresses

Double twisted wire mesh Gabions and Mattresses shall be of style as shown in drawings or as directed by the Project Manager and manufactured with a non-raveling mesh made by twisting continuous pairs of wires through three half turns (commonly called double twisted) to form a hexagonal-shaped opening. Gabion and mattress sizes, wire diameters, mesh opening sizes, and tolerances shall comply with the requirements of ASTM A 975

(Tables 1, 3, 4, 5, 6, and Sections 9). Gabions and Mattresses shall meet the following test requirements:

Metallic coating - The coating weights shall conform to the requirements of ASTM A 641/A 641M, Class 3 (Style 1), ASTM A 856/A 856M (Style 2), ASTM A 90/A 90M or ASTM A 428/A 428M as applicable, and ASTM A 809 (Style 4).

PVC for Coating - The PVC coating shall show no cracks or breaks after the wires are twisted in the fabrication of the mesh. The initial properties of PVC coating material shall have a demonstrated ability to conform to the following requirements:

(a) Specific Gravity - In the range from 1.30 to 1.35 dN/dm3 when tested in accordance with test method ASTM D 792;

(b) Tensile Strength - Not less than 20.6 MPa, when tested in accordance with test method ASTM D 412;

(c) Modulus of Elasticity - Not less than 18.6 MPa, when tested in accordance with test method ASTM D 412;

(d) Hardness - Shore "D" between 50 and 60, when tested in accordance with test method ASTM D 2240;

(e) Brittleness Temperature - Not higher than -9 degrees C, or lower temperature when specified by the purchaser, when tested in accordance with test method ASTM D 746.

(f) Resistance to Abrasion - The percentage of the weight loss shall be less than 12%, when tested in accordance with test method ASTM D 1242;

(g) Salt Spray Exposure and Ultra Violet Light Exposure - The PVC shall show no effect after 3,000 h of salt spray exposure in accordance with ASTM B 117. The PVC shall show no effect of exposure to ultra violet light with test exposure of 3,000 h, using apparatus Spectral Irradiance of Open Flame Carbon Arc with Daylight Filters and 63 degrees C, when tested in accordance with ASTM D 1499 and ASTM G 152;

(h) Evaluation of Coating after Salt Spray and Ultraviolet Exposure Test - After the salt spray test and exposure to ultraviolet light, the PVC coating shall not show cracks nor noticeable change of color, or blisters or splits. In addition, the specific gravity, tensile strength, hardness and resistance to abrasion shall not change more than 6%, 25%, and 10% respectively, from their initial values.

Wire Tensile Strength - The tensile strength of the wire used for the double twisted mesh, lacing wire, and stiffener, when tested in accordance with Test Methods and definitions ASTM A 370, shall be in accordance with the requirements of ASTM A 641/A 641M (Style 1), ASTM A 809 (Style 4), and ASTM A 856/A 856M (Style 2), for soft temper wire.

Mesh strength and panel to panel joint strength - The minimum strength requirements of the mesh, selvedge wire to mesh connection, panel to panel connection, and punch test, when tested in accordance with ASTM A 975 Section 13.1, shall be as shown in **Table 6-**

3. The strength values reported in kN/m are referred to the unitary width of the specimen. The panel to panel test shall demonstrate the ability of the fastening system to achieve the required strength, and indicate the number of wire revolutions for the lacing wire or the ring spacing for ring fasteners used. The same number of wire revolutions or ring spacing shall be used in the field installation.

Table 6-3

Minimum Strength Requirements of Mesh and Connections			
Test description	*Gabions, metallic coated kN/m*	*Gabions, PVC Coated kN/m*	*Revet mattresses (metallic and PVC coated) kN/m*
Tensile strength parallel to twist (kN/m)	51.1	42.3	33.6
Tensile strength perpendicular to twist (kN/m)	26.3	20.4	13.1
Connection to selvedges (kN/m)	20.4	17.5	10.2
Panel to panel (using lacing wire or ring fasteners) (kN/m)	20.4	17.5	10.2
Punch Test (kN)	26.7	23.6	17.8

6-2.4.2 Testing of wire Fasteners

Test records made within one year by certified laboratories will be used to determine the acceptability of the fastening system. Samples of wire fasteners and samples of material for fabricating the gabions and mattresses with their certified test records shall be submitted at least 60 days in advance to the Project Manager for approval.

6-2.4.3 Stone Fill

(a) General

Rock to fill gabions and mattresses shall be durable and of suitable quality to ensure permanence in the structure and climate in which it is to be used.

(b) Stone Quality

Stone fill, crushed stone, shall meet the quality requirements of ASTM C 33, and quality requirements of stone given in **Sub-Clause 6-1.4.1 (c)**.

(c) Gradation

Gradation of stone for gabions shall be performed every 1000 tons placed under this contract in accordance with ASTM C 136. Sizes of rock to fill gabions and mattresses are chosen on the basis of the mesh sizes, the structure's thickness, and within the limits shown in **Table 6-4**. Within each range of sizes, the rock shall be large enough to prevent individual pieces from passing through the mesh openings. Each range of sizes may allow for a variation of 5% oversize rock by weight, or 5% undersize rock by weight, or both.

(i) Oversize Rock

In all cases, the sizes of any oversize rock shall allow for the placement of three or more layers of rock within each gabion compartment and two or more layers of rock within each mattress compartment dependent upon the height of the mattress.

(ii) Undersize Rock

In all cases, undersize rock shall be placed within the interior of the gabion or mattress compartment and shall not be placed on the exposed surface of the structure. There shall be a maximum limit of 5% undersize or 5% oversize rock, or both, within each gabion or mattress compartment. The required rock gradation is reported in **Table 6-4**.

Table 6-4

Required Rock Gradation For Gabions And Mattresses		
Type of structure	***Thickness (height) m***	***Rock sizes mm***
Mattresses	0.17	75 – 130
Mattresses	0.23	75 – 130
Mattresses or Gabions	0.30	100 – 200
Gabions	0.50 or higher	100 – 200

6-2.5 Materials for Geotextile

6-2.5.1 General

The geotextile shall be a non-woven pervious sheet of plastic yarn as defined by ASTM D 123. The geotextile shall equal or exceed the minimum average roll values listed in **Table 6-5**, Minimum Physical Requirements For Drainage Geotextile. Strength values indicated in the table are for the weaker principal direction.

Table 6-5

Minimum Physical Requirements For Drainage Geotextile			
PROPERTY	***UNITS***	***ACCEPTABLE VALUES***	***TEST METHOD***
Tensile	N	>500	ASTM D 5034 grab test 25.4 mm square and 304.8 mm per minute constant rate at traverse.
Elongation	Percent	>15	ASTM D 5034 determine apparent breaking elongation.
Puncture	N	>180	ASTM D 3787 except polished steel ball replaced with a 8 mm diameter solid steel cylinder with a hemispherical tip centered within the ring clamp.

Tear	N	>111.2	ASTM D 1117 trapezoidal tear strength.
PERMEABILITY	cm/sec	> 0.05	ASTM D 4491
APPARENT OPENING SIZE	Mm	<1mm	ASTM D 4751
ULTRAVIOLET DEGRADATION	Percent	50 at 500 Hrs	ASTM D 4355

6-2.5.2 Geotextile Fiber

Fibers used in the manufacturing of the geotextile shall consist of a long-chain synthetic polymer composed of at least 85 percent by weight of polyolefins, polyesters, or polamides. Stabilizers and/or inhibitors shall be added to the base polymer if necessary to make the filaments resistant to deterioration caused by ultraviolet light and heat exposure. Reclaimed or recycled fibers or polymer shall not be added to the formulation. Geotextile shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including the edges. The edges of the geotextile shall be finished to prevent the outer fiber from pulling away from the geotextile.

6-2.5.3 Seams

The seams of the geotextile shall be sewn with thread of a material meeting the chemical requirements given above for geotextile yarn or shall be bonded by cementing or by heat. Seams shall be tested in accordance with method ASTM D 4884. The strength of the seam shall be not less than 90 percent of the required grab tensile strength of the unaged geotextile in any principal direction.

6-2.5.4 Securing Pins

The geotextile shall be secured to the embankment or foundation soil by pins to prevent movement prior to placement of revetment materials. Other appropriate means to prevent movement such as staples, sand bags, and stone could also be used. Securing pins shall be inserted through both strips of overlapped geotextile along the line passing through midpoints of the overlap. Securing pins shall be removed as placement of revetment materials are placed to prevent tearing of geotextile or enlarging holes maximum spacing between securing pins depends on the steepness of the embankment slope. The maximum pins spacing shall be equal to or less than the values listed in **Table 6-6**, Maximum Spacing For Securing Pins. When windy conditions prevail at the construction site, the number of pins should be increased upon the demand of the Project Manager. Terminal ends of the geotextile shall be anchored with key trench or apron at crest, toe of the slope and upstream and downstream limits of installation.

Table 6-6	
Maximum Spacing for Securing Pins	
Embankment	Spacing, meter

Steeper than 1V on 3H	0.6
1v on 3h to 1V on 4H	1.0
Flatter than 1V on 4H	1.5

6-2.6 Concrete Grout

6-2.6.1 Cementitious Materials

Cementitious materials will be accepted on the basis of a manufacturer's certificate of compliance, accompanied by mill test reports, that the materials meet the requirements of the specification under which it is furnished.

(a) Portland Cement

ASTM C 150, Type I

(b) Pozzolan

ASTM C 618, Class C or F, including requirements of Tables 1A and 2A. Pozzolan in amount not to exceed 25 percent, based on absolute volume, may be substituted for an equivalent amount of Portland cement in the grout mixture proportions.

6-2.6.2 Aggregates for Concrete Grout

The fine aggregates for grout shall meet the quality and gradation requirements of either ASTM C 33. The coarse aggregates shall meet the quality and gradation requirements of ASTM C 33, Class designation 4M, Size No. 4.75 to 19.0 mm.

6-2.6.3 Admixtures

Admixtures to be used, when required or approved, shall comply with the following:

(a) Air-Entraining Admixture: ASTM C 260.

(b) Water-Reducing or Retarding Admixture: ASTM C 494/C 494M, Type A, B, or D.

6-2.6.4 Curing Materials

Curing materials shall be as follows:

(a) Impervious Sheet Materials: ASTM C 171, type optional, except polyethylene film, if used, shall be white opaque.

(b) Membrane-Forming Curing Compound: ASTM C 309, Type 1-D or 2, Class A.

6-2.6.5 Water

Water for mixing and curing shall be fresh, clean, potable, and free from injurious amounts of oil, acid, salt, alkali.

PART 3 EXECUTION

6-3.1 Riprap Demonstration Section

Prior to placement of stone, the Contractor shall construct a section of stone protection consisting of to demonstrate his proposed operations for production placement. The section shall demonstrate procedures and capability of grading, placing stone within the tolerances specified. The demonstration section shall be 15 m in length and shall conform to all applicable specifications.

6-3.1.1 Methods and Equipment

Methods and equipment employed for placement shall demonstrate the adequacy for use in placement of and shall conform with the requirements specified. The quantities of all materials placed within the section shall be accurately tabulated and provided immediately to the Project Manager for comparison with computed quantities.

6-3.1.2 Demonstration Section Evaluation

The Contractor shall not proceed with placing stone prior to the approval of the demonstration section. Within a period of 7 days after completion of the section, the Project Manager shall determine the adequacy of the section to function as part of the permanent construction. The Contractor shall be notified as to the acceptability of the section and may be directed to modify methods of construction and remove the section if necessary.

6-3.1.3 Removal of Demonstration Section

If removal of the demonstration section is required, it shall be conducted in such a manner as to maintain the integrity of the underlying subgrade. The Contractor shall make his own arrangements for disposal in areas not located on the site.

6-3.2 Base Preparation

Areas on which bedding material and riprap are to be placed shall be graded and/or dressed to conform to cross sections shown on the contract drawings within an allowable tolerance of plus 50 mm and minus 100 mm from the theoretical lines and grades. The prepared base shall be approved by the Project Manager. Where such areas are below the allowable minus tolerance limit they shall be brought to grade by fill with earth similar to the adjacent material and then compacted to a density equal to the adjacent in place material. Subaqueous areas on which bedding material and riprap are to be placed shall be graded and/or dressed to conform to cross sections shown on the contract drawings within an allowable tolerance of plus 300 mm and minus 600 mm from the specified line and grades. Where such areas are below the allowable minus tolerance limit they shall be filled with sand fill. As an alternative, these areas may be filled with bedding material. No payment will be made for any material thus required. Immediately prior to placing the bedding layers, the prepared base will be inspected by the Project Manager and no material shall be placed thereon until that area has been approved.

6-3.3 Placement of Bedding Layers

6-3.3.1 General

A bedding layer, consisting of a layer of gravel or crushed stone, shall be placed on the prepared base as described below, in accordance with the details shown on the contract drawings, and within the limits shown on the contract drawings or staked in the field.

A tolerance of plus 50 mm and minus 25 mm from the slope lines and grades shown on the contract drawings will be allowed in the finished surface of the bedding, except that the extreme of this tolerance shall not be continuous over an area greater than 18 m^2.

6-3.3.2 Placement of Bedding Material on Prepared Base

Bedding material shall be spread uniformly on the prepared base to the lines and grades as indicated on the contract drawings and in such manner as to avoid damage to the prepared base. Placing of gravel or crushed stone by methods which tend to segregate the particle sizes within the bedding layer or cause mixing of the separate layers will not be permitted. Placement shall begin at the bottom of the area to be covered and continue up slope. Subsequent loads of material shall be placed against previously placed material in such a manner as to ensure a relatively homogenous mass. Any damage to the surface of the prepared base during placing of the material shall be repaired before proceeding with the work. Compaction of material placed on the prepared base will not be required, but the material surface shall be finished to present an adequately even surface, free from mounds or windrows.

6-3.4 Placement of Riprap

6-3.4.1 General

Riprap shall be placed on the bedding layers specified in **Clause 6-2.1 – Bedding Material** within the limits shown on the contract drawings.

6-3.4.2 Placement

Riprap shall be placed in a manner which will produce a well-graded mass of rock with the minimum practicable percentage of voids, and shall be constructed, within the specified tolerances, to the lines and grades shown on the contract drawings or staked in the field. Riprap shall be placed by means of truck, crane operated skip-pan (box), dragline bucket, clamshell, rock-bucket, hydraulic excavator ("Gradall"), trackhoe, or other approved equipment. Pneumatic tired front end loaders may be used provided that in the opinion of the Project Manager no degradation of the rock occurs. Riprap shall be placed to its full course thickness in one operation and in such manner as to avoid displacing the bedding material. The large stones shall be well distributed and the entire mass of stones in their final position shall be graded to conform to the gradation specified in **Clause 6-3.4 – Placement of Riprap**, **Sub Clause 6-3.4.1 - General**. Placement shall begin at the bottom of the area to be covered and continue up slope. Subsequent loads of material shall be placed against previously placed material in such a manner as to ensure a relatively homogenous mass. The finished riprap shall be free from objectionable pockets

of small stones and clusters of larger stones. Placing riprap in layers will not be permitted. Placing riprap by dumping it into chutes, or by similar methods likely to cause segregation of the various sizes, shall not be permitted. Placing riprap by dumping it at the top of the slope and pushing it down the slope shall not be permitted. No equipment shall be operated directly on the completed stone protection system. The desired distribution of the various sizes of stones throughout the mass shall be obtained by selective loading of the material at the quarry or other source; by controlled dumping of successive loads during final placing; or by other methods of placement which will produce the specified results. Each truckload shall be representative of the gradation requirements. All dump trucks used in placing the riprap shall be equipped with bottom hinged tailgates. The gate releasing mechanism shall be arranged so that it may be operated only from, at, or near the front of the truck. Rearranging of individual stones shall be required to the extent necessary to obtain a well-graded distribution of stone sizes as specified above. However, manipulating stone by means of dozers or other blade equipment shall not be permitted. Unless otherwise authorized by the Project Manager, riprap shall be placed in conjunction with the construction of the embankment and with only sufficient lag in construction of the stone protection as may be necessary to prevent mixing of embankment and stone protection materials. The Contractor shall maintain the stone protection until accepted by the Project Manager and any material displaced prior to acceptance and due to the Contractor's negligence shall be replaced at his expense and to the lines and grades shown on the contract drawings.

6-3.5 Construction of Stone Pitching

The surfaces to be stone pitched shall be trimmed and shaped where necessary and the stoned set in a mortar consisting of 3 parts of clean fine aggregate to 1 part of cement by volume.

6-3.6 Gabion and Mattresses

6-3.6.1 Material Delivery

Gabions and mattresses shall be delivered with all components mechanically connected at the production facility with the exception of the mattress lid, which is produced separately from the base. All gabions and mattresses are supplied in the collapsed form, either folded or bundled or rolled, for shipping. Bundles are banded together at the factory for ease of shipping and handling. Mattress bases and lids may be packed in separate bundles.

(a) Mattress lids may be supplied either as individual units (bundled) or in roll form. Lacing wire shall be shipped in coils with a diameter of the coil approximately 0.60 m. Fasteners shall be shipped in boxes. Preformed stiffeners shall be shipped in bundles.

(b) Gabions and mattresses shall be delivered to the jobsite labeled in bundles. Labels shall show the dimensions of the gabions or mattresses included, the number of pieces and the color code.

6-3.6.2 Foundation Preparation

After excavation or stripping, to the extent indicated on the drawings or as directed by the Project Manager, all remaining loose or otherwise unsuitable materials shall be removed. All depressions shall be carefully backfilled to grade. If pervious materials are encountered in the foundation depressions, the areas shall be backfilled with free-draining materials. Otherwise, the depressions shall be backfilled with suitable materials from adjacent required excavation, or other approved source, and compacted to a density at least equal to that of the adjacent foundation. Any debris that will impede the proper installation and final appearance of the gabion layer shall also be removed, and the voids carefully backfilled and compacted as specified above. Immediately prior to placing the material, the Project Manager shall inspect the prepared foundation surface, and no material shall be placed thereon until that area has been approved.

6-3.6.3 Filter Placement under Gabions and Mattresses

The Geotextile filter shall be placed on the prepared foundation surface in accordance with **Clause 6-3.7 - Geotextile** filter and in a manner satisfactory to the Project Manager, and to the slopes, lines, and grades as indicated on the drawings or as directed. Any damage to the foundation surface during the Geotextile filter placement shall be repaired before proceeding with the work.

6-3.6.4 Assembly

(a) Double Twisted Wire Mesh Gabions

The gabions shall be opened and unfolded one by one on a flat, hard surface. Gabion units over 1.82 m in length usually have an extra shipping fold, which must be removed. The sides, ends and diaphragms shall be lifted up into a vertical position to form an open box shape. The back and the front panels of the gabion shall be connected to the end panels and center diaphragms. The top corner of the end panels and center diaphragms have a selvedge wire extending approximately 100 mm out from the corner edge. The end panels and the diaphragms shall be raised to a vertical position and the selvedge wire shall be wrapped around the edge wire of the top and back panels.

(b) Double Twisted Wire Mesh Revet Mattresses

The mattress shall be laid on a flat, hard surface. When the units are unfolded for assembly, depending on their length, they will have one or two shipping folds, which must be removed. The double flap of the side panel shall be folded in and wired to the diaphragm. At the corners, the end flaps shall be folded along the sides and the joint laced up. Each Revet mattress shall be assembled individually, by erecting the sides, ends and diaphragms, ensuring that all creases are in the correct position and the tops of all sides are level.

6-3.6.5 Lacing Operations

Either lacing wire or ring fasteners are permitted to lace double twisted wire mesh Gabions or Revet mattresses.

(a) When using lacing wire, a piece of wire 1.2 to 1.5 times the length of the edge to be laced shall be cut off. If the edge of the basket is 0.91 m long, no more than 1.2 to 1.5 m of wire should be uses at a time to lace. For vertical joints, starting at the bottom end of the panel, the lacing wire shall be twisted and wrapped two times around the bottom selvedge and double and single loops shall be alternated through at intervals not bigger than 100 to 150 mm. The operation shall be finished by looping around the top selvedge wire. The use of pliers to assemble the units with lacing wire is normally recommended.

(b) When steel wire ring fasteners are used, the rings shall be installed at the top and bottom connections of the end and center diaphragms. The ring spacing shall be based on the minimum pull apart strength as specified in **Table 6-3**. In any case, the maximum ring spacing along the edges shall not exceed 0.15 m. The use of either a mechanical or a pneumatic fastening tool for steel wire ring fasteners is required. Ring fasteners shall be galvanized, stainless steel or Zn-5% aluminum-mischmetal alloy coated.

6-3.6.6 Installation and Filling

Empty gabion and mattress units shall be assembled individually and placed on the approved surface to the lines and grades as shown or as directed, with the sides, ends, and diaphragms erected in such a manner to ensure the correct position of all creases and that the tops of all sides are level. All gabion units shall be properly staggered horizontally and vertically as shown in the construction drawings. Finished gabion or mattress structures shall have no gaps along the perimeter of the contact surfaces between adjoining units. All adjoining empty gabion units shall be connected along the perimeter of their contact surfaces in order to obtain a monolithic structure. All lacing wire terminals shall be securely fastened. All joining shall be made through selvedge-to-selvedge or selvedge-to-edge wire connection; mesh-to-mesh or selvedge-to-mesh wire connection is prohibited except in the case where baskets are offset or stacked and selvedge-to-mesh or mesh-to-mesh wire connection would be necessary. As a minimum, a fastener shall be installed at each mesh opening at the location where mesh wire meets selvedge or edge wire.

The initial line of basket units shall be placed on the prepared filter layer surface foundation and adjoining empty baskets set to line and grade, and common sides with adjacent units thoroughly laced or fastened. They shall be placed in a manner to remove any kinks from the mesh and to a uniform alignment. The basket units then shall be partially filled to provide anchorage against deformation and displacement during the filling operation. The stone shall be placed in the units as specified in **Sub-Clause 6-2.4.3 - Stone Fill, part (c) Gradation, part (ii) Undersize Rock**.

Undue deformation and bulging of the mesh shall be corrected prior to further stone filling. Care shall be taken, when placing the stone by hand or machine, to assure that the PVC coating on gabions will not be damaged. All visible faces shall be filled with some hand

placement to ensure a neat and compact appearance and that the void ratio is kept to a minimum.

Gabions and mattresses shall be uniformly overfilled by about 25 to 50 mm to compensate for future rock settlements. Gabions and mattresses can be filled by any kind of earth-filling equipment, such as a backhoe, gradall, crane, etc. The maximum height from which the stones may be dropped into the baskets shall be 0.9 to 1.20 m.

(a) Double Twisted Wire Mesh Gabions

After the foundation has been prepared, the pre-assembled gabions shall be placed in their proper location to form the structure. Gabions shall be connected together and aligned before filling the baskets with rock. All connections (panel-to-panel) and basket-to-basket shall be already carried out as described in **Sub-Clause 6-3.6.4 – Assembly**. Stone fill shall have a gradation of 0.10 to 0.20 m, as described in **Sub-Clause 6-2.4.3 (c) - Gradation**, and shall be placed in 0.30 m lifts. Cells shall be filled to a depth not exceeding 0.30 m at a time. The fill layer should never be more than 0.30 m higher than any adjoining cell. Stiffeners or internal cross ties shall be installed in all front and side of the gabions at 1/3 and 2/3 of the height for 0.91 m or higher gabions, as the cell is being filled. Stiffeners shall be installed in the center of the cells. In 0.46 m high units, stiffeners or internal crossties are not required. Internal cross ties, or alternatively the preformed stiffeners, shall be looped around three twisted wire mesh openings at each basket face and the wire terminals shall be securely twisted to prevent their loosening. The number of voids shall be minimized by using a well-graded stone in order to achieve a dense, compact stone fill. All corners shall be securely connected to the neighboring baskets of the same layer before filling the units. When more than one layer of gabions is required, in order for the individual units to become incorporated into one continuous structure, the next layer of gabions shall be connected to the layer underneath after this layer has been securely closed. Gabions shall be uniformly overfilled by about 25 to 50 mm to compensate for future rock settlements.

(b) Double Twisted Wire Mesh Revet Mattresses

After being assembled, the Revet mattresses shall be placed in their proper location and securely attached to the adjacent units. For structural integrity, all adjoining empty units shall be connected by means of lacing wire or ring fasteners along the edges of their contact surfaces in order to form a monolithic structure. Revet mattresses shall be placed and securely connected while empty. The filling shall be done unit by unit; however, several units can be pre-assembled prior to filling the units. Revet mattress units shall be filled with hard, durable, clean stone having a gradation as indicated in **Sub-Clause 6-2.4.3 (c) - Gradation**. Care shall be taken to ensure that diaphragm tops are accessible for wiring. On slopes, the Revet mattress shall be laid with the 1.83 m dimension (width) longitudinally to the slope and progressing up the slope, except for small ditches or where otherwise specified in the project. When the installation is performed on a slope, the filling of the baskets shall start from the lower side of the bank. Where Revet mattresses are to be placed on steep slopes (3H to 2V), the units shall be secured by hardwood pegs driven

into the ground just below the upper end panel, at 1.83 m centers, or as specified in the project. When the Revet mattress is to be placed over a geotextile, care shall be taken to ensure that any projecting ends of wire are bent upward to avoid puncturing or tearing the cloth. Lids shall be securely connected to the ends of the mattress and to the top sides and diaphragms using alternate double and single loops, or steel wire ring fasteners, as indicated in **Sub-Clause 6-3.6.2 - Foundation Preparation**. In case more adjacent bases are to be covered at one time, mesh rolls shall be used in place of unit size lids. Revet mattresses shall be uniformly overfilled by about 25 to 50 mm to compensate for future rock settlements.

6-3.6.7 Non-rectangular Shapes

Gabion and mattress units can conform to bends up to a radius of curvature of 18 to 21 m without alterations. Units shall be securely connected together first, and be placed to the required curvature, holding them in position by staking the units to the ground with hardwood pegs before filling. For other shapes, bevels and miters can be easily formed by cutting and folding the panels to the required angles.

6-3.6.8 Closing

Lids shall be tightly secured along all edges, ends and diaphragms in the same manner as described for assembling. Adjacent lids may be securely attached simultaneously. The panel edges shall be pulled to be connected using the appropriate closing tools where necessary. Single point leverage tools, such as crowbars, may damage the wire mesh and shall not be used. All end wires shall then be turned in.6-3.7 Geotextile Filter

6-3.7.1 Surface Preparation

Surface on which the geotextile will be placed shall be prepared to a relatively smooth surface condition, in accordance with the applicable portion of this specification and shall be free from obstruction, debris, depressions, erosion feature, or vegetation. Any irregularities will be removed so as to insure continuous, intimate contact of the geotextile with all the surfaces. Any loose material, soft or low density pockets of material, will be removed; erosion features such as rills, gullies etc. must be graded out of the surface before geotextile placement.

6-3.7.2 Installation of the Geotextile

(a) General

The geotextile shall be placed in the manner and at the locations shown. At the time of installation, the geotextile shall be rejected if it has defects, rips, holes, flaws, deterioration or damage incurred during manufacture, transportation or storage.

(b) Placement

(2) When revetment material and geotextile filter are selected to protect against wave attack, the geotextile strips shall be placed vertical to the slope of the bank with the upper strips overlapping the lower strips (**Fig. 1b**). The geotextile shall be keyed at the toe to

prevent uplift or undermining (**Fig. 3**). The key trench shall be located below the mean low water to prevent erosion of the soil adjacent to the trench. When it is not possible to maintain vertical trench walls, the geotextile shall

The geotextile shall be laid smooth and free of tension, stress, folds, wrinkles, or creases. The strips shall be placed to provide a minimum width of 300mm of overlap for each joint. The Contractor shall adjust the actual length of the geotextile used based on initial installation experience. Temporary pinning of the geotextile to help hold it in place until the riprap, gabion or mattress is placed shall be allowed. The temporary pins shall be removed as the riprap, gabion or mattress is placed to relieve high tensile stress which may occur during placement of material on the geotextile. Design protection of riprap should be in compliance with EM 1110-2-1601. Trimming shall be performed in such a manner that the geotextile shall not be damaged in any way.

6-3.7.3 Protection

The geotextile shall be protected at all times during construction from contamination by surface runoff and any geotextile so contaminated shall be removed and replaced with uncontaminated geotextile. Any damage to the geotextile during its installation or during placement of riprap, gabion or mattress shall be replaced by the Contractor at no cost to the Employer. The work shall be scheduled so that the covering of the geotextile with a layer of the specified material is accomplished within 7 calendar days after placement of the geotextile. Failure to comply shall require replacement of geotextile. The geotextile shall be protected from damage prior to and during the placement of riprap or other materials. This may be accomplished by limiting the height of drop to less than 300 mm, by placing a cushioning layer of sand or gravel on top of the geotextile before placing the material, or other methods deemed necessary. Care should be taken to ensure that the utilized cushioning materials shall not impede the flow of water. Before placement of riprap or other materials, the Contractor shall demonstrate that the placement technique will not cause damage to the geotextile. In no case shall any type of equipment be allowed on the unprotected geotextile.

6-3.7.4 Placement of Cushioning Material

Placing of cushioning material shall be performed in a manner to insure intimate contact of the geotextile with the prepared surface and with the cushioning material. The placement shall also be performed in a manner that shall not damage the geotextile including tear, puncture, or abrasion. On sloping surfaces the cushioning material shall be placed from the bottom of the slopes upward. During placement, the height of the drop of riprap material shall not be greater than 300 mm. Any geotextile damaged beneath the cushioning material shall be uncovered as necessary and replaced at no cost to the Employer.

6-3.7.5 Overlapping and Seaming

(a) Overlapping

The overlap of geotextile rolls shall be 300mm. Appropriate measures will be taken to insure required overlap exists after cushion placement.

(b) Sewn Seams

High strength thread should be used such that seam test should conform to ASTM D 4884. The thread shall meet the chemical, ultraviolet, and physical requirements of the geotextile, and the color shall be different from that of the geotextile. The seam strength shall be equal to the strength required for the geotextile in the direction across the seam. Overlapping J-type seams are preferable over prayer-type seams as the overlapping geotextile reduces the chance of openings to occur at the seam. Double sewing shall be used specially for field seams to provide a safety factor against undetected missed stitches.

6-3.8 Placement of Grouted Riprap

6-3.8.1 General

Riprap shall be placed on the bedding material specified in **Clause 6-2.1 – Bedding Material** within the limits shown. Weep holes shall be installed every 3 m and formed by 75-mm diameter pipe. The ends of the pipe shall be installed into the bedding layer so that it will not become clogged with grout. The ends of the pipe, which is buried in the bedding layer, shall be capped and shall be perforated with holes or slots. Care shall be taken to prevent grout from entering the weep holes.

6-3.8.2 Placement

Riprap shall be placed in a manner, which will produce a well-graded mass of rock with the minimum practicable percentage of voids, and shall be constructed, within the specified tolerance, to the lines and grades either shown on the contract drawings or staked in the field.

Riprap shall be placed to its full course thickness in one operation and in such manner as to avoid displacing the bedding material. Placement shall begin at the bottom of the area to be covered and continue up slope. Subsequent loads of material shall be placed against previously placed material in such a manner as to ensure a relatively homogenous mass. The large stones shall be well distributed and the entire mass of stones in their final position shall be graded to conform to the gradation specified in **Clause 6-3.4 - Riprap, Sub-Clause 6-3.4.1 - General**. The finished riprap shall be free from objectionable pockets of small stones and clusters of larger stones. Placing riprap in layers will not be permitted. Placing riprap by dumping it into chutes, or by similar methods likely to cause segregation of the various sizes, will not be permitted. Placing riprap by dumping it at the top of the slope and pushing it down the slope will not be permitted. No equipment shall be operated directly on the completed stone protection system. The desired distribution of the various sizes of stones throughout the mass shall be obtained by selective loading of the material at the quarry or other source; by controlled dumping of successive loads during final placing; or by other methods of placement which will produce the specified

results. Each truckload shall be representative of the gradation requirements. Rearranging of individual stones will be required to the extent necessary to obtain a well-graded distribution of stone sizes as specified above.

6-3.8.3 Grouting of Riprap

Placement of grout shall be as specified in **Sub Clause 6-3.11.1 – Producing, Conveying and Placing of Grout**.

6-3.9 Placement of Hand-Placed Riprap

6-3.9.1 General

Hand-placed riprap shall be placed on the bedding material specified in **Clause 6-2.1 - Bedding Material** within the limits shown. Stone shall conform to the requirements of **Clause 6-2.2.2 - Riprap**. Except for spalls for wedging, stone shall be roughly rectangular in shape of which the least dimension shall be not less than one-third the length.

6-3.9.2 Placement

The riprap shall be carefully placed by hand in such a manner that adjacent stones are in close contact and, in general, have their greatest dimensions across the slope. "Through stones" shall be well-distributed throughout the mass and the sum of their cross sections, parallel to the slope being protected, shall be not less than two-thirds of such area. As used in this specification a "through stone" is defined as a stone whose dimension normal to the surface being riprapped is not less than the full depth of the riprap. Placement shall begin at the bottom of the area to be covered and continue up slope. Subsequent loads of material shall be placed against previously placed material in such a manner as to ensure a relatively homogenous mass. Placement shall begin at the bottom of the area to be covered and continue up slope. Subsequent loads of material placed on the slope shall be immediately adjacent to previously placed material in such a manner to ensure a relatively homogenous mass. The riprap along the lower edge of an area shall consist of the largest stones set in a trench so as to form a band. Except for spalls used to fill voids between larger stone, no stone shall be used in the exposed face of the riprap which will extend less than one-half the thickness of the riprap. Spaces between the larger stones shall be filled with spalls and smaller stones of the largest feasible size to form a compact mass. Spalls and small stone shall not be place in nests in lieu of larger size stone.

6-3.10 Placement of Grouted Hand-Placed Riprap

6-3.10.1 General

Hand-placed riprap shall be placed on the bedding material specified in **Clause 6-2.1 - Bedding Material** within the limits shown. Stone shall conform to the requirements of **Clause 6-2.2.2 - Riprap**. Except for spalls for wedging, stone shall be roughly rectangular in shape of which the least dimension shall be not less than one-third the length.

6-3.10.2 Placement

The riprap paving shall be carefully placed to form a layer of thickness as shown in drawings. The riprap shall be placed in conformance with the general requirements of **Clause 6-3.9 - Placement Of Hand-Placed Riprap**, except that the stone shall be laid with open joints to facilitate grouting and the smaller spaces between stones in the face of the paving shall not be filled with spalls but shall be left open to receive grout readily. Weep holes shall be installed every 3 m and formed by 75-mm diameter pipe. The ends of the pipe shall be installed into the bedding layer so that it will not become clogged with grout. The ends of the pipe, which is buried in the bedding layer, shall be capped and shall be perforated with holes or slots. Care shall be taken to prevent grout from entering the weep holes.

6-3.10.3 Grouting of Hand-Placed Riprap

Placement of the grout shall be as specified in **Sub Clause 6-3.11.1 – Producing, Conveying and Placing of Grout**.

6-3.11 Grouting of Stone Protection

6-3.11.1 Producing, Conveying and Placing of Grout

(a) Producing Grout

The batching and mixing equipment shall provide sufficient capacity to prevent cold joints. Materials shall be stockpiled and batched by methods that will prevent segregation or contamination of aggregates and insure accurate proportioning of the ingredients of the

mixture. No mixing water in excess of the amount required by the job mix shall be added to the grout mixture during mixing, hauling, or after arrival at the delivery point, except as required and approved.

(i) Ready-Mixed Concrete Grout

Ready-mixed concrete grout shall conform to ASTM C 94/C 94M except as otherwise specified.

(ii) Volumetric Batching and Continuous Mixing

Volumetric batching and mixing shall conform to ASTM C 685.

(iii) On-site Batching and Mixing

The Contractor shall have the option of using an on-site batching and mixing facility. The facility shall provide sufficient capacity to prevent cold joints and be able to batch the cement and aggregate by weight, and the water and admixtures by weight or volume. The method of measuring materials, the batching operation, and the mixer shall be approved in accordance with **Clause 6-1.3 - Submittals**. On-site plant shall conform to the requirements of either ASTM C 94/C 94M or ASTM C 685.

(b) Preparation for Placing

Adequate precautions shall be taken to prevent grout from penetrating the bedding layer. The rock shall be flushed with water to remove the fines from the rock prior to placing the grout. The rock shall be kept moist just ahead of the actual placing, but no flowing or standing water shall be present during the grout operation. All equipment needed to place, protect, and cure the grout shall be at the placement site and in good operating condition. The entire preparation shall be accepted by the Project Manager prior to placing the grout.

(c) Conveying and Placing

Grout placement shall not be permitted when, weather conditions prevent proper placement, except upon approval. The grout mixture shall not be placed until the stone protection has been inspected and approved. Grout shall be in place within 15 minutes after discharge from the mixer. Grout shall not be dropped more than 1.5 m vertically unless suitable equipment is used to prevent segregation.

(i) Conveying

When the grout is mixed or transported by a truck mixer, the grout shall be delivered to the site of the work and discharge shall be completed within 1-1/2 hours after introduction of the cement to the aggregate and water. When the air temperature is 29 degrees C or greater) or under conditions contributing to quick stiffening of the grout, the time between the introduction of the cement and discharge of the grout shall not exceed 45 minutes. The Project Manager may allow a longer time, provided the setting time of the grout is increased a corresponding amount by the addition of an approved set-retarding admixture. Grout shall be deposited as close as possible to its final position by methods that will prevent segregation of the aggregates or loss of mortar.

(ii) Placing

The riprap shall be kept moist just ahead of the actual grout placement, but the grout shall not be placed in standing or flowing water. Grout placed on inverts or other nearly level areas may be placed in one course. On slopes, the grout shall be placed in two (2) courses in successive lateral strips approximately 3 m in width starting at the toe of the slope and progressing to the top. The grout shall be delivered to the place of final deposit and discharged directly on the surface of the riprap, using a splash plate of metal or wood to prevent displacement of the rock directly under the discharge. The flow of grout shall be directed with brooms, spades or baffles to prevent it from flowing excessively along the same path and to assure that all intermittent spaces are filled. Sufficient barring shall be done to loosen tight pockets of riprap and otherwise aid the penetration of grout so that all voids shall be filled and the grout fully penetrates the riprap [as specified][from the base of the riprap layer to at least two-thirds of the thickness of the stone layer]. All brooming on slopes shall be uphill and after the grout has stiffened, the entire surface shall be rebroomed to eliminate runs, to fill voids caused by sloughing, and to remove grout from the top surface and pockets or depressions of the upper stones.

(d) Hot Weather Requirements

When the rate of evaporation of surface moisture, as determined by use of **Figure 2.1.5** of ACI 305R, is expected to exceed 100 g/m^2 per hour, provisions for windbreaks, shading, fog spraying, or wet covering with a light-colored material shall be made in advance of placement, and such protective measures shall be taken as quickly as finishing operations will allow.

6-3.11.2 Curing and Protection of Grouted Stone Protection

Beginning immediately after placement and continuing for at least 7 days, all grout shall be cured and protected from premature drying, extremes in temperature, rapid temperature change, freezing, mechanical damage, and exposure to rain or flowing water. All materials and equipment needed for adequate curing and protection shall be available and at the site of the placement prior to the start of grout placement. After completion of any strip or panel, no workman or other load shall be permitted on the grouted surface for a period of twenty-four (24) hours. Exposed surfaces shall be kept continuously moist for the entire period, or until curing compound is applied. Preservation of moisture for grout surfaces shall be accomplished by one of the following methods:

(a) Continuous sprinkling and ponding.

(b) Application of absorptive mats or fabrics kept continuously wet.

(c) Application of sand kept continuously wet.

(d) Application of impervious sheet material conforming to ASTM C 171.

(e) Application of membrane-forming curing compound conforming to ASTM C 309. The compound shall be sprayed on the moist surface as soon as free water has disappeared, but shall not be applied to any surface until finishing of that surface is completed. The compound shall be applied at a uniform rate of not less than 300 ml/m^2 of surface and shall form a continuous adherent membrane over the entire surface. Curing compound shall not be applied to surfaces requiring bond to subsequently placed grout. If the membrane is damaged during the curing period, the damaged area shall be resprayed at the rate of application specified above.

6-3.12 Tests and Inspections

6-3.12.1 Concrete Grout

(a) General

Individuals who sample and test grout as required by this section shall have demonstrated a knowledge and ability to perform the necessary test procedures equivalent to ACI minimum guidelines for certification of Concrete Transportation Construction Inspector or ACI Concrete Construction Inspector Level II.

(b) Preparations for Placing

Riprap shall be inspected in sufficient time prior to each grout placement by the Contractor in order to certify that it is ready to receive the grout.

(c) Air Content

Air Content shall be checked at least twice during each shift that grout is placed. Samples shall be obtained in accordance with ASTM C 172 and tested in accordance with ASTM C 231. Whenever a test result is outside the specification limits, the grout shall not be delivered to the area to be grouted and an adjustment shall be made to the air-entrainment admixture.

(d) Slump

Slump shall be checked twice during each shift that concrete grout is produced. Samples shall be obtained in accordance with ASTM C 172 and tested in accordance with ASTM C 143/C 143M.

(e) Placing

The placing foreman shall not permit placing to begin until he has verified that adequate equipment and workmen are available.

6-3.12.2 Pre-Production

(a) Bulk Specific Gravity

During the process of selecting a source or sources of stone for the project, the Contractor shall make an investigation to determine the lowest and highest bulk specific gravity (SSD) of stone available at the source or sources he proposes to utilize for each gradation range of stone. Tests shall be performed at an approved testing laboratory in accordance with ASTM D6473 (1999). The testing results shall be submitted in accordance with **Clause 6-1.3 - Submittals**. Test results, which display an extraordinarily wide range of values, may necessitate additional testing to determine whether the source contains stratas with stones of an acceptable range of bulk specific gravity.

(b) Material Quality

Before selecting a source for preparation of a demonstration stockpile, the Contractor shall be reasonably certain that the source is capable of meeting the quality and source requirements specified in **Clauses 6-1.4 (b) and (c) - Sources and Evaluation Testing of Stone** respectively, including their respective Sub-Clauses.

(c) Demonstration Stockpile at Source

Following submittal of the Contractor's Quality Control (CQC) Plan and the Contractor's selection of a source, but prior to the Project Manager’s approval of a source and the CQC Plan, the Contractor shall make arrangements to provide a pre-production demonstration stockpile for each of the stone size ranges for the project. The stockpiles shall be located at the source of the stone and be shaped in windrow fashion. The stones with a size range greater than 2.7 tons shall be placed in a single layer with 300 mm of clear space around each stone. Stones under 2.7 tons in weight shall not be stacked higher than 1200 mm. The stones placed in the demonstration stockpiles shall be representative of the overall quality of materials in the source and shall not consist of the best specimens unless it is reasonable to determine that the source will provide the

required amount of stone of the applicable size range with a degree of quality no less than that existent in the demonstration stockpile.

The stones placed in the stockpile shall have been pre-selected by the Contractor's Quality Control Plan (CQCP) inspector or supervisor and acceptable stones over 230 kg in size shall have been marked with spray paint on three mutually perpendicular sides with a coded mark to denote acceptability for a certain size range. A stockpile of representative reject stones marked with a red "X" shall also be maintained at the site as examples of unacceptable materials or shapes.

(d) Evaluation of Demonstration Stockpile at Source

The Contractor shall notify the Project Manager when stockpiles are ready for evaluation. The Contractor's approved Quality Control Plan (QCP) supervisor and all QCP inspectors shall accompany the Project Manager during the Project Manager's evaluation of the demonstration stockpiles. The Contractor shall arrange to have individual stones turned as necessary to accommodate the Project Manager's evaluation. The Project Manager's will mark rejected stones with a red "X" and such stones shall be removed to the reject stockpile or to a crusher if one is available. If more than 2 unacceptable stones are found within a stockpile, the entire stockpile will be rejected by the Project Manager and a replacement stockpile will be created for re-evaluation. If the replacement stockpile is rejected, the Contractor shall revise and resubmit its Quality Control Plan (QCP) and shall create another replacement demonstration stockpile for evaluation. If the third demonstration stockpile for a particular size range at a single source is found unacceptable, the source will be disapproved for such size rang and a new source shall be submitted for approval. In addition the Contractor shall submit the name and qualifications for a person to replace the QCP supervisor. The Contractor may, of its own accord, choose a replacement source at the time a first or second demonstration stockpile is found unacceptable. The replacement of demonstration stockpiles or stone sources shall be at no additional cost to the Employer and with no change in the time of completion.

(e) Approval of Demonstration Stockpile at Source

At the time the Project Manager finds the contents of a demonstration stockpile to be unacceptable, either through visual examination or through laboratory testing, the Contractor will be notified in writing that the source, the QCP plan and QCP staff are approved, whereupon the Contractor may proceed with production of materials for the project provided they are consistent with demonstration stockpiles.

(f) Duration of Demonstration Stockpile at Source

Other than for being shipped as the final quantities of materials to be placed in the work, each demonstration stockpile shall remain unchanged at the source until all other required material of the size range represented by the stockpile has been shipped from the source.

6-3.12.3 Placement Control

The Contractor shall establish and maintain quality control for all work performed at the job site under this section to assure compliance with contract requirements. He shall maintain records of his quality control tests, inspections and corrective actions. Quality control measures shall cover all construction operations including, but not limited to, the placement of all materials to the slope and grade lines shown and in accordance with this section.

6-3.12.4 Bedding Layers

(a) General

The Contractor shall perform gradation tests to assure compliance with contract requirements and shall maintain detailed records. The bedding material, filter materials and/or sand fill shall be sampled in accordance with ASTM D 75 and tested in accordance with ASTM C 136. The Contractor shall perform the tests before and after surveys of each layer of stone protection material placed.

(b) Reporting

Reporting shall be in accordance with **Sub Clause 6-2.2.1 (c) - Gradation Test**.

6-3.12.5 Gradation Tests for Stone

Gradation tests for riprap and other stones shall be performed in accordance with ASTM D 5519, Test Method A.

PART 4 MEASUREMENT AND PAYMENT

6-4.4 Gabion, Mattresses and Riprap

6-4.4.1 Measurement

Gabions and Mattresses meeting the requirements of these specifications and acceptably placed within the limits indicated on the drawings or otherwise established in the field, will be measured for payment by the cubic meter of stone filled gabions in place in different areas of work.

Measurement for providing and weaving G.I.wire netting for wire crate acceptable provided according to the specification shall be made separately in Sq. m.

6-4.4.2 Payment

Payment will be made at the rates quoted for Gabions and Mattresses in different areas of work in Bill of Quantities for costs associated with gabion or mattress protection, including the costs of furnishing, assembling, and placing the wire baskets, the stone fill, and all other materials, labor, equipment, tools, supplies, and incidental costs in connection with furnishing and completing this item of work. The rate shall be deemed to include the costs for stripping and foundation preparations.

Payment for providing and weaving G.I.wire netting for wire crate measured as above shall be made separately in Sq. m.

6-4.4.3 Unit of Measure

Unit of measure: Square Meter.

6-4.5 Stone Pitching

6-4.5.1 Measurement

Measurement for stone pitching shall be made by the volume of stone pitching acceptably in place according to the specifications. The volume of stone pitching shall be calculated from drawings or as approved by the Project Manager.

6-4.5.2 Payment

Payment for stone pitching will be made at the rates quoted in the Priced Bill of Quantities which will constitute full compensation to the Contractor for providing all plant, labor, material, and equipment and performing all operations necessary for this item of work. The rate shall include all costs for the furnishing required samples of stone materials, testing of the stone materials, furnishing and transporting approved stone materials to the point of final use, stocking, placing, spreading, grading and compacting of the stone materials on slope or on level and all other work and operations related to the work. No measurement for payment shall be made of the unused and or rejected materials. The Contractor shall keep an allowable for the loss of material due to compaction.

6-4.5.3 Unit of Measure

Unit of measure: Cubic Meter.

6-4.6 Providing and Laying Crushed Stone on Top of Bunds

6-4.6.1 Measurement

Measurement for crushed stone on top of bunds shall be made by the volume of crushed stone acceptably in place according to the specifications. The Volume of crushed stone shall be calculated from drawings or as approved by the Project Manager. No measurement for payment shall be made of the unused and or rejected materials. The Contractor shall keep an allowable for the loss of material due to compaction.

6-4.6.2 Payment

Payment for crushed stone will be made at the rates quoted in the Priced Bill of Quantities which will constitute full compensation to the Contractor for providing all plant, labor, material, and equipment and performing all operations necessary for this item of work. The rate shall include all costs for furnishing the required samples of stone materials, testing of the stone materials, furnishing and transporting approved stone materials to the point of final use, stocking, placing, levelling, grading and compacting of the stone materials on top of bunds and all other work and operations related to the work.

6-4.6.3 Unit of Measure

Unit of measure: Cubic Meter.

CHAPTER 7 – EMBANKMENT CONSTRUCTION FOR CANALS & DISTRIBUTRIES

PART 1 GENERAL

7-1.1 Scope

This Section specifies requirements for the construction of embankment for Main Canal and Distributaries including the preparation of foundation. The specifications for fills other than Canals embankment are covered in Section 5, Excavation and Miscellaneous Earthwork.

7-1.2 References

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)	
ASTM C535	(2003) e1 Standard Test Method for Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM – C88	(1999) a Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C127	(2001) Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM D 1556	(2000) Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D 2167	(1994; R 2001) Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D 2216	(1998) Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
ASTM D 2487	(2000) Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D 2922	(2001) Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)
ASTM D 698	(2000a) Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))
ASTM D4318	(2000) Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4647-93	(1998) e1 Standard Test Method for Identification and Classification of Dispersive Clay Soils by the Pinhole Test
ASTM D422-63	(2002) Standard Test Method for Particle-Size Analysis of Soils

ASTM D698	(2000) e1 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3))
ASTM D4253	(2000) Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
ASTM D4254	(2000) Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density
ASTM D5550 or Solids by	(2000) Standard Test Method for Specific Gravity of Soil Gas Pycnometer
ASTM D854 Solids	(2000) Standard Test Methods for Specific Gravity of Soil by Water Pycnometer
ASTM D1556 or	(2000) Standard Test Method for Density and Unit or Weight of Soil in Place by the Sand-Cone Method
D2167 (1994, R2000)	Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method
U.S. ARMY CORPS OF ENGINEERS (USACE)	
EM 1110-2-1906	(1970; R 1986) Laboratory Soils Testing

7-1.3 Submittals

Submissions, which the Contractor is required to make in relation to embankments and other fills in accordance with **Clause 1-1.4 - Submittal Procedures**, are specified below:

SD-01 Details of Proposed Methods

The Contractor shall submit:

(a) Proposed methods of placing and compacting fill including a schedule of plant and equipment to be used.

(b) Program for quality control of earthworks.

(c) Proposed sources of all embankment and other fill materials including rip-rap and methods of selective excavation and processing.

(d) Proposed program of embankment construction.

(e) Program and details of construction of test fills.

SD-02 Shop Drawings

(a) Record drawings of the agreed ground level surveys prior to excavation and prior to the placement of fill in those areas.

(b) Record drawings of all agreed level surveys taken for the purposes of measurement of quantities of fill.

Survey records as specified above shall be submitted to the Project Manager within 7 days of the completion of the survey work recorded on them.

SD-04 Samples

The Contractor shall submit samples of materials proposed for use as fill, where specifically required by the Project Manager.

SD-07 Certificates

The Contractor shall submit:

(a) Laboratory test results.

(b) Field test results.

7-1.4 Definitions

The term "embankment" as used in these specifications is defined as the earth and rock fill portions of the canals and distributaries and includes all types of earth fill for canals /distributaries and filter materials for the dam and all other specified or directed earth and rock fills within the limits of the canals and dam, excepting those stone and filter materials used for slope protection, which are described in Section 6-Protection of Slopes and Channels. "Compacted fill" includes all fill, except backfill, deposited in layers and compacted by rolling or tamping. The types of compacted earth fill are:

(a) "Impervious fill" for the impervious section of the embankment.

(b) "Rock fill" consists of those portions of the embankment where rock is used for purpose other than slope protection.

(c) "Filter drainage layers" forming the horizontal and/or vertical or inclined pervious drainage blankets and transition zones designed to prevent the detrimental movement of soil particles.

7-1.5 General Provisions

7-1.5.1 Lines and Grades

The embankment shall be constructed to the lines, grades and cross sections indicated unless otherwise directed. The Project Manager reserves the right to increase or decrease the foundation widths or the embankment slopes or make such other changes in the embankment sections as may be deemed necessary to produce a safe structure.

7-1.5.2 Conduct on the Work

The Contractor shall maintain and protect the embankment in a satisfactory condition at all times until final completion and acceptance of all work under the contract. If in the opinion of the Project Manager the hauling equipment causes horizontal shears or slick sides, rutting, quaking, heaving, cracking or excessive deformation of the embankment, the Contractor shall limit the type, load or travel speed of the hauling equipment on the embankment. Any approved embankment material which is lost in transit or rendered unsuitable after being placed in the embankment and before final acceptance of the work, shall be replaced by the Contractor in a satisfactory manner and no additional payment will be made therefor. The Contractor shall excavate and remove from the embankment any material which the Project Manager considers objectionable and shall also dispose of

such material and refill the excavated area as directed, all at no cost to the Employer. The Contractor shall remove, at his own expense, any embankment material placed outside of prescribed slope lines.

7-1.5.3 Haul Roads

Haul roads shall be located and constructed as approved. They shall be designed to maintain the intended traffic, to be free draining and shall be maintained in good condition throughout the contract period, unless otherwise directed. Haul roads within the area of contact between the embankment and its foundation and abutments shall be removed and the area shall be treated as specified in **Sub-Clause 7-3.1 - Preparation of Foundation, Partial Fill Surface, and Abutments**.

7-1.5.4 Stockpiling from Approved Borrow Sources

When the excavation from approved borrow sources progresses at a faster rate than placement in the fill is being accomplished, such excavated material shall be stockpiled at approved locations adjacent to the work until its use is authorized. No payment will be made for such stockpiling nor for the reloading and hauling of this material to its final position in the embankment.

PART 2 PRODUCTS

7-2.1 Materials

Classification of soils will be in accordance with ASTM D 2487.

7-2.1.1 General

The origin of any fill material in no way determines where it may be used in the embankment. Materials for embankment fills shall be secured from required excavations and from the borrow areas proposed by the Contractor and approved by the Project Manager. The intention is to use the most suitable materials obtainable from these sources. Material to be wasted will be specifically designated at the time the material is excavated. Materials containing brush, roots, sod or other perishable materials will not be considered suitable. The suitability of the materials shall be subject to approval and their disposition in the embankment will be as directed. The Contractor shall excavate in the borrow areas in the location approved by the Project Manager, whenever such control is necessary to obtain the type of material required for the embankment. Mixing of materials during the excavating process at the borrow area may be required.

7-2.1.2 Impervious Fill

Material for compacted impervious fill shall consist of clays, silty clays, or clayey silts obtained from the designated borrow areas or from the required excavation for structures. Silts and clays containing sand may be used, if such materials are sufficiently impermeable and suitable for compacting with a tamping or rubber-tired roller.

The materials when compacted in impervious fill shall have the following properties:

(i) Material shall contain a minimum of 35% by dry weight of soil particles passing ASTM Standard No. 200 sieve (size 0.075 mm).

(ii) Plasticity index of 10 percent or greater as determined in accordance with ASTM D4318 (2000).

(iii) The liquid limit determined by ASTM D4318 (2000) shall not exceed 70 percent.

(iv) The material shall be non-depressive. It shall have pin-hole dispersion classification ND1 or ND2 when tested in accordance with ASTM D4647-93 (1998) e1.

7-2.1.3 Filter Drainage Layers

Filter materials shall be composed of tough, durable particles; shall be reasonably free from thin, flat and elongated pieces; and shall contain neither organic matter nor soft, friable particles in quantities considered objection-able by the Project Manager. Filter materials shall consist of sand, gravel, or crushed stone, well graded between the limits specified by gradation envelopes shown in drawings.

Gradation of the material shall be determined in accordance with EM 1110-2-1906. All points on individual grading curves obtained from representative samples of filter material shall lie between the boundary limits as defined by smooth curves drawn through the tabulated grading limits plotted on a mechanical analysis diagram. The individual grading curves within these limits shall not exhibit abrupt changes in slope denoting skip grading, scalping of certain sizes or other irregularities which would be detrimental to the proper functioning of the filter.

7-2.1.4 Rock Fill

Stone classed as "rock" shall be sound; well graded and free draining. The presence of rock meeting the requirements of slope protection, Section, will not be objectionable. Rock shall be obtained from required excavation and from already existing stockpiles and from quarries proposed by the Contractor and approved by the Project Manager. Shales unsuitable for use as rock fill, mudstone and other unsuitable excavated material shall be wasted in designated spoil areas.

PART 3 EXECUTION

7-3.1 Preparation of Foundation, Partial Fill Surfaces and Abutments

7-3.1.1 Earth

After excavation or stripping of the embankment foundation and excavation of the cut-off trench to the extent indicated or otherwise required, the sides of stump holes, test pits, and other similar cavities or depressions shall be broken down, where so directed, so as to flatten out the slopes, and the sides of the cut or hole shall be scarified to provide bond between the foundation material and the fill. Unless otherwise directed, each depression shall be filled with either impervious material, filter drainage layer or rock material dependent upon the type of material which is to be placed immediately above the foundation. The fill shall be placed in layers, moistened, and compacted in accordance with the applicable provisions of **Sub-Clauses 7-3.2, 7-3.3, 7-3.4 - Placement, Moisture**

Control, and Compaction. Materials which cannot be compacted by roller equipment because of inadequate clearances shall be spread in 150 mm layers and compacted with power tampers to an extent equal to that of the contiguous embankment fill material. After filling of depressions and cut-off trench and immediately prior to placement of compacted fill in any section of the embankment, the foundation of such section shall be loosened thoroughly by scarifying, plowing, discing or harrowing to a minimum depth of 150 mm, and the moisture content shall be adjusted to the amount specified in **Sub-Clause 7-3.3 - Moisture Control** for the appropriate type of material, except in areas where this requirement is waived by the Project Manager. After removal of roots or other debris turned up in the process of loosening, the entire surface of the embankment foundation area shall be compacted by 6 complete coverages of the compaction equipment as specified for the appropriate type of fill. Prior to placement of compacted fill on or against the surfaces of any partial fill section, all soft or loose material, all material containing cracks or gullies, and all material that does not conform with the specified zoning of the embankment shall be removed. The remaining surface of the partial fill shall be loosened by scarifying, plowing, discing or harrowing to a minimum depth of 150 mm, and the moisture content shall be adjusted as specified in **Sub-Clause 7-3.3 - Moisture Control** for the appropriate type of material. The surface of the partial fill section upon which fill is to be placed shall then be compacted as hereinafter specified for the appropriate type of fill. No separate payment will be made for loosening and rolling the foundation area, the abutment area, or the surfaces of partial fill sections, but the entire cost thereof shall be included in the applicable contract price for fill.

7-3.1.2 Rock

All rock surfaces upon which or against which embankment materials are to be placed shall be cleaned in accordance with the applicable provisions of Section 5 Excavation and Miscellaneous Earthworks. Prior to the placement of embankment material upon or against a rock surface, all open joints and cracks in that surface shall be filled with mortar to the depths cleaned. Those portions of such rock surfaces where, in the opinion of the Project Manager, the compaction of the embankment materials cannot be accomplished satisfactorily with power tampers or other specified compaction equipment, shall be filled with mortar or concrete as directed to the extent necessary to permit satisfactory use of the compaction equipment. In no case shall a thin coat of mortar be left on smooth, intact rock surfaces. Large rock overhangs and protrusions shall be removed by the use of pre-splitting or line drilling techniques in such a manner as to minimize damage to the underlying rock, or the spaces beneath overhangs and around protrusions shall be filled with tamped concrete so that satisfactory compaction of embankment materials can be accomplished. Vertical surfaces shall not be more than 1.5 meters in height, and benches of sufficient width shall be provided as necessary so that the average slope of any rock face is not steeper than 2 vertical on 1 horizontal. Mortar and concrete, including forming as necessary, shall conform with the applicable provisions of Section 8-Concrete Work.

7-3.2 Placement

7-3.2.1 General

No fill shall be placed on any part of the embankment foundation until such areas have been inspected and approved. The gradation and distribution of materials throughout the compacted earth fill section of the canals, distributaries and dam shall be such that the embankment will be free from lenses, pockets, streaks, and layers of material differing substantially in texture or gradation from surrounding material of the same class. Successive loads of material shall be dumped at locations on the fill as directed or approved. No fill shall be placed upon a frozen surface, nor shall snow, ice, or frozen earth be incorporated in the embankment.

7-3.2.2 Frozen Material

Embankment shall not be placed on a foundation, which contains frozen material. This prohibition encompasses all foundation types, including the natural ground, all prepared subgrades, whether in an excavation or on an embankment, and all layers of previously placed and compacted earth fill which become the foundations for successive layers of earthfill. All material that freezes or has been subjected to freeze-thaw action during the construction work, or during periods of temporary shutdowns, such as, but not limited to, nights, holidays, weekends, or winter shutdowns or earthwork operations, shall be removed to a depth that is acceptable to the Project Manager and replaced with new material. Alternatively, the material shall be thawed, dried, reworked, and re-compacted to the specified criteria before additional material is placed. The Project Manager will determine when placement of fill shall cease due to cold weather. The Project Manager may elect to use average daily air temperatures, and/or physical observation of the soils for his determination.

7-3.2.3 Rate of Placement

Unless otherwise directed, the embankment shall be maintained at approximately the same level regardless of the number of types of materials being placed, unless this provision is waived in writing by the Project Manager. Method of placement shall be such that contamination of various fill zones is avoided.

7-3.2.4 Impervious Fill

Impervious fill shall be placed in the impervious section, cut-off trench, and impervious blanket. In general, the more impervious materials shall be placed towards the center of the impervious section and the less impervious materials toward the rockfill sections so that a transition in permeability is effected from the core to the rockfill sections.

7-3.2.5 Filter Drainage Layers

Sand filters, gravel filters, and sand and gravel filters shall be placed in the embankment in the manner described and to the lines and grades indicated.

7-3.2.6 Rock Fill

The rock fill embankment shall be constructed of quarry run sizes of durable rock dumped and bulldozed into place in not greater than 1 m lifts to the lines and grades shown, or as

staked in the field, and in such manner as to produce a reasonably well graded mass with the smaller stones adjacent to the filter material and the larger sizes on the outer slopes of the embankment with no objectionable pockets of small stones or clusters of larger stones. The placing shall be supplemented by such hand methods as are required to obtain even surfaces on the outside faces. A tolerance of plus 300 mm and minus 150 mm from the slope lines and grades shown will be allowed in the finished surfaces of the rock fills, except that the extreme minus tolerance shall not be continuous over an area greater than 20 square meters. All bridging in rock fills shall be broken as well as all slabs and slabby rock. Special care shall be exercised in placing rock fill in all areas within 1 m of structures to avoid damage to such structures.

7-3.2.7 Spreading

After dumping, the materials shall be spread by bulldozers or other approved means in approximately horizontal layers over the entire fill areas. Unless otherwise directed, the thickness of these layers before compaction shall be 230 mm or as shown in Bill of Quantities. As soon as practicable after commencement of construction of any section of the embankment, the central portion thereof shall be raised or crowned with grades not to exceed 3 percent so that the surface of the fill will drain freely and shall be so maintained throughout construction. If the compacted surface of any layer of material, exclusive of filter material and rockfill, is determined to be too smooth to bond properly with the succeeding layers, it shall be loosened by harrowing, or by any other approved method, before the succeeding layer is placed. At all times during the dumping and spreading processes, the Contractor shall maintain a force of men adequate to remove all roots and debris from all embankment materials and all stones of greater than 10 mm in maximum dimension from impervious materials. Stone so removed and debris shall be removed from the embankment and disposed of in an approved manner. The entire surface of any section of the embankment under construction shall be maintained in such condition that construction equipment can travel on any part of any one section. Ruts in the surface of any layer shall be removed by scarifying before placing and compacting additional material.

7-3.3 Moisture Control

The materials in each layer of the fill shall contain the amount of moisture, within the limits, specified below or as directed, necessary to obtain the specified compaction. Material that is not within the specified limits after compaction shall be reworked, regardless of density.7-3.3.1Impervious Sections

The moisture content after compaction shall be as uniform as practicable throughout any one layer of impervious materials. The moisture content after compaction as determined by ASTM D 2216 shall be within the limits of 2 percentage points above optimum and 1 percentage point below optimum moisture content. Material that is too wet shall be spread on the embankment and permitted to dry, assisted by discing or harrowing, if necessary, until the moisture content is reduced to an amount within the specified limits. When the material is too dry, the Contractor will be required to sprinkle water in each layer

of the fill. Harrowing or other approved methods will be required to work the moisture into the material until a uniform distribution of moisture is obtained. Water applied on a layer of fill shall be accurately controlled in amount so that free water will not appear on the surface during or subsequent to rolling. Should too much water be added to any part of the embankment, so that the material is too wet to obtain the desired compaction, the rolling on that section of the embankment shall be delayed until the moisture content of the material is reduced to an amount within the specified limits. If it is impracticable to obtain the specified moisture content by wetting or drying the material on the fill, the Contractor may be required to prewet or dry back the material at the sources of excavation. If, in the opinion of the Project Manager, the top or contact surfaces of the partial fill section become too dry to permit suitable bond between these surfaces and the additional fill to be placed thereon, the Contractor shall loosen the dried materials by scarifying or discing to such depths as may be directed; he shall dampen the loosened material to an acceptable moisture content; and he shall compact this layer in accordance with the applicable requirements of **Sub-Clause 7-3.4 - Compaction, Sub-Clause 7-3.4.2 - Impervious Fill**, to densities comparable to the underlying embankment.

7-3.3.1 Filter Drainage Layers

Moisture control of graded gravel filter and bedding layers will not be required and sluicing will not be permitted. Moisture control of filters containing a predominate amount of sand particles will be as required as under.

For moisture control, material shall be wetted by sprinkling water after spreading on the embankment and the moisture content of each layer shall be maintained at the optimum for compaction during rolling. Pre-wetting of material at the sources of excavation or borrow will not be required. Sprinkling shall be done with hoses connected to header pipes along the faces of the embankment, by water trucks with pressure spray bars, or by any other approved method. All connections in the water supply system, including the hose connections to the header pipes, shall be watertight. Jets shall not be directed at the embankment with such force that the finer materials will be washed out. The capacities of pumps and sizes of header pipes shall be sufficient to supply the required amount of water at all times.

7-3.3.2 Rock Fill

No moisture control will be necessary on rock fills. However sufficient water should be sprayed to have lubrication effect.

7-3.4 Compaction

7-3.4.1 Equipment

Compaction equipment shall conform to the following requirements and shall be used as prescribed in subsequent paragraphs.

(a) Tamping Rollers

(i) Towed - Tamping rollers shall consist of two or more non-vibratory roller drums mounted side-by-side in a suitable frame and towed by either a crawler-type or rubber tired tractor having sufficient power to pull the roller satisfactorily when the drums are fully ballasted. Each drum shall be free to pivot about an axis parallel to the direction of travel. Rollers operated in tandem sets shall be controlled in a manner such that the prints produced by the tamping feet of the tandem units are staggered. Each drum of a roller shall have an outside diameter of not less than 1500 mm and shall be not less than 1500 mm in length. The space between two adjacent drums, when on a level surface, shall not be less than 300 mm nor more than 375 mm. Each drum ballasted with fluid shall be equipped with at least one pressure-relief valve and with at least one safety head. The safety head shall be equal to union-type safety heads equipped with rupture discs suitable for rupturing pressures between 350 and 500 kPa. The pressure - relief valve is a manually operated valve and shall be opened periodically. Personnel responsible for opening pressure-relief valves shall be periodically instructed to ascertain that valve openings are free from plugging to assure that any pressure developed in roller drums is released at each inspection. At least one tamping foot shall be provided for each 186 000 square millimeters of drum surface. The length of each tamping foot from the outside surface of the drum shall be not more than 275 mm and shall be maintained at not less than 225 mm. The bearing surface of each tamping foot shall be flat with a surface area not less than 4500 square millimeters nor more than 6500 square millimeters. During the operation of rolling, the spaces between the tamping feet shall be maintained clear of materials which would impair the effectiveness of the tampering rollers. The weight of a roller when fully loaded shall be not less than 58 400 N/m of drum length, and the weight of a roller empty shall be not more than 36,500 N/m of drum length. The bearing surface, tamping foot size, the drum loading, and the operation of the rollers shall be as required to obtain the desired compaction. If more than one roller is used on any one layer of fill, all rollers so used shall be of the same type and essentially of the same dimensions. Rollers shall be drawn by crawler-type or rubber-tired tractors at a speed not to exceed 8 km/h. The use of rubber-tired towing equipment shall be discontinued if the tires leave ruts that prevent uniform compaction by the tamping roller, and the substitution of crawler-type towing equipment may be directed.

(ii) Self-propelled - The use of self-propelled non-vibratory tamping rollers conforming with the following specification will be permitted, and their design and operation shall be subject to approval, and subject to the right, at any time during the prosecution of the work, to direct such modifications to the tamping feet or variations in roller drum weight where applicable, as may be found necessary to secure optimum compaction of the earth fill materials. If use of self-propelled tamping rollers causes shearing of the fill, laminations in the fill, or results in inadequate compaction, the Project Manager may direct that such rollers be removed from the fill and that appropriate towed tamping rollers be used. Two-or three-drum side-by-side units that are either in drive position or drawn by separate power equipment shall have a clearance between adjacent drums not less than 300 mm nor more than 375 mm. Two-drum or four-drum equipment separated by cab and differential and arranged in tandem must have its static weight equally distributed to all compaction drums and must have the tandem

drums positioned such that the prints of the tamping feet produced by the tandem drums are staggered. The surface on which the tamping feet are mounted shall have a minimum outside diameter of 1200 mm and at least one tamping foot for each 186,000 square millimeters of drum surface. The distance between the centers of any two adjacent tamping feet shall be not less than 225 mm. The length of each tamping foot from the outside mounting surface of the drum shall be not more than 275 mm and shall be maintained at not less than 225 mm. The bearing surface of each tamping foot shall be flat and have a surface area not less than 4500 square millimeters nor more than 9000 square millimeters. Cupped recesses within the bearing surface of each tamping foot will be permitted but shall not exceed 13 mm in depth. During rolling operations, the spaces between the tamping feet shall be maintained clear of materials which would impair the effectiveness of the tamping roller. The weight of all roller drums during compaction of fill materials shall be maintained uniform and with the weight per foot of drum length not less than 62,800 N. For self-propelled rollers with drums capable of being ballasted with fluid, each drum shall be equipped with at least one pressure-relief valve and with at least one safety head. The safety head shall be equal to union type safety heads equipped with rupture discs suitable for rupturing pressures between 350 and 500 kPa. The pressure relief valve is a manually operated valve and shall be opened periodically. Personnel responsible for opening pressure-relief valves shall be periodically instructed to ascertain that valve openings are free from plugging to assure that any pressure developed in roller drums is released at each inspection. For self-propelled rollers in which steering is accomplished through the use of rubber-tired wheels, the tire pressure shall not exceed 275 kPa. The use of the compactor shall be discontinued if the tires leave ruts that prevent uniform compaction by the tamping roller and the substitution of appropriate towed tamping rollers may be directed. When a self-propelled roller is provided with a dozer blade, coverages made with the blade in operation shall not be counted as compaction coverages. Self-propelled rollers shall be operated at a speed not to exceed 8 km/h.

(b) Vibratory Rollers

Vibratory rollers for compacting rockfills, pervious sand and gravel fills, or filter and transition drainage layers shall be equipped with a smooth steel compaction drum and shall be operated at a frequency of vibration during compaction operations between 1100 and 1500 vpm. Vibratory rollers may be either towed or self-propelled and shall have an unsprung drum weight that is a minimum of 60 percent of the rollers' static weight. Towed rollers shall have at least 90 percent of their weight transmitted to the ground through the compaction drum when the roller is standing in a level position hitched to the towing vehicle. Rollers for compacting rockfill, sand and gravel fills, or filter and drainage layers shall have a minimum static weight of 90 kN, a minimum dynamic force of 180 kN when operating at 1400 vpm, and an applied force not less than 130 kN/m of compaction drum length. The level of amplitude and vibration frequency during compaction will be maintained uniform throughout the embankment zone within which it is operating. Rollers shall be operated at speeds not to exceed 2.4 km/h. The equipment manufacturer shall furnish sufficient data, drawings, and computation for verification of the above specifications, and the character and efficiency of this equipment shall be subject to approval.

(c) Rubber-tired Rollers

Rubber-tired rollers shall have a minimum of four wheels equipped with pneumatic tires. The tires shall be of such size and ply as can be maintained at tire pressures between 550 and 700 kPa for a 110 kN wheel load during rolling operations. The roller wheels shall be located abreast and be so designed that each wheel will carry approximately equal load in traversing uneven ground. The spacing of the wheels will be such that the distance between the nearest edges of adjacent tires will be greater than 50 percent of the tire width of a single tire at the operating pressure for a 110 kN wheel load. The roller shall be provided with a body suitable for ballast loading such that the load per wheel may be varied, from 80 to 110 kN. The roller shall be towed at speeds not to exceed 8 km/h. The character and efficiency of this equipment shall be subject to approval.

(d) Power Tampers

Compaction of material, in areas where it is impracticable to use a roller or tractor, as provided in **Sub-Clause 7-3.1.1 - Earth**, shall be performed by the use of approved power tampers.

7-3.4.2 Impervious Fill

After a layer of impervious fill material has been dumped and spread, it shall be harrowed if required, to break up and blend the fill materials, unless harrowing, as specified under **Sub-Clause 7-3.3.1 - Impervious Sections**, is performed to obtain uniform moisture distribution. Harrowing shall be performed with a heavy disc plow, or other approved harrow, to the full depth of the layer. If one pass of the harrow does not accomplish the breaking up and blending of the materials, additional passes of the harrow may be required, but in no case will more than three passes of the harrow on any one layer be required for this purpose. When the moisture content and the condition of the layer is satisfactory, the lift shall be compacted to at least 98 percent of maximum density as determined by ASTM D 698, prior to placement of the next layer. Determination of in-place density shall be in accordance with ASTM D 1556, ASTM D 2167, and ASTM D 2922. Portions of the fill which are not accessible to the roller shall be placed in 150 mm layers loose measurement and compacted with power tampers to a degree equal to that obtained on the other portions of the compacted fill by rolling as specified. Dumping, spreading, sprinkling, and compacting may be performed at the same time at different points along a section when there is sufficient area to permit these operations to proceed simultaneously.

7-3.4.3 Filter and Transition Drainage Layers

The requirements for compacted pervious fills will apply to these materials except for bedding layers under dumped riprap. Bedding layers under dumped riprap will require no special compaction other than controlled movement of dumping and spreading equipment.

7-3.4.4 Rock Fill

After the rock fill has been dumped and spread to the thickness specified, the entire surface of the layer shall be compacted by not less than 5 complete coverages of the

vibratory roller specified in **Sub-Clause 7-3.4.1(b) - Vibratory Rollers**. A complete coverage shall consist of the entire coverage of the area with one trip of the equipment specified. Each trip of the roller shall overlap the adjacent trip not less than 300 mm.

7-3.5 Slides

In the event of slides in any part of the embankment prior to final acceptance of the work the Contractor shall remove material from the slide area, as directed, and shall rebuild such portion of the embankment. In case it is determined that the slide was caused through the fault of the Contractor the removal and disposal of material and the rebuilding of the embankment shall be performed without cost to the Employer; otherwise this work will be paid for at the applicable contract unit prices for compacted fill.

7-3.6 Test fills

The Contractor shall carry out compaction trials prior to the beginning of embankment construction using the specified roller and any other provisionally approved compaction device.

Test fills shall be a minimum of 20 m long and the compacted width shall be at least three roller widths. An additional roller width of fill shall be placed adjacent to each edge of the compacted fill. The minimum test fill thickness for each combination of variables to be tested shall be three fill layer thicknesses.

For impervious fill, the Contractor shall demonstrate that the methods he proposes to use for excavating, processing, watering, transporting, placing and compacting will achieve the specified requirements.

For filters the densities of each zone achieved by various compactive efforts and with the addition of varying amounts of water shall be measured, together with particle size determinations before and after compaction.

Before commencing any trials, the Contractor shall submit his proposals to the Project Manager for approval.

No separate payment will be made for test fills.

7-3.7 Testing

Following tests shall be carried out on materials for various zones of embankment:

(i) Gradation Tests – ASTM D422-63 (2002)

(ii) Liquid Limit and Plastic Limit – ASTM D4318 (2000)

(iii) Los Angeles Abrasion - ASTM C535 (2003) e1

(iv) Sodium Sulphate Soundness Test - ASTM – C88 (1999) a

(v) Compaction Test – ASTM D698 (2000) e1

(vi) Maximum and minimum dry density – ASTM D4253 (2000) and D4254 (2000)

(vii) Specific gravity and absorption of rock / aggregate samples - ASTM C127 (2001)

(viii) Specific gravity of soil solids – ASTM D5550 (2000) or D854 (2000)

(ix) Field density Test – ASTM D1556 (2000) or D2167(1994, R2000)

(x) Pinhole Dispersion Test – ASTM D4647-93 (1998) e1

Representative tests shall be performed at the sites and at the frequency indicated below:

Test	**Frequency of Test Rock fill**			
	Impervious fill	Fine Filter	Coarse Filter	Rock fill
Gradation	(i) 1 test for every 2000m^3 of fill or,	(i) 1 test for every 500m^3 of fill or,	(i) 1 test for every 500m^3 of fill or,	Total 5 tests
	(ii) at lest one test for every shift of compaction, whichever is greater	(ii) at lest one test for every shift, whichever is greater	(ii) at lest one test for every shift, whichever is greater	-
Sodium Sulphate Soundness	-	Total 5 tests	Total 5 tests	Total 5 tests
Liquid Limit and Plastic Limit	One set of tests every 2000m^3 of fill	-	-	-
Los Angeles Abrasion	-	-	Total 5 tests	Total 5 tests
Specific Gravity	10 tests	10 tests	10 tests	10 tests
Pinhole Dispersion	10 tests	-	-	-
Field density Test	(i) One test per 500m^3 of material placed or,	(i) One test per 500m^3 of material placed or,	(i) One test per 500m^3 of material placed or,	-

Test	Frequency of Test Rock fill			
	(ii) At lest one test for every shift of compaction, whichever is greater	(ii) At lest one test for every shift, whichever is greater	(ii) At lest one test for every shift, whichever is greater	
Compaction Test in Laboratory	One test for every 5 field density tests	-	-	-
Maximum and Minimum dry density	-	One test for every 5 field density tests	One test for every 5 field density tests	-

Project Manager may vary the frequency of tests depending on variation in fill material and change in material source.

The tests for which facility is not available at field laboratory, shall be arranged by the Contractor at other laboratories approved by the Project Manager. No payment will be made for the tests carried out as required under this Clause.

PART 4 MEASUREMENT AND PAYMENT

7-4.1 Earthwork for Canal and Distributaries Embankments

7-4.1.1 Measurement

Measurement, for payment, of furnishing, placing and compacting canal and distributaries embankments will be made of the volume of compacted material in place to the lines grades and dimensions shown on the Drawings or directed. Clearing and stripping of top soil upto depth of 150 mm shall not be measured for payment.

7-4.1.2 Payment

Payment for furnishing, placing and compacting embankment fill other than canal and distributaries embankments will be made at the rate per cubic meter tendered therefor in the priced Bill of Quantities. These rates shall the costs of all labour, material, equipment for temporary constructions, clearing and stripping of top soil, preparation of foundations for embankment, furnishing and preparation of required test fills, providing fill materials from stockpiles or sources other than required excavation, placing and spreading of fill materials in layers of specified thickness, removal of objectionable and unsuitable materials, moistening the fill materials at the place of excavations, stockpiles or at the embankments, embankment compaction, providing machinery for compaction, testing, and all other activities and operations incidental to the furnishing, placement and compaction of the fill materials in canal and distributaries embankments according to the Specifications set forth or as directed by the Project Manager.

Material from required excavation used for embankment fill will be paid for both as excavation when removed from required excavation and as fill when placed. Payment will not be made for excavating materials from stockpiles or sources other than required excavation.

7-4.1.3 Unit of Measure

Unit of measure: Cubic Meter.

CHAPTER 8 - CONCRETE WORKS

PART 1 GENERAL

8-1.1 Scope

This section contains requirements for the manufacture, transportation, placement, finishing, repair and curing of concrete; for the detailing, supply and placing of reinforcement; for formworks; for joints, joint materials, joint treatment; for design of Pre-cast Pre-stressed concrete; and for all other work associated with cast-in-place and pre-cast concrete.

8-1.2 References

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ACI INTERNATIONAL (ACI)	
ACI 117	(1990) Standard Tolerances for Concrete Construction and Materials & Commentary
ACI 211.1	(1991) Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
ACI 214R	(2002) Evaluation of Strength Test Results of Concrete
ACI 305R	(1999) Hot Weather Concreting
ACI 347	(2001) Guide to Formwork for Concrete
ACI SP-66	(1994) ACI Detailing Manual
ACI 318/318R	(2002) Building Code Requirements for Structural Concrete and Commentary
ACI 318M/318RM	(2002) Metric Building Code Requirements for Structural Concrete and Commentary
AMERICAN WELDING SOCIETY (AWS)	
AWS D1.4	(1998) Structural Welding Code - Reinforcing Steel
AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)	
AASHTO	(2003) Standard Specification for Highway Bridge- 17th Edition
ASTM INTERNATIONAL (ASTM)	
ASTM A 185	(2002) Steel Welded Wire Reinforcement, Plain, for Concrete
ASTM A 370	(2003a) Mechanical Testing of Steel Products
ASTM A 416/A 416M	(2002) Steel Strand, Uncoated Seven-Wire for Prestressed Concrete

ASTM A 421	(1998a) Uncoated Stress-Relieved Steel Wire for Pre-stressed Concrete
ASTM A 497	(2002) Steel Welded Wire Reinforcement, Deformed, for Concrete
ASTM A 615/A 615M	(2003a) Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM A 616/A 616M	(1996a) Rail-Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A 617/A 617M	(1996a) Axle-Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A 706/A 706M	(2004)a Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A 722/A 722M	(1998; R 2003) Uncoated High-Strength Steel Bar for Pre-stressing Concrete
ASTM B 152/B 152M	(2000) Copper Sheet, Strip, Plate, and Rolled Bar
ASTM C 920	(2002) Elastomeric Joint Sealants
ASTM C 928	(2000) Standard Specification for Packaged, Dry, Rapid-Hardening Cementious Materials for Concrete Repairs
ASTM C 1059	(1999) Latex Agents for Bonding Fresh to Hardened Concrete
ASTM C 1064/C 1064M	(20031) Temperature of Freshly Mixed Portland Cement Concrete
ASTM C 1074	(1998) Estimating Concrete Strength by the Maturity Method
ASTM C 1077	(2003) Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation
ASTM C 109/C 109M	(2002) Compressive Strength of Hydraulic Cement Mortars (Using 2-in. [50-mm] Cube Specimens)
ASTM C 117	(2003) Materials Finer Than 75 micrometer (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C 123	(2003) Lightweight Particles in Aggregate
ASTM C 127	(2001) Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregate
ASTM C 128	(2001e1) Density, Relative Density (Specific Gravity), and Absorption of Fine Aggregate
ASTM C 131	(2003) Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 136	(2001) Sieve Analysis of Fine and Coarse Aggregates

ASTM C 142	(1997) Clay Lumps and Friable Particles in Aggregates
ASTM C 150	(2002ae1) Portland Cement
ASTM C 171	(2003) Sheet Materials for Curing Concrete
ASTM C 172	(1999) Sampling Freshly Mixed Concrete
ASTM C 192/C 192M	(2002) Making and Curing Concrete Test Specimens in the Laboratory
ASTM C 231	(2003) Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C 260	(2001) Air-Entraining Admixtures for Concrete
ASTM C 295	(2003) Petrographic Examination of Aggregates for Concrete
ASTM C 309	(2003) Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C 31/C 31M	(2003a) Making and Curing Concrete Test Specimens in the Field
ASTM C 33	(2003) Concrete Aggregates
ASTM C 39/C 39M	(2003) Compressive Strength of Cylindrical Concrete Specimens
ASTM C 40	(1999) Organic Impurities in Fine Aggregates for Concrete
ASTM C 42/C 42M	(2003) Obtaining and Testing Drilled Cores and Sawed Beams of Concrete
ASTM C 494/C 494M	(1999ae1) Chemical Admixtures for Concrete
ASTM C 535	(2003e1) Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C 566	(1997) Total Evaporable Moisture Content of Aggregate by Drying
ASTM C 597	(1997) Pulse Velocity Through Concrete
ASTM C 618	(2003) Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete
ASTM C 666	(2003) Resistance of Concrete to Rapid Freezing and Thawing
ASTM C 684	(2003) Standard Test Method for Making, Accelerated Curing, and Testing Concrete Compression Test Specimens
ASTM C 685	(2000) Concrete Made by Volumetric Batching and Continuous Mixing
ASTM C 803/C 803M	(2003) Penetration Resistance of Hardened Concrete
ASTM C 805	(2002) Rebound Number of Hardened Concrete
ASTM C 87	(2003) Effect of Organic Impurities in Fine Aggregate on Strength of Mortar
ASTM C 881	(1999) Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C 881/C 881M	(2002) Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C 94/C 94M	(2003a) Ready-Mixed Concrete
ASTM D412	(2002)e1 Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers—Tension
ASTM D2240	(2003) Standard Test Method for Rubber Property—Durometer Hardness
ASTM D471	(1998)e1 Standard Test Method for Rubber Property-Effect of Liquids

ASTM D518	(1999) Standard Test Method for Rubber Deterioration-Surface Cracking
ASTM D573	(1999) Standard Test Method for Rubber-Deterioration in an Air Oven
ASTM D 1751	(1999) Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D 1752	(1984; R 1996e1) Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
ASTM D 2628	(1991; R 1998) Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements
ASTM D 2835	(1989; R 1998) Lubricant for Installation of Preformed Compression Seals in Concrete Pavements
ASTM D 75	(2003) Sampling Aggregates
ASTM D 4791	(1999) Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM E 11	(2001) Standard Specification for Wire Cloth and Sieves for Testing Purposes
NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)	
NIST HB 44	(2004) NIST Handbook 44: Specifications, Tolerances, and other Technical Requirements for Weighing and Measuring Devices
NATIONAL READY MIXED CONCRETE ASSOCIATION (NRMCA)	
NRMCA CPMB 100	(2000) Concrete Plant Standards
PRECAST/PRESTRESSED CONCRETE INSTITUTE (PCI)	
PCI MNL-120	(1999) Design Handbook – Pre-cast and Pre-stressed Concrete
U.S. ARMY CORPS OF ENGINEERS (USACE)	
COE CRD-C 100	(1975) Method of Sampling Concrete Aggregate and Aggregate Sources, and Selection of Material for Testing
COE CRD-C 104	(1980) Method of Calculation of the Fineness Modulus of Aggregate
COE CRD-C 130	(2001) Standard Recommended Practice for Estimating Scratch Hardness of Coarse Aggregate Particles
COE CRD-C 143	(1962) Specifications for Meters for Automatic Indication of Moisture in Fine Aggregated
COE CRD-C 318	(1979) Federal Specifications for Cloth, Burlap, Jute (or Kenaf)
COE CRD-C 400	(1963) Requirements for Water for Use in Mixing or Curing Concrete
COE CRD-C 521	(1981) Standard Test Method for Frequency and Amplitude of Vibrators for Concrete
COE CRD-C 513	(1974) Specifications for Rubber Water stops
COE CRD-C 572	(1974) Specifications for Poly vinyl chloride Water stops

COE CRD-C 94	(1966) Specification for Surface Retarders
COE CRD-C 55	(1992) Test Method for within – Batch Uniformity of Freshly Mixed Concrete

8-1.3 Submittals

The following shall be submitted by the Contractor for Project Manager's review and approval in accordance with **Clause 1-1.4 - Submittal Procedures**:

SD-02 Shop Drawings

Concrete Lift Drawings

Showing sizes and limits of various concrete pours, position of joints etc.

Formwork

Drawings and design computations for all formwork required shall be submitted at least 30 days before fabrication on site or before delivery of prefabricated forms. If reshoring is permitted, the method, including location, order, and time of erection and removal shall also be submitted for review.

Fabrication and Placement of Reinforcement

The Contractor shall submit shop drawings which include: reinforcement steel placement drawings; reinforcement steel schedules showing quantity, size, shape, dimensions, weight per meter, total weights and bending details; and details of bar supports showing types, sizes, spacing and sequence.

Erection of Pre-cast Concrete

The Contractor shall prepare and submit for approval complete shop drawings that show the pre-cast unit manufacturer's recommended details and materials for the work required by **Clause 8-1.8 - Delivery, Storage, and Handling of Pre-cast Pre-stressed Members**. The shop drawings shall include: design computations; marking of the units for the placing drawings; anchorages for work of other trades; anchorages to support construction; size and location of steel tendons; methods of stressing; location and sizes of all openings 300 mm wide or larger to be cast into members; formwork; joints between units and other construction; reinforcing steel details; method of curing; and, pickup points and lifting devices.

Installation Drawings

Installation drawings for tendons and accessories shall be submitted and approved prior to commencing the work.

SD-03 Product Data

System of Identification of Materials

A system of identification, which shows the disposition of specific lots of approved materials in the work, shall be established and submitted before completion of the contract.

Materials for formwork

Manufacturer's literature shall be submitted for plywood, concrete form hard board, form accessories, prefabricated forms, and form coating, and form-lining materials.

Concrete Mix Proportioning

Concrete mixture proportions shall be determined by the Contractor and submitted for review and approval by the Project Manager. The concrete mix quantities of all ingredients per cubic meter and nominal maximum coarse aggregate size that will be used in the manufacture of each quality of concrete shall be stated. Proportions shall indicate the mass of cement, pozzolana and ground granulated blast-furnace (GGBF) slag when used, and water; the mass of aggregates in a saturated surface-dry condition; and the quantities of admixtures. The submission shall be accompanied by test reports from a laboratory complying with ASTM C 1077 which show that proportions thus selected will produce concrete of the qualities indicated. No substitution shall be made in the source or type of materials used in the work without additional tests to show that the quality of the new materials and concrete are satisfactory.

Batch Plant

The Contractor shall submit batch plant data to the Project Manager for review for conformance with applicable specifications.

Concrete Mixers Capacity

The Contractor shall submit concrete mixer data, which includes the make, type, and capacity of concrete mixers proposed for mixing concrete.

Conveying Equipment

Data on the conveying equipment and methods for transporting, handling, and depositing the concrete.

Placing Equipment

Data on placing equipment and methods.

Tests and Inspections

Testing Technicians

Concrete Transportation Construction Inspector (CTCI)

Statements that the concrete testing technicians and the concrete inspectors meet the specified requirements.

Construction Joint Treatment

The method and equipment proposed for joint cleanup and waste disposal shall be submitted for review and approval.

Curing and Protection

The curing medium and methods to be used shall be submitted for review and approval.

Hot-Weather Placing

If concrete is to be placed under hot-weather conditions, the proposed materials and methods shall be submitted for review and approval.

Cold Weather Protection

When concrete is to be placed under cold-weather conditions, a description of the materials and methods proposed for protection of the concrete shall be furnished 60 days in advance of anticipated need date for review.

Finishing

Splicing Water stops

Procedures for splicing water stops shall be as recommended by the Manufacturer of the water stop and submitted for approval.

Erection Plan for Pre-cast Concrete

The Contractor shall prepare a detailed erection plan which shall be submitted at least 15 days prior to the date that erection of members is to begin.

Design Calculations for Pre-cast Concrete

Design calculations shall be submitted prior to the initiation of manufacture of members to be used under this contract.

Construction Records for Pre-cast Concrete

Construction records of the manufacturing, handling, and erection of the pre-cast pre-stressed concrete members shall be submitted.

Pre-stressing Method and Equipment

Descriptions of proposed Pre-stressing method and equipment shall be submitted and approved prior to the start of Pre-stressing operations.

Materials Disposition Records

Records which identify the incorporation of approved materials into the work shall be submitted before completion of the contract.

Pre-stressing Operations Records

Complete records of the Pre-stressing operations shall be submitted before completion of the contract.

SD-04 Samples

Aggregates

Cementitious Materials, Admixtures, and Curing Compound

Samples of materials for Project Manager testing and approval.

Sample formwork Panels

After shop drawings have been reviewed, sample panels for Class A finish with applied architectural treatment shall be built on the project site where directed.

Panels shall be of sufficient size to contain joints and shall be not less than 2 meters long and 1.5 meters wide. The panels shall be of typical wall thickness and constructed containing the full allocation of reinforcing steel that will be used in the structure, with the forming system that duplicates in every detail the one that will be used in construction of the structure. The same concrete mix proportion and materials, the same placement techniques and equipment, and the same finishing techniques and timing shall be used that are planned for the structure. Construction of Class A finish will not be permitted until sample panels have been approved. Sample panels shall be protected from construction operations in a manner to protect approved finish, and are not to be removed until all Class A finish concrete has been accepted.

Field Molded Sealants and Primer

Four liters of field-molded sealant and 1 liter of primer (when primer is recommended by the sealant manufacturer) shall be provided for testing.

Water stops

Water stop materials and splice samples shall be submitted for inspection and testing and shall be identified to indicate manufacturer, type of material, size and quantity of material and shipment represented. Each materials sample shall be a piece not less than 300 mm long cut from each 60 m of finished water stop furnished, but not less than a total of 1.2 linear meters of each type and size furnished. For spliced segments of water stops to be installed in the work, one spliced sample of each size and type for every 50 splices made in the factory and every 10 splices made at the job site shall be furnished for inspection and testing. The spliced samples shall be made using straight run pieces with the splice located at the mid-length of the sample and finished as required for the installed water stop. The total length of each spliced sample shall be not less than 300 mm long.

SD-06 Test Reports

Mixture Proportions

The recommended mixture proportions, sources of materials, and all test results shall be submitted for approval.

Quality of Aggregates

Aggregate quality tests shall be submitted at least 30 days prior to start of concrete and shotcrete placement.

Inspection of Forms

The Contractor shall submit field inspection reports for concrete forms and embedded items.

Formwork Not Supporting Weight of Concrete

If forms are to be removed in less than 24 hours, which are not supporting the weight of concrete, the evaluation and results of the control cylinder tests or maturity instrumentation shall be submitted to and approved before the forms are removed.

Accelerator Compatibility

The Contractor shall establish the compatibility of the job cement and the proposed accelerators.

Mixer Uniformity

The results of the initial mixer uniformity tests shall be submitted at least 5 days prior to the initiation of placing.

Material Tests, Inspections, and Verifications for Reinforcement

Certified tests reports of reinforcement steel showing that the steel complies with the applicable specifications shall be furnished for each steel shipment and identified with specific lots prior to placement. Three copies of the heat analyses shall be provided for each lot of steel furnished and the Contractor shall certify that the steel conforms to the heat analyses.

Pre-molded Expansion Joint Filler Strips

Compression Seals and Lubricant

Pre-stressed Concrete

The results of concrete strength testing by the contractor shall be submitted not more than 5 days after the tests are completed.

Tests and Inspections

Test results and inspection reports shall be submitted daily and weekly.

Stressing Tendons and Accessories

Certified Materials Test Reports shall be submitted for all required materials tests, showings note the specific standards followed in the performance of tests, and stating unambiguously show that materials comply with the applicable specifications. Such Test Reports shall be submitted for each material shipment and be identified with specific lots prior to use of materials in the work.

SD-07 Certificates

Cementitious Materials

Cementitious Materials, including Cement and Pozzolan, and Ground Granulated Blast-Furnace Slag will be accepted on the basis of the manufacturer's certification of compliance, accompanied by mill test reports that materials meet the requirements of the specification under which they are furnished. Certification and mill test reports shall be from samples taken from the particular lot furnished. No Cementitious materials shall be used until notice of acceptance has been given by the Project Manager. Cementitious materials will be subject to check testing from samples obtained at the source, at transfer points, or at the project site, as scheduled by the Project Manager, and such sampling will be by Contractor under the supervision of the Project Manager. Material not meeting specifications shall be promptly removed from the site of work.

Accelerating Admixtures

Accelerating admixtures shall be certified for compliance with all specification requirements.

Curing Materials

Curing materials shall be certified for compliance with all specification requirements.

Steel Reinforcement bars and Fiber Reinforcement

Steel reinforcement bars and Fiber reinforcement shall be certified for compliance with all specification requirements.

Air-Entraining Admixture

Air-Entraining Admixture shall be certified for compliance with all specification requirements.

Other Chemical Admixtures

Other Chemical Admixtures shall be certified for compliance with all specification requirements.

Epoxy Resin

Latex Bonding Compound

Epoxy Resin and Latex Bonding Compound shall be certified for compliance with all specification requirements.

PVC and Rubber Water stops

Certification of Pre-stressing Technicians

Certificates for Pre-stressing technicians shall be submitted prior to start of Prestressing operations who will use the proposed system in the work shall certify by name that these technicians are thoroughly trained and skilled in the use of the system.

8-1.4 Project Manager's Testing and Sampling

The Contractor is required to carry out necessary testing of constituent materials and concrete and shotcrete to show the compliance with specification's requirements. The mixture proportioning shall be carried out according to **Clause 8-2.12 – Concrete Mix Proportioning**. The Project Manager may require to sample and test aggregates and concrete to determine compliance with the specifications. The Contractor shall provide facilities and labor as may be necessary for procurement of representative test samples. Samples of aggregates will be obtained at the point of batching in accordance with ASTM D 75. Concrete will be sampled in accordance with ASTM C 172.

8-1.4.1 Preconstruction Sampling and Testing

(a) Aggregates

NOTE: The Designer should consult the appropriate DM, identify the sources for aggregates, and attach them to the end of this section. A Format Template for Aggregate Sources is located in the Template Menu of UFGS. Contact the Director, U.S. Army Corps of Engineers, Engineer Research and Development Center - Structures Laboratory, 3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199, ATTN: CEERD-SC for information to fill in the blanks below.

The Contractor shall furnish materials from a source proposed by the Contractor. Samples from any source of coarse aggregate and any source of fine aggregate selected by the Contractor, consisting of not less than 70 kg of each size coarse aggregate and 35 kg of fine aggregate taken under the supervision of the Project Manager in accordance with COE CRD-C 100 shall be delivered to site laboratory when directed by the Project Manager. Sampling and shipment of samples shall be at the Contractor's expense. 30 days will be required to complete evaluation of the aggregates.

Testing will be performed at the site laboratory in accordance with the applicable ASTM test methods. Tests to which aggregate may be subjected are listed in Sub-Clause 8-2.2.2 - Quality. The material from the proposed source shall meet the quality requirements of this Clause. Testing of aggregates by the Project Manager does not relieve the Contractor of the requirements outlined in Clause 8-3.11 - Tests and Inspections.

(b) Cementitious Materials, Admixtures, and Curing Compound

NOTE: When the optional sentence below is deleted, the corresponding manufacturer's certification described in paragraph SUBMITTALS should be used. EM 1110-2-2000, "Standard Practice for Concrete," provides guidance in selecting the options for Government or for Contractor testing."

At least 60 days in advance of concrete placement, the Contractor shall notify the Project Manager of the sources for Cementitious materials, admixtures, and curing compound, along with sampling location, brand name, type, and quantity to be used in the manufacture and/or curing of the concrete.

8-1.4.2 Construction Testing by the Project Manager

Sampling and testing will be performed by the Project Manager except as otherwise specified. No material shall be used until notice has been given by the Project Manager that test results are satisfactory. The Project Manager will sample and test chemical admixtures, curing compounds, and Cementitious materials.

(a) Chemical Admixtures Storage

Chemical admixtures that have been in storage at the project site for longer than 6 months shall be retested at the expense of the Contractor when directed by the Project Manager and shall be rejected if test results are not satisfactory. Chemical admixtures will be accepted based on compliance with the requirements of **Clause 8-2.3 - Chemical Admixtures**.

(b) Cement

NOTE: Delete this paragraph if materials are to be accepted on the basis of a manufacture's certification of compliance and mill test reports, and the optional sentence in paragraph SUBMITTALS, SD-07 Certificates will be used. See the appropriate DM or consult the Materials Engineer to select prequalified sources, (1) and (2), sealed bins, (3) and (4), or both options, (1), (2), (3) and (4). Selection of the sealed bin method, subparagraphs (3) and (4), must be fully justified in the appropriate DM.

Cement remaining in bulk storage at the mill, prior to shipment, for more than six (6) months or cement stored in local storage by the contractor for more than three (3) months after shipment from the factory may be retested before use and shall be rejected if fails to meet any of the specification requirements. All cement used will be type I and type V as per design requirements. If cement is to be obtained from more than one source, the initial notification shall state the estimated amount to be obtained from each source and the proposed schedule of shipments.

Cement shall be sampled at the source and stored in sealed bins pending completion of testing. Sampling, testing, and the shipping inspection from the point of sampling, when the point is other than at the site of the work, will be made by or under the supervision of the Project Manager. No cement shall be used until notice has been given by the Project Manager that test results are satisfactory. In the event of failure, the cement may be re-sampled and tested at the request of the Contractor, at his expense. When the point of sampling is other than at the site of the work, the fill gates of the sampled bin and conveyances used in shipment will be sealed under Project Manager’s supervision and kept sealed until shipment from the bin has been completed. If tested cement is re-handled at transfer points, the extra cost of inspection shall be at the Contractor's expense. The cost of testing cement excess to project requirements shall also be at the expense of the Contractor.

(c) Concrete Strength

Compressive strength test specimens will be made by the Contractor under supervision of Project Manager and cured in accordance with ASTM C 31/C 31M and tested in accordance with ASTM C 39/C 39M. The strength of the concrete will be considered satisfactory so long as the average of all sets of three consecutive test results equals or exceeds the specified compressive strength f'c and no individual test result falls below the specified strength f'c by more than 3.5 MPa. A "test" is defined as the average of two companion cylinders, or if only one cylinder is tested, the results of the single cylinder test. Additional analysis or testing, including nondestructive testing, taking cores and/or load tests may be required at the Contractor's expense when the strength of the concrete in the structure is considered potentially deficient.

(i) Investigation of Low-Strength Test Results - When any strength test of standard-cured test cylinders falls below the specified strength requirement by more than 3.5 MPa or if tests of field-cured cylinders indicate deficiencies in protection and curing, steps shall be taken to assure that the load-carrying capacity of the structure is not jeopardized. Nondestructive testing in accordance with ASTM C 597, ASTM C 803/C 803M, or ASTM C 805 may be permitted by the Project Manager to estimate the relative strengths at various locations in the structure as an aid in evaluating concrete strength in place or for selecting areas to be cored. Such tests shall not be used as a basis for acceptance or rejection.

(ii) Testing of Cores - When the strength of concrete in place is considered potentially deficient, cores shall be obtained and tested in accordance with ASTM C 42/C 42M. At least three representative cores shall be taken from each member or area of concrete in place that is considered potentially deficient. The location of cores will be determined by the Project Manager to least impair the performance of the structure. Concrete in the area represented by the core testing will be considered adequate if the average strength of the cores is equal to at least 85 percent of the specified strength requirement and if no single core is less than 75 percent of the specified strength requirement.

(iii) Load Tests - If the core tests are inconclusive or impractical to obtain or if structural analysis does not confirm the safety of the structure, load tests may be directed by the Project Manager in accordance with the requirements of ACI 318M/318RM. Concrete work evaluated by structural analysis or by results of a load test shall be corrected in a manner satisfactory to the Contacting Officer. All investigations, testing, load tests, and correction of deficiencies will be performed and approved by the Project Manager at the expense of the Contractor, except that if all concrete is in compliance with the plans and specifications, the cost of investigations, testing, and load tests will be at the expense of the Project Manager.

8-1.5 Design Requirements of Concrete Mix

8-1.5.1 Concrete Strength

Specified compressive strength f'c shall be as follows:

Grades of concrete	***Minimum compressive cylinder strength (f'c) at 28 days*** **(N/mm^2)**
C 41	41
C 34	34
C 27	27
C 25	25

C 24	24
C 20	20
C 21	21
C 15	15
C 13	13
C 10	10

8-1.5.2 Maximum Water-Cement (W/C) Ratio

Maximum W/C shall be as follows:

Water-Cement Ratio, by Mass	***Structure or Portion of Structure***
0.45 + 0.02	Parts of the Structures exposed to severe weathering; Top one meter of walls Bridge piers Roadway
0.50 + 0.02	General exterior portion of the Structure; Spillway apron Retaining wall
0.55 + 0.02	Special exterior construction Parts of structure covered with backfill Parts of structure continually submerged

These W/C's may cause higher strengths than that required by **Sub-Clause 8-1.5.1 - Concrete Strength**.

8-1.6 Construction Tolerances

NOTE: Finished or formed surfaces subject to high-velocity flow (12 m/s (40 fps) and greater) will meet the tolerances for Class A-HV surfaces specified in paragraph Formed Concrete Surfaces below.

Level and grade tolerance measurements of slabs shall be made as soon as possible after finishing. When forms or shoring are used, the measurements shall be made prior to removal. Tolerances are not cumulative. The most restrictive tolerance controls. Tolerances shall not extend the structure beyond legal boundaries. Except as specified otherwise, plus tolerance increases the amount or dimension to which it applies, or raises a level alignment and minus tolerance decreases the amount or dimension to which it applied, or lowers a level alignment. A tolerance without sign means plus or minus. Where only one signed tolerance is specified, there is no limit in the other direction. The unformed finished surfaces subject to high-velocity flow (12 m/s) shall be finished to meet the tolerances for A-HV surfaces specified in Table, "Tolerances for Finished Formed Concrete Surfaces".

The definitions of the terms used in the following tabulations are used as defined and used in ACI 117. Level and grade tolerance measurements of slabs shall be made as soon as possible after finishing.

Tolerances for Foundation		
(1)	Lateral alignment	
	As cast to the center of gravity as specified; 0.02 times width of footing in direction of misplacement but not more than	50 mm
	Supporting masonry construction	13 mm
(2)	Level alignment	
	Top of footings supporting masonry	13 mm
	Top of other footings	+13 mm
		-50 mm
(3)	Cross-sectional dimensions	
	Horizontal dimensions of formed members	+50 mm
		-13 mm
	Horizontal dimensions of unformed members cast against soil 600 mm or less	+75 mm
		-13 mm
	Greater than 600 mm but less than 1800 mm	+150 mm
		-13 mm
	Over 1.8 m	+300 mm
		-13 mm
	Vertical dimension (thickness)	-5 percent
(4)	Relative alignment	
	Slope of footing side and top surfaces with respect to the specified plan	25 mm/3000 mm
Tolerances for Cast-in-Place Reinforced Concrete for Buildings		
(1)	Vertical alignment	
	For heights 30 m	
	Lines, surfaces, and arises	25 mm
	Outside corner of exposed corner columns and control joint grooves in concrete exposed to view	13 mm
	For heights greater than 30 m	
	Lines, surfaces, and arises, 1/1,000 times the height at any point but not more than	150 mm
	Outside corner of exposed corner columns and control joint grooves in concrete, 1/2,000 times the height at any point but not more than	75 mm
(2)	Lateral alignment	
	Members	25 mm
	In slabs, centerline location of openings 300 mm or smaller and edge location of larger openings	13 mm
	Sawcuts, joints, and weakened plane embedment in slabs	19 mm
(3)	Level alignment	

	Top of slabs	
	Elevation of slabs-on-grade	19 mm
	Elevation of top surfaces of formed slabs before removal of supporting shores	19 mm
	Elevation of formed surfaces before removal of shores	19 mm
	Lintels, sills, parapets, horizontal grooves, and other lines exposed to view	13 mm
(4)	Cross-sectional dimensions	
	Members, such as columns, beams, piers, walls (thickness only) and slabs (thickness only)	
	300 mm dimension or less	+10 mm
		-6 mm
	More than 300 mm but not over 900 mm dimension	+13 mm
		-10 mm
	Over 900 mm dimension	+25 mm
		-19 mm
(5)	Relative alignment	
	Stairs	
	Different in height between adjacent risers	3 mm
	Different in width between adjacent treads	6 mm
	Grooves	
	Specified width 50 mm or less	3 mm
	Specified width more than 50 mm but not more than 300 m	6 mm
	Sawcuts, joints, and weakened plane on slab	
	Lateral, gradual	19mm in 3000mm
	Lateral, abrupt	0 mm
(6)	Openings through members	
	Cross-sectional size of opening	+25 mm
	Location of centerline of opening	13 mm
Tolerance for Finished Formed Concrete Surfaces		
(1)	Vertical alignment	
	Formed surfaces slope with respect to the specified plane	
	Vertical alignment of outside corner of exposed corner columns and control joint grooves in concrete exposed to view	7mm in 3000mm
	All other conditions	10mm in 3000mm
(2)	Abrupt variation	

	The offset between concrete surfaces under adjacent pieces of formwork for the following classes of surface: (For Class A-HV, positive means raise of elevation in the direction of water flow, negative means drop of elevation in the direction of water flow)	
	*Class A-HV, in the direction of water flow	+0 mm
		-3 mm
	Perpendicular to the direction of water flow	3 mm
	Class A	3 mm
	Class B	6 mm
	Class C	6 mm
	Class D	25 mm
	*Includes any high-velocity flow surface.	
(3)	Gradual variation	
	Surface finish tolerances as measured by placing a freestanding (unleveled), 1.5 m straightedge for plane surface or curved template for curved surface anywhere on the surface and allowing it to rest upon two high spots within 72 hrs after concrete placement. The gap at any point between the straightedge or template and the surface shall not exceed:	
	*Class A (including Class A-HV)	3 mm
	Class B	6 mm
	Class C	13 mm
	Class D	25 mm
	*Includes any high-velocity flow surface.	
Tolerances for Cast-in-Place, Vertically Slipformed Building Elements		
(1)	Translation and rotation from a fixed point at the base of the structure:	
	For heights 30 m or less	50 mm
	For heights greater than 30 m, 1/600 times the height but not more than	205 mm
(2)	Lateral alignment	
	Between adjacent elements	50 mm
(3)	Cross-sectional dimensions	
	Wall thickness	+19 mm
		-10 mm
(4)	Relative alignment	

	Formed surface slope with respect to the specified plane	19in 3000 mm
Tolerances for Mass Concrete Structures Other Than Buildings		
(1)	Vertical alignment	
	Visible surfaces	30 mm
	Concealed surfaces	65 mm
	Side walls for radial gates and similar watertight joints	5 mm
(2)	Lateral alignment	
	Visible surfaces	30 mm
	Concealed surfaces	65 mm
(3)	Level alignment	
	Visible flatwork and formed surfaces	13 mm
	Concealed flatwork and formed surfaces	25 mm
	Sills for radial gates and similar watertight joints	5 mm
(4)	Relative alignment	
	Formed surface slope with respect to the specified plane	
	Slopes in lateral and level alignments	
	Visible surfaces	7mm in 3000 mm
	Concealed surfaces	13mm in 3000mm
	Slopes in vertical alignment	
	Visible surfaces	13mm in 3000mm
	Concealed surfaces	25mm in 3000mm
Tolerances for Bridges, Erosion-Protection Structures, and Small Hydraulic Structures		
(1)	Vertical alignment	
	Exposed surfaces	19 mm
	Concealed surfaces	40 mm
(2)	Lateral alignment	
	Centerline alignment	25 mm
(3)	Level alignment	
	Profile grade	25 mm

	Top of other concrete surfaces and horizontal grooves	
	Exposed	19 mm
	Concealed	40 mm
	Mainline pavements in longitudinal direction, the gap below 3 m unleveled straightedge resting on high spots shall not exceed	3 mm
	Mainline pavements in transverse direction, the gap below a 3 m unleveled straightedge resting on high spots shall not exceed	6 mm
	Ramps, sidewalks, and Intersection, in any direction, the gap below a 3 m unleveled straightedge resting on high spots shall not exceed	6 mm
(4)	Cross-sectional dimensions	
	Bridge slab thickness	+6 mm
		-3 mm
	Members such as columns, beams, piers, walls, and others (slabs--thickness only)	+13 mm
		-6 mm
	Openings through concrete members	13 mm
(5)	Relative alignment	
	Location of openings through concrete members	13 mm
	Formed surface slope with respect to the specified plane	
	Watertight joints	3 in 3000 mm
	Other exposed surfaces	13 in 3000 mm
	Concealed surfaces	25 in 3000 mm
	Unformed exposed surfaces slopes with respect to the specified plane	7mm in 3000mm
		10mm in 6000mm
	Tolerances for Conduits, and Culverts Lateral alignment	
(1)	Centerline alignment	
	Water conveying tunnels, conduits, and culverts	13 mm
	Others	25 mm
	Inside dimensions	0.005 times inside dimension

(2)	Level alignment	
	Profile grade	
	Water conveying tunnels, conduits, and culverts	13 mm
	Others	25 mm
	Surface of invert	6 mm
	Surface of side slope	13 mm
(3)	Cross-sectional dimension Thickness at any point	
	Tunnel and culvert lining	-0 mm
	Conduits	+5 percent thickness but not more than 13 mm
		-2.5 percent thickness but not less than 6 mm
Tolerances for Pre-cast Members		
(1)	Length of Member	19mm or 1 mm per m, whichever is greater
(2)	Cross-Sectional Dimensions	
	Dimension Less than 900 mm	9mm
(3)	Horizontal Alignment (Sweep)	
	Deviation from a straight line parallel theoretical countreline	13mm or 1mm/m of length which ever is greater
	The maximum gap between members	+25mm
(4)	Camber	
	Deviation from computed camber	1mm per m, but not greater than 12mm
(5)	Camber Differential	
	At mid span between adjacent members	+2mm/m of length but not grater than +19mm
(6)	Position of Tendons	
	Deviation from design position	6mm
(7)	Handling Devices	
	Deviation of actual position of handling devices from the designed position	150mm
(8)	Anchors and Inserts	
	Actual position of anchors and inserts from position shown in the drawing	25mm
(9)	Flange Thickness	

	Plus 6mm or minus 3 mm	+ 6mm -3mm
(10)	Depth of Member at support	6mm
(11)	Distance between Stems	3mm
(12)	Squareness of Ends	6mm

8-1.7 System Description for Pre-cast – Pre-stressed Concrete

8-1.7.1 Design Requirements

(a) Pre-cast Pre-stressed Members and Connections

Design of members and connections shall be in accordance with ACI 318/318R and PCI MNL-120.

(b) Loads

Loadings for members and connections shall include all dead load, live load, applicable lateral loads such as wind and earthquake, applicable construction loads such as handling, erection loads, and other applicable loads.

(c) Design Calculations

Design calculations for members and connections not shown in the contract drawings shall be made by a registered professional Engineer experienced in the design of pre-cast pre-stressed concrete.

8-1.7.2 Performance Requirements

Perform the following test to ensure that the materials and method used meet the requirements of these specifications and will produce pre-cast pre-stressed concrete members which are suitable for their intended use.

(a) High-Strength Steel Tendons

Testing shall be as specified in **Sub-Clause 8-1.3 - Submittals SD-06 Test Reports of Stressing Tendons and Accessories for Pre-stressed Concrete**.

(b) Concrete

Concrete shall be sampled and cylinders made in accordance with ASTM C 172 and ASTM C 31/C 31M.

(i) Concrete Test Cylinders

A minimum of two concrete test cylinders per bed shall be made to verify the strength of concrete at the time of stress transfer and a minimum of two test cylinders per day or 38 cubic meters of concrete or fraction thereof, whichever results in the most cylinders, shall be made for each mix design to verify the attainment of the specified strength.

(ii) Cylinder Making

Cylinders shall be made as near as possible to the location where they will be cured and shall not be disturbed in any way from 1/2 hour after casting until they are either 24 hours old or ready to be tested. Concrete in cylinders may be consolidated by rodding or by vibration as specified in ASTM C 31/C 31M.

(iii) Cylinder Curing

(1) Test cylinders shall be cured with similar methods as the members they represent. In lieu of actual curing with the members, cylinders may be cured in curing chambers correlated in temperature and humidity with the beds. In such a case, the correlation

shall be constantly verified by use of recording thermometers in the curing chambers and comparison with the temperature records of beds and by use of the same methods of moisture retention for curing chambers and casting beds.

(2) For beds cured by steam or radiant heat, cylinders shall be placed at random points along the bed. If there is any indication of variable heat, cylinders shall be placed in the coolest area.

(3) Test cylinders to indicate compliance with specified 28-day or earlier strength shall remain in the bed with the member until the member is removed. At that time, the cylinders shall be removed from their molds and placed in storage in a moist condition at 23 degrees plus or minus 1.5 degrees C.

(iv) Testing of Cylinders

(1) Testing of cylinders to determine compressive strength shall be performed in accordance with ASTM C 39/C 39M. The strength of concrete at any given age shall be determined as the average of two cylinders, except a single cylinder test can be used to determine stress transfer strength or predictive strengths at less than 28 days.

(2) Testing machines shall be calibrated in accordance with ASTM C 39/C 39M.

(c) Air Content

The air content tests shall be conducted in accordance with ASTM C 231. At least one air content test shall be conducted on the concrete from which each member is cast.

(d) Pre-cast Panel

Before casting pre-cast members, one sample pre-cast concrete panel not less than 600 by 600 by 125 mm deep shall be submitted with proposed surface texture, including surface sealer. After approval, the sample panels shall be retained at the job site to serve as the standard of quality for texture, surface finish, and concrete color.

8-1.8 Delivery, Storage, and Handling of Pre-cast Pre-stressed Members

8-1.8.1 Transportation

(a) Transporting Members

In transporting members by truck, railroad car, or barge, provision shall be made for supporting the members as described above, except battens can be continuous over more than one stack of units, with adequate bracing to ensure their maintaining the vertical position and damping of dangerous vibrations. Trucks with double bolsters are satisfactory provided the members are fully seated on the outer bolsters at not more than 1 m or the depth of the member from the end and the inner bolster is not more than 2.3 m from the end of the member or the designated pickup point. Adequate padding material shall be provided between tie chains or cables to preclude chipping of concrete.

(b) Lateral Deflection or Vibration

Any noticeable indication of lateral deflection or vibration during transportation shall be corrected by rigid bracing between members or by means of lateral trussing.

8-1.8.2 Storage

(a) Storage Areas

Storage areas for pre-stressed members shall be stabilized, and suitable foundations shall be provided, so differential settlement or twisting of members will not occur.

(b) Stacked members

Stacked members shall be separated and supported by battens placed across the full width of each bearing point. Battens shall be arranged in vertical planes at a distance not greater than the depth of the member from designated pickup points. Battens shall not be continuous over more than one stack of pre-cast units. Stacking of members shall be such that lifting devices will be accessible and undamaged. The upper members of a stacked tier shall not be used as storage areas for shorter members or equipment.

8-1.8.3 Handling of Members

The location of pickup points for handling of the members and details of the pickup devices shall be shown in shop drawings. Members shall be handled only by means of approved devices at designated locations. Members shall be maintained in an upright position at all times and picked up and supported as shown in approved shop drawings.

8-1.9 Design Requirements for Formwork

The design, Engineering, and construction of the formwork shall be the responsibility of the Contractor. The formwork shall be designed for anticipated live and dead loads and shall comply with the tolerances specified in **Clause 8-1.6 - Construction Tolerances**. The formwork shall be designed as a complete system with consideration given to the effects of cementitious materials and mixture additives such as fly ash, cement type, plasticizers, accelerators, retarders, air entrainment, and others. The adequacy of formwork design and construction shall be monitored prior to and during concrete placement as part of the Contractor's approved Quality Control Plan.

8-1.10 Construction, Contraction, Expansion and Control Joints

8-1.10.1 Construction Joints

The location of construction joints except where shown on the drawings shall be at the discretion of the Project Manager. At least 60 days before construction of the separate features of the Works begins the Contractor shall submit for approval all Lift drawings showing the location of all his proposed construction joints for the parts of the features.

Certain joints may be shown as compulsory construction joints on the drawings. These joints may not be altered and no concrete shall be placed adjacent to the joint for at least 7 days for features up to 1m in thickness and for 10 days where the thickness exceeds 1m.

The constructions for mass concrete with lifts greater than 1.5 m shall be green cut with water jetting within 24 hours of the pour.

The cost of construction joints shall be included in the rate tendered in the priced Bill of Quantities for the concrete in which the joints are required, except that where construction joints requiring water stops are shown on the Drawings or directed the water stops will be paid for as provided in **Clause 8-4.3**.

8-1.10.2 Contraction Joints

Contraction joints shall be located and constructed as shown on the Drawings. The joints shall be made by forming the concrete on one side of the joint and allowing it to set before concrete is placed on the other side of the joint. The surface of the concrete first placed at contraction joints shall be coated with curing compound or bitumen paint to break the bond before the concrete on the other side of the joint is placed.

The cost of contraction joints shall be included in the rate tendered in the priced Bill of Quantities for the concrete in which the joints are required except that payment for water stops if required, will be made as provided in **Clause 8-4.3**.

8-1.10.3 Expansion Joints

Expansion joints shall be located and constructed as shown on the Drawings. The joints shall be made by forming the concrete on one side of the joint and allowing it to cure for a minimum of 3 days before concrete is placed on the other side of the joint. The surface of the concrete on either side of the expansion joint shall be separated by approved joint filler as shown on the Drawings.

The cost of expansion joints shall be included in the rate tendered in the priced Bill of Quantities for the concrete in which the joints are required except that payment for water stops, bond breaking coat and joint filler if required, will be made as provided in **Clauses 9.12 and 9.13** respectively.

PART 2 PRODUCTS

8-2.1 Cementitious Materials

NOTE: See the appropriate DM to select the proper requirements for the Cementitious Materials Options. Other cementitious materials may be added if specifically recommended and approved in the concrete materials DM.

Cementitious materials shall be Portland cement, Portland-pozzolan cement, Portland blast-furnace slag cement, Portland cement in combination with pozzolan or GGBF slag and shall conform to appropriate specifications listed below. Use of cementitious materials in architectural concrete shall be restricted to one color, one source, and one type.

8-2.1.1 Portland Cement

ASTM C 150, Type I or II, except that the maximum amount of C3A in Type I cement shall be 15 percent.

8-2.1.2 Pozzolan

Pozzolan shall conform to ASTM C 618, Class C, with the optional requirements for multiple factor, drying shrinkage, and uniformity of **Table 2A**.

8-2.2 Aggregates

NOTE: See the concrete materials design memorandum to select the aggregate composition options.

8-2.2.1 Aggregate Composition

Fine aggregate shall consist of natural sand, manufactured sand, or a combination of natural and manufactured sands. Coarse aggregate shall consist of gravel, crushed gravel, crushed stone, air-cooled blast-furnace slag, or a combination thereof.

8-2.2.2 Quality

NOTES: The tests selected should be those which are applicable to the concrete to be used in the project. These tests may include those in the following list in addition to others not listed. See EM 1110-2-2000 for schedule of tests.

A list of properties and test values are unique to each project and should be taken from the concrete materials design memorandum. Delete the quality tests not required in the design memorandum.

The petrographic examination shall be used to identify deleterious substances in aggregates. Deleterious substances shall be listed individually with respective limits.

Aggregates delivered to the mixer shall meet the following requirements:

Test Limits			
Property	*Fine Aggregate*	*Coarse Aggregate*	*Tests*
Specific Gravity	2.56	2.56	ASTM C 127 ASTM C 128
Loss in Sodium soundness test	< 8%	< 10%	ASTM C88
Clay Lumps and Friable Particles	< 1%	< 0.5%	ASTM C 142
Material Finer than 75-μm (No. 200) Sieve	< 2%	< 0.5%	ASTM C 117
Organic Impurities	0%	0 %	ASTM C 40 ASTM C 87
L.A. Abrasion	—	< 10%	ASTM C 131 ASTM C 535
Soft Particles	< 2 %	< 2%	COE CRD-C 130
Other deleterious materials	< 2%	< 1%	ASTM C 295

8-2.2.3 Grading

a) Fine Aggregate

The grading of the fine aggregate as delivered to the mixers shall be such that the individual percent retained on any sieve shall not vary more than 3 percent from the percent retained on that sieve in a fixed grading selected by the Contractor with the approval of the Project Manager. The fixed grading may be selected at the start of concrete placement and based upon 30 days fine aggregate production or selected after the first 30 days of concrete placement. The minimum individual percent retained on the 2.36 mm (No. 8) sieve shall be 5 percent and on all smaller sieves, except the 75 m (No. 200), shall be 10 percent. In addition to the grading limits, the fine aggregate, as delivered to the mixer, shall have a fineness modulus of not less than 2.25 nor more than 2.85. The grading of the fine aggregate shall also be controlled so that the fineness moduli groups (average of the current test and the previous two tests) of the fine aggregate as delivered to the mixer shall not vary more than 0.10 from the target fineness modulus of the fixed grading selected by the Contractor and approved by the Project Manager. The range of each group shall not exceed 0.20. The fineness modulus shall be determined in accordance with COE CRD-C 104. At the option of the Contractor, fine aggregate may be separated into two or more sizes or classifications, but the uniformity of grading of the separate sizes shall be controlled so that they may be combined throughout the job in fixed proportions established during the first 30 days of concrete placement. The selected fixed grading shall be within the following limits, except any individual test result may be outside these limits if within the allowable 3 percent variation from the selected grading.

U.S. Standard Sieve Designation	***Permissible Limits Percent By Weight, Passing***
9.5-mm (3/8-in.)	100
4.75-mm (No. 4)	95 - 100
2.36-mm (No. 8)	80 - 95
1.18-mm (No. 16)	60 - 80
600-m (No. 30)	35 - 60
300-m (No. 50)	15 - 30
150-m (No. 100)	5 - 10
75-m (No. 200)	0 - 5

b) Coarse Aggregate

The coarse aggregate shall be re-screened just prior to delivery to the concrete batch plant bins. The grading of the coarse aggregate within the separate size groups shall conform to the following requirements as delivered to the mixer.

Percent by Weight Passing Individual Sieves

Nominal Gradation				
U.S. Standard Sieve Designation	4.75 to	19.0 mm to	37.5 mm to	75 mm to
	19.0 mm	37.5 mm	75 mm	150 mm
	(No. 4 to	(3/4 inch to	(1-1/2 inch	(3 inch to
	3/4 inch)	1-1/2 inch)	to 3 inch)	6 inch)
175 mm (7 inch)				100
150 mm (6 inch)				90 – 100
100 mm (4 inch)			100	20 – 55
75 mm (3 inch)			90 - 100	0 – 15
50 mm (2 inch)		100	20 - 55	0 – 5
37.5 mm (1-½ inch)		90 - 100	0 - 15	
25.0 mm (1 inch)	100	20 - 55	0 - 5	
19.0 mm (3/4 inch)	90 - 100	0 - 15		
9.50 mm (3/8 inch)	20 - 55	0 - 5		
4.75 mm (No. 4)	0 - 15			
2.36 mm (No. 8)	0 - 5			

8-2.2.4 Particle Shape

The quantity of flat and elongated particles in the separate size groups of coarse aggregate, as determined by ASTM D 4791, using a value of 3 for width-thickness ratio and length-width ratio shall not exceed 25 percent in any size group.

8-2.2.5 Moisture Content

The fine aggregate shall not be placed in bins at the batch plant until it is in a stable state of moisture content. A stable moisture content shall be reached when the variation in the percent of total moisture tested in accordance with ASTM C 566 and when sampled at the same location will not be more than 0.5 percent during 1 hour of the 2 hours prior to placing the material in the batch plant bins and the variation in moisture content when sampled at the same location shall not be more than 2.0 percent during the last 8 hour period that the aggregate remains in the stockpile. The coarse aggregate shall be delivered to the mixers with the least amount of free moisture and the least variation in free moisture practicable under the job conditions. Under no conditions shall the coarse aggregate be delivered to the mixer "dripping wet".

8-2.2.6 Concrete Aggregate Sources

NOTE: The list of sources and required tests will be taken from the concrete materials design memorandum.

Concrete aggregates may be furnished from any source capable of meeting the quality requirements stated in Sub-Clause 8-2.2 - Aggregates. After the award of the contract, the Contractor shall designate in writing only one source or combination of sources from which he proposes to furnish aggregates.

8-2.3 Chemical Admixtures

Chemical admixtures to be used, when required or permitted, shall conform to the appropriate specification listed.

8-2.3.1 Air-Entraining Admixture

The air-entraining admixture shall conform to ASTM C 260 and shall consistently cause the concrete to have an air content in the specified ranges under field conditions.

8-2.3.2 Accelerating Admixture

Accelerators shall meet the requirements of ASTM C 494/C 494M, Type C or E, except that calcium chloride or admixtures containing calcium chloride shall not be used.

8-2.3.3 Water-Reducing or Retarding Admixture

Water-Reducing or Retarding Admixtures: ASTM C 494/C 494M, Type A, B, or D, except that the 6-month and 1-year compressive strength tests are waived.

High-Range Water Reducing Admixture: ASTM C 494/C 494M, Type F or G except that the 6-month and 1-year strength requirements shall be waived. The admixture may be used only when approved by the Project Manager, such approval being contingent upon particular mixture control as described in the Contractor's Quality Control Plan.

8-2.3.4 Other Chemical Admixtures

NOTE: Use this paragraph when the optional sentences in paragraph SLUMP is used.

Other chemical admixtures for use in producing flowing concrete shall comply with ASTM C 1017/C 1017M, Type 1 or 2. These admixture shall be used only for concrete listed in Sub-Clause 8-2.14.4 - Slump.

8-2.4 Curing Materials

8-2.4.1 Impervious-Sheet Curing Materials

Impervious-sheet curing materials shall conform to ASTM C 171, type optional, except polyethylene film shall not be used.

8-2.4.2 Membrane-Forming Curing Compound

The membrane-forming curing compound shall conform to ASTM C 309, Type 1-D or 2, except a styrene acrylate or chlorinated rubber compound meeting Class B requirements

shall be used for surfaces that are to be painted or are to receive bituminous roofing, or waterproofing, or floors that are to receive adhesive applications of resilient flooring. The curing compound selected shall be compatible with any subsequent paint, roofing, coating, or flooring specified. Nonpigmented compound shall contain a fugitive dye and shall have the reflective requirements in ASTM C 309 waived.

8-2.4.3 Burlap

Burlap used for curing shall conform to COE CRD-C 318.

8-2.4.4 Water

Water for mixing and curing shall be fresh, clean, potable, and free of injurious amounts of oil, acid, salt, or alkali, except that nonportable water may be used if it meets the requirements of COE CRD-C 400.

8-2.5 Latex Bonding Compound

Latex bonding compound agents for bonding fresh to hardened concrete shall conform to ASTM C 1059.

8-2.6 Epoxy Resin

Epoxy resin for use in repairs shall conform to ASTM C881/C881M, Type-III, Grade I or II.

8-2.7 Reinforcement

8-2.7.1 Steel Bars

NOTE 1: The grade of steel bars used in the design must be indicated. ASTM A 615/A 615M, Grade 300(40) bars are manufactured only in sizes 10 through 20 (3 through 6). ASTM A 616/A 616M, Grade 350 (50) bars and ASTM A 617/A 617M, Grade 300 (40) bars are furnished only in sizes 10 through 35 (3 through 11). Bar sizes 10 through 35 (3 through 11) shall be Grade 300, 350, 400 (40, 50, or 60). Bar sizes 45 and 55 (14 and 18) shall be Grade 400 (60). Due to the frequent unavailability of Grade 300 (40) bars, designers may choose to not use Grade 300 (40) bars. However, if Grade 300 (40) bars are used, include the sentence below enclosed with brackets in these specifications.

NOTE 2: Zinc-coated or epoxy-coated bars shall be used in bridge decks and other applications where bars would be subjected to corrosive action.

Steel bars shall comply with the requirements of ASTM A 615/A 615M or ASTM A 616/A 616M including Supplementary Requirements, ASTM A 617/A 617M or ASTM A 706/A 706M, deformed, of the grades, sizes and lengths shown. If the Grade 300 bars shown are unavailable the Contractor may substitute Grade 350 or Grade 400 bars of the same size and spacing as indicated for Grade 300 bars when authorized. The type reinforcement prescribed is shown on drawings.

8-2.7.2 Steel Welded Wire Fabric

Steel welded wire fabric shall comply with the requirements of ASTM A 185, or ASTM A 497 wire sizes and spacings as shown. For wire with a specified yield strength (fy) exceeding 400 MPa, fy shall be the stress corresponding to a strain of 0.35 percent.

8-2.7.3 Accessories

(a) Bar Supports

Bar supports shall comply with the requirements of ACI SP-66. Supports for bars in concrete with formed surfaces exposed to view or to be painted shall be plastic-coated wire, stainless steel or pre-cast concrete supports. Pre-cast concrete supports shall be wedged-shaped, not larger than 90 by 90 mm, of thickness equal to that indicated for concrete cover and have an embedded hooked tie-wire for anchorage. Bar supports used in pre-cast concrete with formed surfaces exposed to view shall be the same quality, texture and color as the finish surfaces.

(b) Wire Ties

Wire ties shall be 16 gage or heavier black annealed wire. Ties for epoxy-coated bars shall be vinyl-coated or epoxy-coated. Ties for zinc-coated bars shall be zinc-coated.

8-2.8 Pre-molded Expansion Joint Filler Strips

Pre-molded expansion joint filler strips shall conform to ASTM D 1751 or ASTM D 1752, Type I, or resin impregnated fiberboard conforming to the physical requirements of ASTM D 1752.

8-2.9 Joint Seals and Sealants

8-2.9.1 Field Molded Sealants and Primer

Field molded sealants and primer shall conform to ASTM C 920, Type M, Grade NS or P, Class 25, Use T for horizontal joints and Type M, Grade NS, Class 25, Use NT for vertical joints. Field molded sealants and primer shall conform to ASTM C 920, Type M, Grade NS or P, Class 25, Use T for horizontal joints and Type M, Grade NS, Class 25, Use NT for vertical joints. Bond breaker material shall be polyethylene tape, coated paper, metal foil or similar type materials. The back-up material shall be compressible, nonshrink, nonreactive with sealant, and nonabsorptive material type such as extruded butyl or polychloroprene foam rubber.

8-2.9.2 Compression Seals and Lubricant

Compression seals shall conform to ASTM D 2628; lubricant for installation shall conform to ASTM D 2835.

8-2.10 Water stops

8-2.10.1 Non-Metallic Water stops

Rubber water stops shall conform to COE CRD-C 513. Polyvinylchloride water stops shall conform to COE CRD-C 572.

8-2.10.3 G-Seal (Cap Seal)

(a) Provision of sealing control, expansion, and/or construction joints in concrete to create a continuous diaphragm to prevent fluid migration and accumulation of debris.

(a) References

A. American Society for Testing Materials (ASTM)

(a) Provide flexible, modified PVC (polyvinyl chloride) “G-SEAL” as manufactured by Green streak or approved equivalent, for 25mm opening.

(b) The modified PVC paving cap seal shall be extruded from an elastomeric plastic material of which the basic resins are prime virgin materials. The compound shall not contain any scrapped or reclaimed material whatsoever.

(c) Performance Requirements as follows:

Property	***Test Method***	***Requirements***
Tensile Strength	ASTM D412-02e1	16Mpa.
Elongation	ASTM D412-02e1	375% min.
Hardness	ASTM D2240-03	81+/-3 Shore A
Oil Swell (ASTM Oil #3, 70 hrs @ 100^{o}C change in volume/weight)	ASTM D471-98e1	+/- 15% by vol. +/- 15% by wt.
Ozone Resistance (20% strain, 300 pphm, 70 hrs @ 40^{o}C)	ASTM D518-99	No Cracking
Abrasion Resistance (10,500 cycles, 1000 g load)	ASTM D 3884-01e1	Material Loss: -0.35 grams max.
Adhesive Bond Strength	ASTM D412-02e1	7 Mpa min.
Results after Heat Aging (24 hrs @ 70 o F)	ASTM D573-99	Tensile Strength retained: 90% Elongation retained: 90% Hardness change:+/-3 Shore A

(d) The specific profile style chosen shall weigh a minimum of 0.75 kg per lineal meter.

(e) The profile shall have a minimum of two fins on the embedded legs for the purpose of anchorage and creating a water stop.

Provide factory made fabrications for all changes of direction, intersections, and transitions leaving only straight butt joint splices for field assembly.

Provide Green streak “G-SEAL” Adhesive for sealing of all butt splices.

8-2.11 Steel Tendons

Stressing tendons and accessories shall conform to the requirements of ACI 318M/318RM except as specified.

8-2.11.1 Stressing Tendons

Stressing tendons shall be clean and free of loose rust, scale and pitting. Unbonded tendons shall be permanently protected from corrosion with an approved applied coating.

(a) Seven-Wire Stress-Relieved Strand and Strand Assemblies

Seven-wire stress-relieved strand and strand assemblies shall conform to ASTM A 416/A 416M, Grade 270, strand diameter as shown on approved drawings. Strand assemblies may be either shop or field assembled with anchor fittings positively attached to strands.

(b) Stress-Relieved Wire and Wire Assemblies

Stress-relieved wire and wire assemblies shall conform to ASTM A 421, Type BA or WA, wire diameter as shown. Wire assemblies shall be shop assembled with anchor fittings positively attached to wires.

(c) High-Strength Steel Bars

High-strength steel bars shall conform to ASTM A 722/A 722M, Type I or II, meeting all supplementary requirements.

8-2.11.2 Accessories

(a) Ducts

Tendon ducts shall be of ferrous metal, capable of transmitting forces from grout to the surrounding concrete, flexible enough to conform to the tendon profile and strong enough to maintain their shape without deforming, sagging, or collapsing during concrete placement and vibration. The inside diameter of the ducts shall be large enough to provide an internal area at least twice the gross area of multiple wire, bar or strand assemblies and shall be at least 6 mm larger than the diameter of a single wire, bar or strand placed in the ducts. Ducts shall be designed for watertight connections with all fittings. Galvanized ducts will not be permitted.

(b) Anchorages and Couplers

Anchorages and couplers shall be metal of proven corrosion resistance and compatible with the stressing tendons, capable of fully developing the minimum guaranteed ultimate strength of tendons without excessive slip and approved. Anchorages shall be the button-head, wedge, nut and thread, grip nut, thread-bar, threaded plate or other approved type and shall be provided with bearing plates bars, rings, bells or other positive-attaching anchor fittings. Couplers shall be provided with housings long enough to permit the necessary movements and fittings which allow complete grouting of all components.

(c) Grout

Grout for grouting post-tensioned tendons shall consist of a mixture of Portland cement, shrinkage compensating admixture and potable water of which final proportions shall be based on test results of sample mixtures. Cement shall conform to ASTM C 150, Type I or II. The shrinkage compensating admixture shall produce a 2 percent minimum and a 10 percent maximum unconfined expansion when tested in accordance with ASTM C 940, shall not contain aluminum powder, chlorides, fluorides or nitrates, may be dispensed in solid or liquid form and must be approved by the Project Manager prior to its use. The water content shall be the minimum necessary for proper placement but the water-cement

ratio shall not exceed 0.50 by weight. The pumpability of grout shall be determined in accordance with ASTM C 939. The efflux time of a grout sample immediately after mixing shall not be less than 11 seconds. The minimum 7-day compressive strength of 50 mm grout cubes, molded, cured and tested in accordance with ASTM C 109/C 109M shall be 17.2 MPa.

8-2.11.3 Tests, Inspections and Verifications

The Contractor shall have required material tests performed on stressing tendons and accessories by an approved laboratory to demonstrate that the materials are in conformance with the specifications. These tests shall be at the Contractor's expense.

8-2.12 Concrete Mix Proportioning

8-2.12.1 Quality of Mix

For each portion of the structure, mixture proportions shall be selected so that the strength and W/C requirements listed in **Clause 8-1.5 - Design Requirements** are met.

8-2.12.2 Nominal Maximum-Size of Aggregate

The nominal maximum-size of coarse aggregate to be used in the various parts of the work shall be in accordance with the following tabulation except as directed. The NMSA may be changed for Section requiring a special quality of concrete as directed.

Features	*Nominal Maximum-Size Aggregate*
Sections 190 mm or less in width or slabs 100 mm or less in thickness or any section with a clear distance between reinforcement less than 55 mm	19 mm
Sections over 190 mm or slabs at least 100 mm in thickness. However, this size shall not be used in any section in which the clear distance between reinforcement is less than 55 mm	40 mm
Unreinforced SECTION over 300 mm in width and reinforced SECTION over 450 mm in width or slabs 255 mm or greater in thickness. However, this size shall not be used in any section in which the clear distance between reinforcing bars is less than 115 mm	75 mm
Massive SECTION exceeding 1.8 m in width and slabs 600 mm in thickness, in which the clear distance between reinforcing bars is at least 225 mm	150 mm

8-2.12.3 Air Content

The air content by volume shall be determined by ASTM C 231. When the nominal maximum size of coarse aggregate is 37.5 mm or larger, the air content of the sample measured in accordance with ASTM C 231 shall be 5.5 $\pm$ 1.5 percent. When the nominal maximum-size coarse aggregate is 19 mm, the air content shall be 6 $\pm$ 1 percent. The specified air content shall be present in the concrete when the concrete has been placed in the forms.

8-2.12.4 Slump

The slump shall be determined in accordance with ASTM C 143/C 143M and shall be 50 ± 25 mm for massive features and between 25 and 100 mm for all others except where placement by pump is approved, in which case the slump shall be 114 ± 38 mm. In addition, the range of each set of two consecutive tests for each mixture shall be not more than 50 mm. The above-specified slump is that required at the forms.

8-2.12.5 Concrete Proportioning

Trial batches and testing requirements for various qualities of concrete specified shall be the responsibility of the Contractor. Samples of aggregates shall be obtained in accordance with the requirements of ASTM D 75. Samples of materials other than aggregate shall be representative of those proposed for the project and shall be accompanied by the manufacturer's test reports indicating compliance with applicable specified requirements. Trial mixtures having proportions, consistencies, and air content suitable for the work shall be made based on methodology described in ACI 211.1, using at least three different water-cement ratios, which will produce a range of strength encompassing those required for the work. The maximum water-cement ratios required in **Sub-Clause 8-1.5.2 - Maximum Water-Cement Ratio** will be converted to a weight ratio of water to cement plus pozzolan by mass, silica fume, or GGBF slag by mass equivalency as described in ACI 211.1. In the case where GGBF slag is used, the weight of the slag shall be included in the equations for the term P, which is used to denote the mass of pozzolan. If pozzolan is used in the concrete mixture, the minimum pozzolan content shall be 15 percent of the total cementitious material. Trial mixtures shall be proportioned for maximum permitted slump and air content with due consideration to the approved conveying and placement method. The temperature of concrete in each trial batch shall be reported. For each water-cement ratio, at least three test cylinders for each test age shall be made and cured in accordance with ASTM C 192/C 192M. They shall be tested at 7 days and at the design age specified in **Clause 8-1.5 - Design Requirements of Concrete Mix** in accordance with ASTM C 39/C 39M. From these test results, a curve will be plotted showing the relationship between water-cement ratio and strength.

8-2.12.6 Required Average Compressive Strength

In meeting the strength requirements specified in Sub-Clause 8-1.5.1 - Concrete Strength, the selected mixture proportion shall produce a required average compressive strength f'cr exceeding the specified strength f'c by the amount indicated below.

(a) Average Compressive Strength from Test Records

Where a concrete production facility has test records, a standard deviation shall be established in accordance with the applicable provisions of ACI 214R. Test records from which a standard deviation is calculated shall represent materials, quality control procedures, and conditions similar to those expected, shall represent concrete produced to meet a specified strength or strengths (f'c) within 6.89 MPa of that specified for proposed work, and shall consist of at least 30 consecutive tests. A strength test shall be

the average of the strengths of two cylinders made from the same sample of concrete and tested at 28 days or at another test age designated for determination of f'c.

Required average compressive strength f'cr used as the basis for selection of concrete proportions shall be the larger of the equations that follow using the standard deviation as determined above:

f'cr = f'c + 1.34S

f'cr = f'c + 2.33S - 3.45

Where S = standard deviation

(b) Average Compressive Strength without Previous Test Records

When a concrete production facility does not have sufficient field strength test records for calculation of the standard deviation, the required average strength for shall be determined as follows:

If the specified compressive strength f'c is less than 20.7 MPa,

f'cr = f'c + 6.89

If the specified compressive strength f'c is 20.7 to 34.5 MPa,

f'cr = f'c + 8.27

If the specified compressive strength f'c is over 34.5 MPa,

f'cr = f'c + 9.65

8-2.13 Materials and Accessories for Formwork

8-2.13.1 Forms and Form Liners

NOTE: See the appropriate Concrete Materials Design Memorandum and EM 1110-2-2000 for description of class finishes. See paragraph 5.4.e in EM 1110-2-2000 for guidance in selecting appropriate finishes.

Forms and form liners shall be fabricated with facing materials that will produce a finish meeting the specified irregularities in formed surface requirements as defined in ACI 347. Forms and form liners shall be fabricated with facing materials as specified below. The class of finish shall be as shown on drawings.

(a) Class "A" Finish

For this class of finish the form facing material shall be composed of new, well-matched tongue-& groove lumber or new plywood panels conforming to PS1, Grade B-B concrete form, Class 1.

(b) Class "B" Finish

This class of finish the form facing material shall be composed of tongue-and-groove or shiplap lumber, plywood conforming to PS1, Grade B-B concrete form, tempered concrete form hard board or steel. Steel lining on wood sheathing will not be permitted.

(c) Class "C" Finish

For this class of finish the form facing may be tongue and groove lumber, plywood, concrete form hard board or steel. Wood form facing for curved or warped surfaces shall be composed of splines of lumber which can be bent to the required shape without splitting or cracking.

(d) Class "D" Finish

For this class of finish the form facing may be of wood or steel.

8-2.13.2 Form Coating

Form coating shall be commercial formulation that will not bond with, stain, cause deterioration, or any other damage to concrete surfaces. The coating shall not impair subsequent treatment of concrete surfaces depending upon bond or adhesion nor impede the wetting of surfaces to be cured with water or curing compounds. If special form liners are to be used, the Contractor shall follow the recommendation of the form coating manufacturer.

8-2.13.3 Accessories

NOTE: Removable tie rods are not allowed for structures intended to be a water barrier. Specify the locations where removable tie rods are not to be used.

Ties and other similar form accessories to be partially or wholly embedded in the concrete shall be of a commercially manufactured type. After the ends or end fasteners have been removed, the embedded portion of metal ties shall terminate not less than 50 mm from any concrete surface either exposed to view or exposed to water. Plastic snap ties may be used in locations where the surface will not be exposed to view. Form ties shall be constructed so that the ends or end fasteners can be removed without spalling the concrete.

8-3.1 Equipment

8-3.1.1 Capacity

NOTE: See the concrete materials design memorandum or EM 1110-2-2000 for the plant size requirements.

The capacity of the batching, mixing, conveying, and placing systems shall be adequate to complete all concrete work in scheduled time.

8-3.1.2 Batch Plant

NOTE: See EM 1110-2-2000, and the concrete materials design memorandum for selection of automatic or semiautomatic plant.

Batch plant shall meet the following requirements.

(a) Location

The concrete plant may be located at the site of the work in the general area indicated on the drawings, or may be located offsite.

(b) Bins and Silos

Separate bins, compartments, or silos shall be provided for each size or classification of aggregate and for each of the cementitious materials. The compartments shall be of ample size and so constructed that the various materials will be maintained separately under all working conditions. All compartments containing bulk cement, Pozzolan, ground granulated blast-furnace slag, or silica fume shall be separated from each other by a free-draining air space. All filling ports shall be clearly marked with a permanent sign stating the contents.

(c) Batching Equipment

(i) Batchers

Aggregate shall be weighed in separate weigh batchers with individual scales. Bulk cement and/or other cementitious materials shall each be weighed on a separate scale in a separate weigh batcher. Water shall be measured by weight or by volume. If measured by weight, it shall not be weighed cumulatively with another ingredient. Ice shall be measured separately by weight. Admixtures shall be batched separately and shall be batched by weight or by volume in accordance with the manufacturer's recommendations.

(ii) Water Batcher

A suitable water-measuring and batching device shall be provided that will be capable of measuring and batching the mixing water within the specified tolerances for each batch. The mechanism for delivering water to the mixers shall be free from leakage when the valves are closed. The filling and discharge valves for the water batcher shall be so interlocked that the discharge valve cannot be opened before the filling valve is fully closed. When a water meter is used, a suitable strainer shall be provided ahead of the metering device.

(iii) Admixture Dispensers

A separate batcher or dispenser shall be provided for each admixture. Each plant shall be equipped with the necessary calibration devices that will permit convenient checking of the accuracy of the dispensed volume of the particular admixture. The batching or dispensing devices shall be capable of repetitively controlling the batching of the admixtures to the accuracy specified. Piping for liquid admixtures shall be free from leaks and properly valved to prevent backflow or siphoning. The dispensing system shall include a device or devices that will detect and indicate the presence or absence of the admixture or provide a convenient means of visually observing the admixture in the process of being batched or discharged. Each system shall be capable of ready adjustment to permit varying the quantity of admixture to be batched. Each dispenser shall be interlocked with

the batching and discharge operations so that each admixture is added separately to the batch in solution in a separate portion of the mixing water or in fine aggregate in a manner to ensure uniform distribution of the admixtures throughout the batch during the required mixing period. Storage and handling of admixtures shall be in accordance with the manufacturer's recommendations.

(iv) Moisture Control

The plant shall be capable of ready adjustment to compensate for the varying moisture content of the aggregates and to change the weights of the materials being batched. A moisture meter complying with the provisions of COE CRD-C 143 shall be provided for measurement of moisture in the fine aggregate. The sensing element shall be arranged so that the measurement is made near the batcher charging gate of the fine aggregate bin or in the fine aggregate batcher.

(v) Scales

Adequate facilities shall be provided for the accurate measurement and control of each of the materials entering each batch of concrete. The weighing equipment and controls shall conform to the applicable requirements of NIST HB 44, except that the accuracy shall be within 0.2 percent of the scale capacity. The Contractor shall provide standard test weights and any other auxiliary equipment required for checking the operating performance of each scale or other measuring device. Tests shall be made at the frequency required in Clause 8-3.11 - Tests and Inspections, and in the presence of a Project Manager. Each weighing unit shall include a visible indicator that shall indicate the scale load at all stages of the weighing operation and shall show the scale in balance at zero load. The weighing equipment shall be arranged so that the concrete plant operator can conveniently observe the indicators.

(vi) Operation and Accuracy

The weighing operation of each material shall start automatically when actuated by a single starter switch and shall end automatically when the designated amount of each material has been reached. These requirements can be met by providing an automatic batching system as defined in NRMCA CPMB 100. There shall be equipment to permit the selection of 3 preset mixes each by the movement of not more than two switches or other control devices. Cumulative weighing will not be permitted. The weigh batchers shall be so constructed and arranged that the sequence and timing of batcher discharge gates can be controlled to produce a ribboning and mixing of the aggregates, water, admixtures, and cementitious materials as the materials pass through the charging hopper into the mixer. The plant shall include provisions to facilitate the inspection of all operations at all times. Delivery of materials from the batching equipment shall be within the following limits of accuracy:

Material	***Percent***
Cementitious materials	1

Water	1
Aggregate smaller than 37.5 mm size	2
Aggregate larger than 37.5 mm size	3
Chemical admixtures	3

(vii) Interlocks

Batchers and mixers shall be interlocked so that:

(1) The charging device of each batcher cannot be actuated until all scales have returned to zero balance within 0.2 percent of the scale capacity and each volumetric device has reset to start or has signaled empty.

(2) The charging device of each batcher cannot be actuated if the discharge device is open.

(3) The discharge device of each batcher cannot be actuated if the charging device is open.

(4) The discharge device of each batcher cannot be actuated until the indicated material is within the allowable tolerances.

(5) One admixture is batched automatically with the water.

(6) Each additional admixture is batched automatically with a separate portion of the water or with the fine aggregate.

(7) The mixers cannot be discharged until the required mixing time has elapsed.

(viii) Recorder

An accurate recorder or recorders shall be provided and shall conform to the following detailed requirements:

(1) The recorder shall produce a graphical or digital record on a single visible chart or tape of the weight or volume of each material in the batchers at the conclusion of the batching cycle. The record shall be produced prior to delivery of the materials to the mixer. After the batchers have been discharged, the recorder shall show the return to empty condition.

(2) A graphical recording or digital printout unit shall be completely housed in a single cabinet that shall be capable of being locked.

(3) The chart or tape shall be so marked that each batch may be permanently identified and so that variations in batch weights of each type of batch can be readily observed. The chart or tape shall be easily interpreted in increments not exceeding 0.5 percent of each batch weight.

(4) The chart or tape shall show time of day at intervals of not more than 15 minutes.

(5) The recorder chart or tape shall become the property of the Employer.

(6) The recorder shall be placed in a position convenient for observation by the concrete plant operator and the Project Manager's inspector.

(7) The recorded weights or volumes when compared to the weights or volumes actually batched shall be accurate within 2 percent.

(ix) Batch Counters

The plant shall include devices for automatically counting the total number of batches of all concrete batched and the number of batches of each preset mixture.

(x) Re-screening Plant

A re-screening plant shall be located, arranged, and operated in a manner that all coarse aggregate will be routed through the plant and that its operation will ensure delivery to the mixers of graded coarse aggregate free from excessive variation and conforming to the size groups and grading of **Clause 8-2.2 - Aggregates** and with moisture content conforming to the provisions of **Sub-Clause 8-2.2.5 - Moisture Content**. Coarse aggregate may be re-screened and delivered to the batch plant bins one size group at a time or two or more adjacent size groups at a time. Simultaneous re-screening of nonadjacent size groups is not permitted. All material passing the bottom screens of the smallest size of coarse aggregate being screened shall be wasted.

(xi) Washing Plant

All coarse aggregates shall be washed immediately prior to entering the re-screening plant. The rewashing plant shall contain adequate water nozzles and vibrating screens to remove foreign materials and coatings from aggregate particles. Water used for washing shall meet the requirements of **Sub-clause 8-2.4.4 - Water**.

(xii) Trial Operation

Not less than 7 days prior to commencement of concrete placing, a test of the batching and mixing plant shall be made in the presence of the Project Manager to check operational adequacy. The number of full-scale concrete batches required to be produced in trial runs shall be as directed, will not exceed 20, and shall be proportioned as directed. All concrete produced in these tests shall be wasted or used for purposes other than inclusion in structures covered by this specification. All deficiencies found in plant operation shall be corrected prior to the start of concrete placing operations. No separate payment will be made to the Contractor for labor or materials required by provisions of this Clause. The Contractor shall notify the Project Manager of the trial operation not less than 7 days prior to the start of the trial operation.

(xiii) Protection

The weighing, indicating, recording, and control equipment shall be protected against exposure to dust, moisture, and vibration so that there is no interference with proper operation of the equipment.

(d) Plant Layout Drawings

Drawings, in triplicate, showing the layout of the plant the Contractor proposes to use on the work shall be submitted by the Contractor for review. The drawings shall show the locations of the principal components of the construction plant; offices; shop and storage building; housing facilities, if any; and storage areas and yards which the Contractor

proposes to construct at the site of the work and elsewhere. The Contractor shall also furnish for review drawings, in triplicate, showing the general features of his aggregate processing plant; aggregate transporting; storage and reclaiming facilities; aggregate rinsing and dewatering plant, if required; coarse aggregate re-screening plant, if required; concrete batching and mixing plant; concrete conveying and placing plant; and when pre-cooling of concrete is required, the cooling plant. The drawing shall appropriately show the capacity of each major feature of the plant including the rated capacity of the aggregate production plant in tons (metric) per hour of fine and coarse aggregates; rated capacity of the aggregate transporting, storage and reclaiming facilities; volume of aggregate storage; capacity of cement and pozzolan storage; rated capacity of the concrete batching and mixing plant in cubic meters per hour; rated capacity of the concrete transporting and placing plant in cubic meters per hour; and when used rated capacity of plant for pre-cooling of concrete. Drawings in triplicate showing any changes in plant made during design and erection or after the plant is in operation shall be submitted for review. Two sets of the drawings will be retained and one set will be returned to the Contractor with comments.

8-3.1.3 Mixers

Mixers shall be stationary mixers or truck mixers. Each mixer shall combine the materials into a uniform mixture and discharge this mixture without segregation. Mixers shall not be charged in excess of the capacity recommended by the manufacturer on the nameplate. Excessive over-mixing requiring introduction of additional water will not be permitted. The mixers shall be maintained in satisfactory operating condition, and mixer drums shall be kept free of hardened concrete. Mixer blades or paddles shall be replaced when worn down more than 10 percent of their depth when compared with the manufacturer's dimension for new blades. Should any mixer at any time produce unsatisfactory results, its use shall be promptly discontinued until it is repaired or replaced.

(a) Stationary Mixer Uniformity Requirements

The size of the batch, the mixing time, the charging sequence, and other factors identified by the contractor shall be adjusted to provide concrete that meets the uniformity limits specified herein. All testing shall be performed in accordance with COE CRD-C 55. When regular testing is performed, the concrete shall meet the limits of any five of the six uniformity requirements. When abbreviated testing is performed, the concrete shall meet only those requirements listed for abbreviated testing. The initial mixer evaluation test shall be a regular test and shall be performed prior to the start of concrete placement. The concrete proportions used for the evaluation shall contain the largest size aggregate on the project and shall be as directed. Regular testing shall consist of performing all six tests on three batches of concrete. The range for regular testing shall be the average of the ranges of the three batches. Abbreviated testing shall consist of performing the three required tests on a single batch of concrete. The range for abbreviated testing shall be the range for one batch. If more than one mixer is used and all are identical in terms of make, type, capacity, condition, speed of rotation, etc., the results of tests on one of the mixers

shall apply to the others, subject to approval. Mixer evaluations shall be performed by the Contractor in accordance with **Sub-Clause 8-3.11.2(k) - Mixer Uniformity**. However, the initial evaluation will be performed by the Project Manager. The Contractor shall provide labor and equipment as directed to assist the Project Manager in performing any evaluation made by the Project Manager.

Parameter	*Regular Tests Allowable Maximum Range for Average of 3 Batches*	*Abbreviated Tests Allowable Maximum Range For 1 Batch*
Unit weight of air-free mortar, kg/m^3	32	32
Air content, percent	1.0	---
Slump, mm	25	---
Coarse aggregate, percent	6.0	6.0
Compressive strength at 7 days, percent	10.0	10.0
Water content, percent	1.5	---

(b) Truck Mixers

Truck mixers and the mixing of concrete therein shall conform to the requirements of ASTM C 94/C 94M. A truck mixer may be used for complete mixing (transit-mixed) or to finish the partial mixing done in a stationary mixer (shrink-mixed). Each truck shall be equipped with two counters from which it shall be possible to determine the number of revolutions at mixing speed and the number of revolutions at agitating speed. Truck mixers shall not be used to mix or agitate concrete with greater than 37.5 mm nominal maximum-size aggregate or concrete with a slump of 50 mm or less. The acceptability of truck mixers shall be determined by uniformity tests in accordance with ASTM C 94/C 94M.

8-3.1.4 Sampling Facilities

(a) Concrete

The Contractor shall provide suitable facilities and labor for obtaining representative samples of concrete in accordance with ASTM C 172 for Contractor quality control (QC) and Project Manager quality control (QA) testing.

(b) Coarse Aggregate

Suitable facilities shall be provided for readily obtaining representative samples of coarse aggregate for test purposes immediately prior to the material entering the mixer. The facilities shall include automatic equipment capable of obtaining, sieving, and weighing samples of the coarse aggregate as follows:

Aggregate Size	*Approximate Size of Sample*
4.75 to 19.0 mm	250 kg
19.0 to 37.5 mm	250 kg
37.5 to 75 mm	500 kg
75 to 150 mm	1000 kg

The equipment shall be capable of running a complete sieving of any required sample, without the necessity of intermittent loading. To accomplish this, adequate areas of individual sieves and controlled feeding of samples shall be provided. The assembly shall be designed to permit selection, screening, and weighing of any individual sample in 10 minutes or less. The equipment shall be designed by a company engaged in the design and manufacture of aggregate sieving devices. The Contractor shall have complete responsibility for providing equipment that will accomplish the desired purpose. Sieves shall meet the applicable requirements of ASTM E 11, except for the frame size requirements. The equipment shall be arranged so that all controls will be enclosed and operable from a single position commanding a view of the screen device and the scale or scales. Communication shall be provided from the batch plant operation to this control area. The Contractor shall be responsible for charging of the assembly as directed, disposal of waste material, and proper service and maintenance of the assembly. Each sieve shall be provided with individual controls for frequency and angle. The contractor shall run correlation tests with equipment used for ASTM C 136 before concrete placement begins and at least every 60 days while concrete is being placed. The correlation test will determine the optimum angle, volume of feed, and the frequency for each sieve.

8-3.1.5 Transporting Equipment

Transporting equipment shall be designed, operated, and maintained so that it does not cause or permit segregation or loss of material. The concrete shall not be dropped vertically more than 1.5 m except where suitable equipment is provided to prevent segregation and where specifically authorized.

(a) Buckets

Bottom-dump buckets shall conform to the following requirements: the interior hopper slope shall be not less than 70 degrees from the horizontal; the minimum dimension of the clear gate opening shall be at least five times the nominal maximum size of the aggregate, and the area of the gate opening shall not be less than 0.2 square meters; the bucket gates shall be grout-tight when closed, shall be of the double clamshell type, and shall be manually, pneumatically, or hydraulically operated; and the gate-opening mechanism shall be designed to close the gates automatically when the control is released or when the air or hydraulic line is broken. If gate actuation is dependent on integral air or hydraulic reservoirs, the capacity of the reservoirs shall be sufficient to open and close the gates three times without recharging the reservoir.

(b) Trucks

Truck mixers or agitators used for transporting central-mixed concrete shall conform to the applicable requirements of ASTM C 94/C 94M. Truck mixers shall not be used to transport concrete with larger than 37.5 mm nominal maximum-size aggregate or 50 mm or lower slump. Non-agitating trucks may be used for transporting central-mixed concrete over a smooth road when the hauling time is less than 15 minutes and the slump is less than 75 mm. Bodies of non-agitating trucks shall be smooth, watertight, metal containers specifically designed to transport concrete, shaped with rounded corners to minimize segregation, and equipped with gates that will permit positive control of the discharge of the concrete.

(c) Chutes

When concrete can be placed directly from a truck mixer, agitator, or non-agitating truck, the chutes supplied by the truck manufacturer as standard equipment may be used. A discharge deflector shall be used when required by the Project Manager. Separate chutes and other similar equipment shall not be permitted for conveying concrete except when specifically approved and in no case shall slump be increased to accommodate their use.

(d) Belt Conveyors

Belt conveyors shall be designed and operated to assure a uniform flow of concrete from mixer or delivery truck to final place of deposit without segregation of ingredients or loss of mortar and shall be provided with positive means for preventing segregation of the concrete or loss of mortar at the transfer point(s) and the point of placing. The idler spacing shall not exceed 900 mm. Belt speed shall be a minimum of 90 m per minute and a maximum of 230 m per minute. Belt width shall be a minimum of 600 mm if the NMSA is 150 mm and shall be a minimum of 400 mm if the NMSA is 75 mm or less. The NMSA required in mixture proportions will not be changed to accommodate the belt width.

(e) Pump Placement

Concrete may be conveyed by positive-displacement pump when approved. Pump placement will be approved only for areas where placement by bucket or conveyor is difficult or impractical. The pumping equipment shall be piston or squeeze-pressure type. The pipeline shall be rigid-steel pipe or heavy-duty flexible hose. Aluminum pipe shall not be used. The inside diameter of the pipe shall be at least 3 times the nominal maximum size of the coarse aggregate in the concrete to be pumped but not less than 100 mm.

8-3.2 Forms

8-3.2.1 Installation

(a) Form Construction

Forms shall be constructed true to the structural design and required alignment. The form surface and joints shall be mortar tight and supported to achieve safe performance during

construction, concrete placement, and form removal. The Contractor shall continuously monitor the alignment and stability of the forms during all phases to assure the finished product will meet the required surface class or classes specified in **Sub-Clause 8-2.15.1 - Forms and Form Liners** and tolerances specified in **Clause 8-1.9 - Design Requirements for Form work**. Failure of any supporting surface either due to surface texture, deflection or form collapse shall be the responsibility of the Contractor as will the replacement or correction of unsatisfactory surfaces. When forms for continuous surfaces are placed in successive units, care shall be taken to fit the forms over the completed surface to obtain accurate alignment of the surface and to prevent leakage of mortar. Forms shall not be re-used if there is any evidence of defects which would impair the quality of the resulting concrete surface. All surfaces of used forms shall be cleaned of mortar and any other foreign material before reuse.

(b) Chamfering

All exposed joints, edges and external corners shall be chamfered by molding placed in the forms unless the drawings specifically state that chamfering is to be omitted or as otherwise specified. Chamfered joints shall not be permitted where earth or rockfill is placed in contact with concrete surfaces. Chamfered joints shall be terminated 300 mm outside the limit of the earth or rock fill so that the end of the chamfers will be clearly visible.

(c) Coating

Forms for exposed or painted surfaces shall be coated with form oil or a form-release agent before the form or reinforcement is placed in final position. The coating shall be used as recommended in the manufacturer's instructions. Forms for unexposed surfaces may be wet with water in lieu of coating immediately before placing concrete, except that, in cold weather when freezing temperatures are anticipated, coating shall be mandatory. Surplus coating on form surfaces and coating on reinforcing steel and construction joints shall be removed before placing concrete.

8-3.2.2 Form Removal

NOTES: For unsupported concrete, form removal is based upon a minimum time requirement of 24 hours. As an option, form removal may be allowed between 18 hours and 24 hours after placement. In this case, form removal is based upon a minimum time (18 hours), minimum ambient temperature (10 degrees C (50 degrees F)), and minimum compressive strength requirement. For supported concrete, form removal is based solely upon a minimum compressive strength requirement.

An experienced concrete materials engineer should be consulted before allowing the use of the maturity concept instead of compressive strength test on field cured cylinders.

Forms shall not be removed without approval. The minimal time required for concrete to reach strength, adequate for removal of formwork without risking the safety of workers or the quality of the concrete depends on a number of factors including, but not limited to,

ambient temperature, concrete lift heights, type and amount of concrete admixture, and type and amount of cementitious material in the concrete. It is the responsibility of the Contractor to consider all applicable factors and leave the forms in place until it is safe to remove them. In any case forms shall not be removed unless the minimum time or minimum compressive strength requirements below are met, except as otherwise directed or specifically authorized. When conditions are such as to justify the requirement, forms will be required to remain in place for a longer period. All removal shall be accomplished in a manner which will prevent damage to the concrete and ensure the complete safety of the structure. Where forms support more than one element, the forms shall not be removed until the form removal criteria are met by all supported elements. Form removal shall be scheduled so that all necessary repairs can be performed as specified. Evidence that concrete has gained sufficient strength to permit removal of forms shall be determined by tests on control cylinders. All control cylinders shall be stored in the structure or as near the structure as possible so they receive the same curing conditions and protection methods as given those portions of the structure they represent. Control cylinders shall be removed from the molds at an age of no more than 24 hours. All control cylinders shall be prepared and tested in accordance with ASTM C 31/C 31M and ASTM C 39/C 39M at the Project Manager's Site Laboratory. After obtaining approval, the Contractor may use maturity instrumentation instead of control cylinders to determine the compressive strength of the concrete. ASTM C 1074 procedures shall be used for estimating concrete strength by means of the maturity method. All expenses associated with instrumenting the concrete and evaluating the strength using maturity relationships shall be the responsibility of the Contractor.

(a) Formwork Not Supporting Weight of Concrete

NOTES: If form removal is to be allowed before 24 hours, the concrete must have sufficient strength to resist damage from the removal operation. A minimum of 3.5 MPa (500 psi) is recommended.

If the bracketed sentences below are deleted from the project specification, the corresponding submittal requirements for the evaluation and results of control cylinder tests [or maturity instrumentation] should also be deleted from paragraph SUBMITTALS.

Formwork for walls, columns, sides of beams, gravity structures, and other vertical type formwork not supporting the weight of concrete shall not be removed in less than 24 hours after concrete placement is completed. Form removal before 24 hours will be allowed for simple floor slab, sidewalks, and driveways provided the ambient temperature during this period has not fallen below 10 ºC at any time since placement and evidence from compressive tests on field-cured concrete control cylinders or maturity instrumentation indicates that the concrete has attained a compressive strength of at least 8 MPa. Control cylinders shall be prepared for each set of forms to be removed before 24 hours. The stability of the concrete shall be evaluated by a structural Engineer prior to removal of the forms.

(b) Formwork Supporting Weight of Concrete

NOTE: ACI 347 suggests that at least 70 percent of the design strength should be achieved before removal of formwork support from horizontal members, unless otherwise approved by the Contracting Officer. (ACI 347, paragraph 3.7.2.1) When specifications are being prepared, a structural engineer should determine the actual minimum percentage of design strength that should be achieved for the specific conditions on each structure.

Formwork supporting weight of concrete and shoring shall not be removed until structural members have acquired sufficient strength to safely support their own weight and any construction or other superimposed loads to which the supported concrete may be subjected. As a minimum, forms shall be left in place until control concrete test cylinders or maturity instrumentation indicate evidence the concrete has attained at least 70 percent of the compressive strength required for the structure.

8-3.2.3 Inspection

Forms and embedded items shall be inspected in sufficient time prior to each concrete placement by the Contractor in order to certify to the Project Manager that they are ready to receive concrete. The results of each inspection shall be reported in writing.

8-3.3 Preparation for Placing

8-3.3.1 Vibrators

An adequate number of vibrators shall be on hand to meet placing requirements, and spare vibrators shall be available to maintain production in the event of breakdown. There shall be adequate air pressure available for air vibrators and adequate voltage for electric vibrators. Vibrators of the proper size, frequency, and amplitude shall be used for the type of work being performed in conformance with the following requirements:

Application	***Head Diameter Millimeters***	***Frequency VPM***	***Amplitude Millimeters***
Thin walls, beams, etc.	32 - 64	9,000 - 13,500	0.5 - 1.0
General construction	50 - 88	8,000 - 12,000	0.6 - 1.2
Heavy Section	75 - 150	7,000 - 10,500	0.75 - 1.5
Mass concrete	125 - 175	5,500 - 8,500	1.0 - 2.0

NOTE: The following table to be used with SI units.

The frequency and amplitude shall be within the range indicated in the tabulation as determined in accordance with **Clause 8-3.11 - Tests and Inspections**.

8-3.3.2 Fabrication and Placement of Reinforcement

NOTE: Details of reinforcement which are not in accordance with ACI SP-66 or ACI 318M/318RM and ACI 318/318R must be indicated.

Reinforcement steel and accessories shall be fabricated and placed as specified and shown and approved shop drawings. Fabrication and placement details of steel and accessories not specified or shown shall be in accordance with ACI SP-66 and ACI 318M/318RM or as directed. Steel shall be fabricated to shapes and dimensions shown, placed where indicated within specified tolerances and adequately supported during concrete placement. At the time of concrete placement all steel shall be free from loose, flaky rust, scale (except tight mill scale), mud, oil, grease or any other coating that might reduce the bond with the concrete.

(a) Hooks and Bends

Steel bars, except for zinc-coated or epoxy-coated, shall be mill or field-bent. Zinc-Coated and epoxy-coated bars shall be mill-bent prior to coating. All steel shall be bent cold unless authorized. No steel bars shall be bent after being partially embedded in concrete unless indicated or authorized.

(b) Welding

Welding of steel bars will be permitted only where indicated or authorized. Welding shall be performed in accordance with AWS D1.4 except where otherwise specified or indicated.

(c) Placing Tolerances

(i) Spacing

The spacing between adjacent bars and the distance between layers of bars may not vary from the indicated position by more than one bar diameter nor more than 25 mm.

(ii) Concrete Cover

The minimum concrete cover of main reinforcement steel bars shall be as shown. The allowable variation for minimum cover shall be as follows:

MINIMUM COVER	*VARIATION*
150 mm	plus 13 mm
100 mm	plus 10 mm
75 mm	plus 10 mm
50 mm	plus 6 mm
38 mm	plus 6 mm
25 mm	plus 3 mm
19 mm	plus 3 mm

(d) Splicing

Splices in steel bars shall be made only as required. Bars may be spliced at alternate or additional locations at no additional cost to the Employer subject to approval by Project Manager.

(i) Lap Splices

Lap splices shall be used only for bars smaller than size 45 and welded wire fabric. Lapped bars may be placed in contact and securely tied or spaced transversely apart to permit the embedment of the entire surface of each bar in concrete. Lapped bars shall not be spaced farther apart than 1/5 the required length of lap or 150 mm.

8-3.3.3 Embedded Items

Before placing concrete, care shall be taken to determine that all embedded items are securely fastened in place as indicated in the drawings or required. Embedded items shall be free of oil and other foreign matter such as loose coatings of rust, paint, and scale. The embedding of wood in concrete will be permitted only when specifically authorized or directed. Any air or water lines or other materials embedded in structures as authorized construction expedients shall conform to the above requirements and upon completion of their use shall be backfilled with concrete or mortar as directed. Welding will not be permitted on embedded or otherwise exposed metals which are in contact with concrete surfaces. Tack welding of or to embedded items will not be permitted.

8-3.3.4 Concrete on Earth Foundations

Earth foundations upon which concrete is to be placed shall be clean, damp, and free from frost, ice, and standing or running water. Prior to placement of concrete, the earth foundation shall have been satisfactorily compacted in accordance with the provisions of Section 5-Excavatin and Miscellaneous Earthworks.

8-3.3.5 Concrete on Rock Foundations

Rock surfaces upon which concrete is to be placed shall be clean and free from oil, standing or running water, ice, mud, drummy rock, coatings, debris, and loose, semidetached, overhanging, or unsound fragments. Faults or joints shall be cleaned to a satisfactory depth and to firm rock on the sides as directed by the Project Manager. Immediately before concrete is placed, all rock surfaces shall be cleaned thoroughly by the use of air-water jet, high-pressure water jet, or sandblasting as described in Sub-**Clause 8-3.3.6 - Construction Joint Treatment**. All rock surfaces shall be kept continuously wet for at least 24 hours immediately prior to placing concrete thereon. All approximately horizontal surfaces shall be covered immediately before the concrete is placed with a 13 mm layer of mortar composed of the same sand and cementitious materials used in the concrete. The sand-cementitious materials ratio and the water-cementitious material ratio of the mortar shall be approximately the same as those used in the concrete mixture. The mortar shall be covered with concrete before the mortar has reached its initial time of setting.

8-3.3.6 Construction Joint Treatment

(a) Joint Preparation

Concrete surfaces to which other concrete is to be bonded shall be prepared for receiving the next lift or adjacent concrete by cleaning by sandblasting, high-pressure water jet, or air-water cutting. Surface cutting by air-water jets will not be permitted for concrete surfaces congested with reinforcing steel or if they are relatively inaccessible. If, for any other reason, it is considered undesirable to disturb the surface of a lift before it has hardened, the use of sandblasting or high-pressure water jet after hardening will be required. Regardless of the method used, the resulting surface shall be free from all laitance and inferior concrete so that clean, well-bonded coarse aggregate particles are exposed uniformly over the lift surface. Application of the joint treatment method shall be such that the edges of the larger particles of aggregate are not undercut. Where joint preparation occurs more than 2 days prior to placing the next lift or where the work in the area subsequent to the joint preparation causes dirt or debris to be deposited on the surface, the surface shall be cleaned as the last operation prior to placing the next lift. The surface of the construction joint shall be kept continuously wet for the first 12 hours of the 24 hours prior to placing concrete, except that the surface shall be damp with no free water at the time of placement.

(b) Air-Water Cutting

Air-water cutting of a construction joint shall be performed at the proper time, generally between 4 and 12 hours after placement and only on horizontal construction joints. This period may be modified if a retarder is used to prolong the setting of the cement at surface of the concrete. The air pressure used in the jet shall be 620 to 760 kPa, and the water pressure shall be just sufficient to bring the water into effective influence of the air pressure. When approved a surface retarder complying with the requirements of COE CRD-C 94 may be applied to the surface of the lift to prolong the period of time during which air-water cutting is effective. Prior to receiving approval, the Contractor shall furnish samples of the material to be used and shall demonstrate the method to be used in its application. After cutting, the surface shall be washed and rinsed until the wash water is no longer cloudy. If air-water cutting does not produce acceptable results, the surface shall be prepared by high-pressure water jet or sandblasting.

(c) High-Pressure Water Jet

A stream of water under a pressure of not less than 21 MPa may be used for cleaning. Its use shall be delayed until the concrete is sufficiently hard so that only the surface skin or mortar is removed and there is no undercutting of coarse-aggregate particles. If the high-pressure water jet is incapable of a satisfactory cleaning, the surface shall be cleaned by sandblasting.

(d) Wet Sandblasting

This method of joint preparation may be used when the concrete has reached sufficient strength to prevent undercutting of coarse aggregate particles. The operation shall be continued until all accumulated laitance, coatings, stains, debris, and foreign materials are

removed. The surface of the concrete shall then be washed thoroughly to remove all loose material. This method may be used on both horizontal and vertical surfaces.

(e) Waste Water Disposal

NOTE: Specification Writer will fill in the section number for the Environment Protection Plan.

The method used in disposing of waste water employed in cutting, washing, and rinsing of concrete surfaces shall be such that the waste water does not stain, discolor, or affect exposed surfaces of the structures, or damage the environment of the project area. The method of disposal shall meet all requirements of Section 3 - Environmental Protection.

8-3.3.7 Joints

Joint locations and details, including materials and methods of installation of joint fillers and water stops, shall be as specified, as shown on drawings, and as directed. In no case shall any fixed metal be continuous through an expansion or contraction joint except as shown on drawings.

(a) Expansion Joints

Pre-molded filler strips shall have oiled wood strips secured to the top thereof and shall be accurately positioned and secured against displacement to clean, smooth concrete surfaces. The wood strips shall be slightly tapered, dressed and of the size required to install filler strips at the desired level below the finished concrete surface and to form the groove for the joint sealant or seals to the size shown. Material used to secure pre-molded fillers and wood strips to concrete shall not harm the concrete and shall be compatible with the joint sealant or seals. The wood strips shall not be removed until after the concrete curing period. The groove shall be thoroughly cleaned of all laitance, curing compound, foreign materials, protrusions of hardened concrete and any dust which shall be blown out of the groove with oil-free compressed air.

(i) Joints with Field-Molded Sealant

Joints shall not be sealed when the sealant, air or concrete temperature is less than 4 degrees centigrade. Immediately prior to installation of field molded sealants, the joint shall be cleaned of all debris and further cleaned using water, chemical solvents or other means as recommended by the sealant manufacturer. The joints shall be dry prior to filling with sealant. Bond breaker and back-up material shall be installed where required. Joints shall be primed and filled flush with joint sealant in accordance with the manufacturer's recommendations.

(ii) Joints with Preformed Compression Seals

The joint seals shall be installed with equipment, which shall be capable of installing joint seals to the prescribed depth without cutting, nicking, twisting, or otherwise distorting or damaging the seal and with no more than five percent stretching of the seal. The sides of the joint and, if necessary, the sides of the compression seal shall be covered with a

coating of lubricant, and the seal shall be installed to the depth indicated with joint installation equipment. Butt joints shall be coated with liberal applications of lubricant.

(b) Contraction Joints

Joints requiring bond breaking shall be coated with curing compound or with bituminous paint. Water stops shall be protected during application of bond breaking material to prevent them from being coated.

(c) Water stops

Water stops shall be carefully and correctly positioned during installation to eliminate faulty installation that may result in joint leakage. The bottom of each waterstop shall be embedded a minimum of 150mm in firm rock or sealed to other cut-off systems. All water stops shall be installed so as to form a continuous watertight diaphragm in each joint. Adequate provision shall be made to support and protect the water stops during the progress of work. Any waterstop punctured or damaged shall be replaced or repaired at the Contractor's expense. The concrete shall be thoroughly consolidated in the vicinity of the waterstop. Suitable guards shall be provided to protect exposed projecting edges and ends of partially embedded water stops from damage when concrete placement has been discontinued.

(i) Splices

Joints in water stops shall be spliced together by qualified splicers using the approved splicing procedures to form a continuous watertight diaphragm. Splices shall be as followed:

(1) Non-Metallic Water stops

All splices shall be made on a bench in a temporary shop provided at the site of the installation or at the manufacturer's plant. A miter guide and portable power saw shall be used to cut the ends to be joined to insure good alignment and contact between joined surfaces. Continuity of the characteristic features of the cross section of the waterstop (ribs, tabular center axis, protrusions and the like) shall be maintained across the splice.

(2) Rubber Water stops

Splices shall be vulcanized in accordance with the approved procedure.

(3) Polyvinylchloride Water stops

Splices shall be made by heat-sealing the adjacent surfaces in accordance with the approved procedure. A thermostatically controlled electrical heat source shall be used to make all splices. The correct temperature at which splices should be made will differ with the material concerned but the applied heat should be sufficient to melt but not char the plastic. Water stops shall be reformed at splices with a remolding iron with ribs or corrugations to match the pattern of the waterstop. The spliced area, when cooled and bent by hand in as sharp an angle as possible shall show no sign of separation.

8-3.4 Transporting and Placing Concrete

8-3.4.1 Transporting

Methods and equipment for conveying and depositing the concrete into the form shall be subject to approval. The capacity of the transporting system shall be sufficient to supply concrete at a rate to prevent cold joints forming during placement. A properly designed and sized elephant trunk and rigid drop chute bottom section which will prevent free-fall within the elephant trunk and rigid drop chute will be used if concrete is to drop more than 1.5 m. If concrete is to be placed through installed horizontal or sloping reinforcing bars, the concrete shall discharge into a pipe or elephant trunk that is long enough to extend through the reinforcing bars to within 1.5 m of the placing surface. In no case will concrete be discharged to free fall through the reinforcing bars.

(a) Transporting by Bucket

There shall be provided indicating and signaling devices for the control of identification of types or classes of concrete as they are mixed and discharged into buckets for transfer to the forms. Each type or class of concrete shall be visually identified by placing a colored tag or marker on a bucket as it leaves the mixing plant so that the concrete may be positively identified in the forms and placed in the structure in the desired position.

(b) Transporting by Pump

The nominal maximum-size coarse aggregate will not be reduced or mixture proportions changed to accommodate a pump except as specifically determined appropriate. The distance and height to be pumped shall not exceed limits recommended by the pump manufacturer. The concrete shall be supplied to the pump continuously. When pumping is completed, concrete remaining in the pipeline shall be ejected without contamination of concrete in place. After each operation the equipment shall be thoroughly cleaned and flushing water shall be wasted outside the forms.

(c) Transporting by Belt Conveyor

Methods and equipment for transporting the concrete by belt conveyor into the form shall be subject to approval.

8-3.4.2 Placing

The capacity of the placing system shall be sufficient to supply concrete at a rate which will prevent cold joints in any placement. 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, and in so depositing, there shall be no vertical drop greater than 1.5 m except where suitable equipment is provided to prevent segregation and where specifically authorized. Depositing of the concrete shall be so regulated that it will be effectively placed and consolidated in horizontal layers not exceeding 1.5 m in thickness with a minimum of lateral movement. The amount of concrete deposited shall be such that it can be readily and thoroughly consolidated and shall not exceed 3 cubic meters in one

pile. All concrete-placing equipment and methods shall be subject to approval. Concrete placement will not be permitted during heavy rains or dust storm or when the air temperature falls below 5 degree C or rise above 38 degree C.

(a) Time Interval between Mixing and Placing

Concrete mixed in stationary mixers and transported by nonagitating equipment shall be placed within 30 minutes after it has been mixed, unless otherwise authorized. When concrete is truck mixed or when a truck mixer or agitator is used for transporting concrete mixed by stationary mixers, the concrete shall be delivered to the site of the work, and discharge shall be completed within 1 hour after introduction of the cement to either the water or aggregate.

(b) Placing Temperature

Unless specified otherwise for particular parts of the works, the temperature of the concrete when delivered to the forms shall be as low as practicably can be produced but in no case at a temperature in excess of 13 degree C for mass concrete and 24 degree C for the other structures. The requirements specified below for different types of concrete sections. The temperature of the fresh concrete shall be measured in accordance with ASTM C 1064/C 1064M.

(c) Hot-Weather Placing

NOTE: See EM 1110-2-2000 for the proper placing temperature.

All hot weather concrete shall comply with the requirements of ACI 305R. In hot weather, the contractor shall take steps to ensure adequate protection of concrete work. Hot weather is defined as any combination of high air temperature, low relative humidity and wind velocity tending to impair the quality of fresh or hardened concrete or otherwise resulting in abnormal properties. To that end the Contractor shall provide sun shades over stockpiles of aggregates, batching and mixing plant, cement silos, and mixing water tanks and pipelines; insulate facilities and, in addition, shall carry out one or more of the following procedures which shall be submitted to the Project Manager for approval:

- Shade and /or wet the outside of the formwork.
- Apply a fine moisture (fog) spray of clean water at a temperature not exceeding 25 degree C in order to cool and moisten the surrounding air and the sub-surface, to cool the formwork and reinforcement, to lessen rapid evaporation from unformed concrete surface and keep concrete surfaces cool.
- Refrigerate the mixing water.
- Add chip, crushed, tube, or other forms of ice up to the full amount of added mixing water.
- Placement only at night.

(d) Cold Weather Placing

The temperature of the concrete when deposited in the forms shall not be less than 5 degrees C. The ambient temperature of the placement area and all surfaces to receive concrete shall be above 0 degrees C. Materials entering the mixer shall be free from ice, and frozen lumps. The heating of mixing water or aggregates necessary to keep the concrete temperature above 5 degrees C shall be closely regulated so that the concrete temperature does not exceed 15 degrees C. An accelerator may be used when approved in advance.

(e) Concrete Lifts

NOTE: The required construction joints should be shown in the drawings.

All concrete shall be deposited in approximately horizontal layers about 0.5 m in thickness in stepped progression at such a rate that the formation of cold joints will be prevented. Slabs shall be placed in one lift, unless 0.8m or more deep. Where 2.3 m or greater lift depths are permitted, the Contractor shall furnish approved cantilever forms that are jointed or hinged approximately mid height to facilitate placement against surfaces sloping more than 10 degree from vertical. At the beginning of the placing of a lift, the top half of a hinged or jointed form shall be retracted to such a position that it does not interfere with the operation of buckets placing concrete adjacent to the form. A minimum of five successive horizontal layers in stepped progression shall be used for 2.3m lifts. Where 1.5 m lifts are required, a minimum of three successive horizontal layers in stepped progression shall be used. Each new layer of concrete shall be placed on the oldest exposed layer. The maximum exposed bulkhead face of concrete between adjacent monoliths shall not exceed 12m except as otherwise approved.

(f) Consolidation

Immediately after placing, each layer of concrete shall be consolidated by internal vibrating equipment. Vibrators shall not be used to cause concrete to flow for significant distances within the forms. Hand spading may be used if necessary together with internal vibration along formed surfaces permanently exposed to view. Form vibrators shall not be used unless forms are specifically designed for this use and unless specifically approved. The vibrator shall be inserted vertically at uniform spacing over the entire area of placement. The distance between insertions shall be approximately 1.5 times the radius of action of the vibrator. The vibrator shall penetrate rapidly to the bottom of the layer and at least 150 mm into the preceding unhardened layer if such exists. It shall be held stationary until the concrete is consolidated and then withdrawn slowly. Slabs 200 mm or less in depth shall be consolidated by approved methods.

(g) Placing Concrete in Unformed Curved Sections

The unformed portion of the ogee crest, spillway bucket, and similar features shall be finished by placing concrete slightly above grade, consolidating and striking off to grade by accurate screeding. It may be accomplished by semi mechanical devices or by a mechanical screed that consolidates and screeds the surface in one operation. Ribs embedded in the fresh concrete as guides for screeds will not be permitted.

8-3.5 Finishing

8-3.5.1 Unformed Surfaces

The ambient temperature of spaces adjacent to surfaces being finished shall be not less than 5 degrees C. In hot weather when the rate of evaporation of surface moisture, as determined by use of **Figure 2.1.5** of ACI 305R, may reasonably be expected to exceed 1.0 kg/square meter per hour, provisions for windbreaks, shading, fog spraying, or evaporation retarding film shall be made in advance of placement to prevent plastic shrinkage cracks, and such protective measures shall be taken before, during, and immediately after finishing as operations require. All unformed surfaces of concrete that are not to be covered by additional concrete or backfill shall have a float finish, unless a trowel finish is specified, and shall be true to elevation as shown on the drawings. Surfaces to receive additional concrete or backfill shall be brought to the elevation shown and left true and regular. Exterior surfaces shall be sloped for drainage unless otherwise shown in the drawing or directed. Joints shall be carefully made with a jointing or edging tool. The finished surfaces shall be protected from stains or abrasions. The concrete shall be thoroughly consolidated before finishing operations commence or before leaving it for future concrete or backfill placement.

(a) Float Finish

Surfaces to receive a float finish shall be screeded and darbied or bullfloated to bring the surface to the required finish level with no coarse aggregate visible. No water, cement, or mortar shall be added to the surface during the finishing operation. Floating may be performed by use of suitable hand floats or power-driven equipment. Hand floats shall be of aluminum or magnesium. After the water sheen has disappeared, the concrete, while still green but sufficiently hardened to bear a man's weight without deep imprint, shall be floated to a true even plane.

(b) Trowel Finish

NOTE: Refer to the appropriate design memorandum for surfaces to be trowel finished. Be sure these are shown in the drawings.

A trowel finish shall be applied to the surfaces where shown in drawings. Concrete surfaces shall first be given a float finish. After surface moisture has disappeared, the surface shall be troweled to a smooth, even, dense finish, free from blemishes, including trowel marks. In lieu of hand finishing, an approved power finishing machine may be used in accordance with the directions of the machine manufacturer. A final hard steel troweling shall be done by hand. Joints shall be carefully made with a jointing or edging tool. The finished surfaces shall be protected from stains or abrasions. Surfaces or edges likely to be injured during the construction period shall be protected from damage.

(c) Broom Finish

NOTE: Refer to the appropriate design memorandum for surfaces to be broom finished. Be sure these are shown in the drawings.

A broom finish shall be applied to the following surfaces where indicated in drawings. The concrete surface to be broom finished shall first be given a float finish. The surface shall then be broomed with a stiff fiber-bristle broom.

(d) High Velocity Finishes

NOTE: Refer to the appropriate design memorandum for surfaces to receive high velocity finishes. Be sure these are shown in the drawings.

Unformed surfaces subjected to high velocity flow (12 m/s) and shown in drawings shall receive a trowel finish.

8-3.5.2 Formed Surface Repair

NOTE: Refer to EM 1110-2-2000 for direction on class of finish. Please note that definitions for class of finish have been changed recently. Class of finish shall also be shown in the drawings. Paragraph CONSTRUCTION TOLERANCES presents surface tolerances. Section 03101A FORMWORK FOR CONCRETE presents materials for each class.

After removal of forms, all ridges, lips, and bulges on surfaces permanently exposed shall be removed. All repairs shall be completed within 48 hours after form removal.

(a) Classes A, A-HV, & B Finishes

Surfaces as shown in the drawings to have classes A, A-HV, and B finishes, shall have surface defects repaired as follows: defective areas, voids, and honeycombs smaller than 10 000 square mm in area and less than 13 mm deep; bug holes exceeding 13 mm in diameter shall be chipped and filled with dry-packed mortar; holes left by removal of tie rods shall be reamed and filled with the below specified material; defective and unsound concrete areas larger than described shall be defined by 13 mm deep dovetailed saw cuts in a rectangular pattern with lines parallel to the formwork, the defective concrete removed by chipping and the void repaired with replacement concrete. The prepared area shall be brush-coated with an epoxy resin meeting the requirements of ASTM C 881/C 881M, Type V; a latex bonding agent meeting the requirements of ASTM C 1059, Type II; or a neat cement grout after dampening the area with water. The void shall be filled with replacement concrete in accordance with the **Sub-Clause 8-3.5.2(d) - Material and Procedure for Repairs**.

(b) Class C Finish

Surfaces as shown in the drawings, to have Class C finish shall have defects repaired as follows: defective areas, voids, and honeycombs smaller than 15 000 square mm and less than 50 mm deep; bug holes exceeding 38 mm in diameter shall be chipped and filled with dry-packed mortar; and holes left by removal of the tie rods shall be reamed and filled with dry-packed mortar. Defective and unsound concrete areas larger than 15 000 square mm and deeper than 38 mm shall be defined by 13 mm deep dovetailed saw cuts in a rectangular pattern, the defective concrete removed by chipping, and the void repaired

with replacement concrete. The prepared area shall be brush-coated with an epoxy resin meeting the requirements of ASTM C 881/C 881M, Type V; a latex bonding agent meeting the requirements of ASTM C 1059, Type II; or a neat cement grout after dampening the area with water. The void shall be filled with replacement concrete in accordance with the **Sub-Clause 8-3.5.2(d) - Material and Procedure for Repairs**.

(c) Class D Finish

Surfaces as shown in the drawings to have class D finish, shall have surface defects repaired as follows: defective areas, voids, and honeycombs greater than 30 000 square mm in area or more than 50 mm deep shall be defined by 13 mm deep dovetailed saw cuts in a rectangular pattern, the defective concrete removed by chipping and the void repaired with replacement concrete. The prepared area shall be brush-coated with an epoxy resin meeting the requirements of ASTM C 881/C 881M, Type V; a latex bonding agent meeting the requirements of ASTM C 1059, Type II; or a neat cement grout after dampening the area with water. The void shall be filled with replacement concrete in accordance with Sub-Clause 8-3.5.2(d) - Material and Procedure for Repairs.

(d) Material and Procedure for Repairs

The cement used in the dry-packed mortar or replacement concrete shall be a blend of the cement used for production of project concrete and white Portland cement properly proportioned so that the final color of the mortar or concrete will match adjacent concrete. Trial batches shall be used to determine the proportions required to match colors. Dry-packed mortar shall consist of one part cement to two and one-half parts fine aggregate. The fine aggregate shall be that used for production of project concrete. The mortar shall be remixed over a period of at least 30 minutes without addition of water until it obtains the stiffest consistency that will permit placing. Mortar shall be thoroughly compacted into the prepared void by tamping, rodding, ramming, etc. and struck off to match adjacent concrete. Replacement concrete shall be produced using project materials and shall be proportioned by the Project Manager. It shall be thoroughly compacted into the prepared void by internal vibration, tamping, rodding, ramming, etc. and shall be struck off and finished to match adjacent concrete. Forms shall be used to confine the concrete. If an expanding agent is used in the repair concrete, the repair shall be thoroughly confined on all sides including the top surface. Metal tools shall not be used to finish permanently exposed surfaces. The repaired areas shall be cured for 7 days. The temperature of the in situ concrete, adjacent air, and replacement mortar or concrete shall be above 5 degrees C during placement, finishing, and curing. Packaged materials meeting the requirements of ASTM C 928 may be used in lieu of dry-packed mortar when approved. Other methods and materials for repair may be used only when approved in writing. Repairs of the so called "plaster-type" will not be permitted.

8-3.6 Curing and Protection

8-3.6.1 Curing Time

NOTE: Curing time may be extended if required by the thermal study. See the concrete materials design memorandum for the approved types of cementitious materials.

All concrete shall be cured by one of the following methods or combination of methods for the period of time given below corresponding to the cementing materials used in the concrete:

Type I Portland cement	7 days
Portland cement in combination with silica fume	7 days
Type II Portland cement	14 days
Portland cement blended with 25 percent or less fly-ash or GGBF slag	14 days
Portland cement blended with more than 25 percent fly-ash or GGBF slag	21 days

Curing shall begin immediately after placing. The Contractor shall have all equipment needed for adequate curing and protection of the concrete on hand and ready to install before actual concrete placement begins. The curing medium and method, or the combination of media and methods used, shall be as approved in accordance with **Clause 8-1.3 - Submittals, SD-03 Product Data**, submittal item "Curing and Protection".

8-3.6.2 Moist Curing

Concrete containing silica fume shall be moist cured. Horizontal and nearly horizontal surfaces shall be moist cured by ponding, by covering with a minimum uniform thickness of 50 mm of continuously saturated sand, or by covering with saturated nonstaining burlap or cotton mats. Burlap and cotton mats shall be rinsed to remove soluble substances before using. Other surfaces shall be moist cured when approved or directed. Concrete that is moist cured shall be maintained continuously, not periodically, wet for the duration of the entire curing period. Water for curing shall comply with the requirements of the Sub-**Clause 8-2.4.4 - Water**. If the water, sand, mats, etc. cause staining or discoloration of permanently exposed concrete surfaces, the surfaces shall be cleaned by a method approved. When wood forms are left in place during curing, the forms shall be kept continuously wet except for sealed insulation curing in cold weather. When steel forms are left in place on vertical surfaces during curing, the forms shall be carefully broken loose from the hardened concrete and curing water continuously introduced into the void. Horizontal construction joints shall be allowed to dry sufficiently to remove free water immediately prior to placing the next lift.

8-3.6.3 Membrane Curing

Membrane curing may be used on surfaces that are not specified or directed to receive moist curing and that are not to receive a grout-cleaned finish. Membrane-forming curing compound shall not be used on surfaces that contain protruding steel reinforcing, that are

heated by free steam, that will have additional concrete bonded to them, or that are to be grout-cleaned.

(a) Pigmented Curing Compound

Pigmented compound conforming to ASTM C 309, Type 2, Class A, may be used on surfaces that will not be exposed to view when the project is completed. Only pigmented compound of the styrene acrylate or chlorinated rubber formulation conforming to ASTM C 309, Class B, requirements may be used on surfaces that are to be painted or to receive bituminous roofing or water proofing or floors that are to receive adhesive applications of resilient flooring. The curing compound selected by the Contractor for such use shall be compatible with any subsequent paint, roofing, coating, or flooring specified elsewhere in the contract.

(b) Non-pigmented Curing Compound

NOTE: See the concrete materials design memorandum for guidance on the optional sentence.

Non-pigmented compound conforming to ASTM C 309, Type ID, containing a fugitive dye may be used on surfaces that will be exposed to view when the project is completed. The reflective requirements of ASTM C 309 are waived. Surfaces cured with non-pigmented compound shall be shielded from direct rays of the sun for 3 days.

(c) Application

The curing compound shall be applied to formed surfaces immediately after the forms are removed. The surfaces shall be thoroughly moistened with water, and the curing compound applied as soon as free water disappears. The curing compound shall be applied to unformed surfaces as soon as free water has disappeared provided steps have been taken when necessary to prevent premature loss of free water due to excessive evaporation as described in **Sub-Clause 8-3.5.1 - Unformed Surfaces**. The curing compound shall be applied in a two-coat continuous operation by motorized power-spraying equipment or pressure-tank equipment operating at a minimum pressure of 520 kPa with provisions for continuous agitation. The application equipment shall be approved in advance. Hand-operated pressure applicators ("garden sprayers") shall not be used except in small, isolated areas as approved. The compound shall be applied at a uniform coverage of not more than 10 square meters per liter for each coat. The second coat shall be applied perpendicular to the first coat. Concrete surfaces that have been subjected to rainfall within 3 hours after the curing compound has been applied shall be re-sprayed by the method and at the coverage specified. All concrete surfaces on which the curing compound has been applied shall be adequately protected for the duration of the entire curing period from pedestrian and vehicular traffic and from any other influence that will disrupt the continuity of the curing membrane.

8-3.6.4 Sealed Insulation Curing

Whenever freezing temperatures are imminent and where cold weather protection is provided entirely by insulation, all joints in the insulation shall be sealed to retard moisture loss and maintain a seal throughout the curing period.

8-3.6.5 Protection

NOTE: Add more sophisticated requirements for vibration control where appropriate.

No fire or excessive heat shall be permitted near or in direct contact with concrete at any time. No vibratory earth compaction equipment or pile-driving equipment shall be operated within 30 m horizontally of concrete less than 5 days old. Blasting shall not be permitted within 30 m horizontally of concrete less than 90 days old. Blasting plans shall be approved by the Project Manager. All galleries, conduits, and other openings through the concrete shall be kept closed or sealed during the entire construction period. The surface of the concrete shall be protected from rain during placing.

8-3.6.6 Cold Weather Protection

Whenever freezing temperatures are imminent all concrete immediately after placing shall be covered for a period of 5 days with insulation and maintain the concrete at temperature of not less than 10 degrees C.

a. The insulation shall be maintained in such a condition that the temperature shall not drop below 10 degrees C during the period of protection. Edges and corners of the placement shall be protected with a double layer of the insulation specified above for a minimum distance of 0.6 m in all directions.

b. Concrete placed prior to the starting date shall be insulated from the starting date until it reaches an age of 5 days. Concrete placed after the starting date shall be continuously insulated during and subsequent to placement until it reaches an age of 5 days or until the end of the protection period, whichever comes first.

c. Insulation and the combined form-insulation system shall remain in place for at least 5 days after placement of the concrete. After 5 days, forms and insulation on vertical surfaces may be removed for periods not to exceed 4 hours in a 24 hour period to allow forms to be moved, and insulation on horizontal surfaces may be removed for periods not to exceed 8 hours in a 24 hour period to allow reinforcement to be installed, insulation to be installed, lift joints to be prepared, etc. provided that suitable precautions are taken to prevent the concrete from being subjected at any time to ambient temperatures of minus 7 degrees C or below.

d. The first 1.8 m of all steel protruding from insulated concrete shall be insulated. All form bolts and metal ribs on the forms shall be insulated in a like manner. During the period of protection there shall be no holes or openings in the insulation or between the insulation and concrete, which permit ambient air to penetrate the insulation except as noted for construction purposes. Special attention shall be given to seams, corners, and edges to prevent holes or openings in the insulation.

8-3.7 Base Plates and Bearing Plates

8-3.7.1 Setting of Plates

After being plumbed and properly positioned, column base plates, bearing plates for beams and similar structural members, and machinery and equipment base plates shall be provided full bearing using nonshrink grout. The space between the top of the concrete bearing surface and the bottom of the plate shall not be less than 1/24 of the width of the plate or 13 mm, whichever is greater. Concrete surfaces shall be clean, free of oil, grease, and laitance, and shall be damp. Metal surfaces shall be clean and free of oil, grease, and rust.

8-3.8 Block-Out Concrete

8-3.8.1 Composition and Proportions

Block-out concrete shall be composed of Portland cement, water, fine and coarse aggregate, and admixtures. The concrete mixture proportions, including admixture, will be provided by the Project Manager. An expansive admixture shall be used to cause the blockout concrete to expand to fit snugly in the space that confines it. The expansive admixture shall conform to the requirements of ASTM C 937 for grout fluidifier. Any block-out concrete not placed within 30 minutes after contact of the cement and admixture shall be wasted. The block-out shall be confined on all sides to provide restraint.

8-3.8.2 Placing Block-out Concrete

Blockouts shall be provided as shown on the plans for the embedment of gate seal seats, gate guides, bulkhead guides, beams embedded for bulkhead seals, crane rails, and other embedded metalwork as appropriate. Prior to installation of embedded items, the block-outs or recesses shall be cleaned in accordance with applicable requirements of the **Sub-Clause 8-3.3.6 - Construction Joint Treatment**. After installation of embedded items and prior to placing any forms, all surfaces of the block-outs or recesses and surfaces of items to be embedded shall be thoroughly cleaned of all loose material, oil, grease, and other contaminants which might reduce the bond between the surfaces of the blockouts or recesses and new concrete. Extreme caution shall be exercised in placing block-out concrete to avoid distortion or displacement of the embedded items.

8-3.9 Construction of Pre-cast Pre-stressed Concrete

8-3.9.1 Fabrication

Fabrication of pre-cast pre-stressed members shall follow the applicable provisions of the PCI MNL-116, except as specified herein.

8-3.9.2 Beds and Forms

(a) Casting Beds

All casting beds shall have concrete support on unyielding foundations.

(b) Forms

Forms, both fixed and movable, shall be of steel. All forms and beds shall be thoroughly cleaned after each use.

(c) Bulkheads

Bulkheads, spacers, templates, and similar equipment having influence on the accuracy of dimensions and alignment shall be regularly inspected and maintained after each casting.

(d) Alignment

Accurate alignment of forms shall be maintained during the casting operation to assure compliances with tolerances specified in Clause 8-1.6 – Construction Tolerances. Leakage of the paste in form joints is not acceptable, and measures shall be taken to prevent such leakage. Measures shall also be taken to provide corner chamfers.

(e) Form Ties

For exposed members, form ties, if used, shall be of the threaded or snap-off type so no parts will be left at the surface of the finished concrete.

8-3.9.3 Tendons

Stressing tendons and accessories shall be installed or placed as specified and as shown on contract and approved installation drawings. Installation details of stressing tendons and accessories not specified or shown shall be in accordance with ACI SP-66 or ACI 318M/318RM. Welding shall not be performed near or adjacent to stressing tendons. Stressing tendons shall not be installed until all welding has been completed on supports or any part which might be in contact with the tendons.

(a) Pre-stressing Method and Equipment

Descriptions of the proposed pre-stressing methods and equipment indicating the manufacturer of all pre-stressing equipment, including tensioning jacks, stress measurement gages, dynamometers and load cells or other devices for measuring stressing loads, shall be provided by the contractor. Descriptions shall include certified calibration records for each set of jacking equipment and testing curves for stress measurement gages which show that the gages have been calibrated for the jacks for which they are to be used.

(b) Installation Drawings

Detailed installation drawings for stressing tendons and accessories showing the type and size of stressing tendons and anchorages, erection methods, sequence of stressing and stressing calculations shall be provided by the Contractor.

(c) Anchorages

Anchorages must be set in a plane normal to the axis of the tendons such that uniform bearing on the concrete is assured. Positive connecting anchorages rather than gripping types shall be used for anchoring embedded ends of tendons. Anchorages and anchor

fittings shall be permanently protected against corrosion. Parallel wire anchorage wedges or cores shall be recessed within the members.

(d) Stressing Tendons and Ducts

Protective coverings and wrappings shall be removed and each stressing tendon shall be closely inspected to see that nicks, scoring, pits or other damage does not exist and high strength steel bars shall be closely inspected to assure that they are not bent and that threaded ends are in satisfactory condition immediately prior to installation. Strand, wire and bar tendons shall be shop or field assembled as required and positively attached to anchorages. Type WA wire assemblies shall be anchored only with wedge type anchorages. Stressing tendons and ducts shall be assembled to required shapes and dimensions and placed where indicated on drawings within specified tolerances and adequately supported. Ducts shall be securely fastened at close intervals and grout openings and vents must be securely anchored to ducts and to either the forms or reinforcing steel to prevent displacement during concrete placing. The ends of ducts shall be effectively protected to prevent entry of water, concrete, grout or debris. Wires of parallel-wire assemblies shall not be spliced. Steel bar tendons may be joined by couplers where shown or approved, provided they are capable of developing the guaranteed minimum ultimate strength of the bars. Strands to be spliced shall have the same lay or direction of twist and the ends shall be cut by shears or abrasive grinders. No more than one strand shall be spliced in any one member where single strand tensioning is employed. Strand splices shall be capable of developing the full ultimate strength of the strand. Slippage of the splice shall be checked and correction made for differential slippage. Where multiple strand tensioning is used, not more than 10 percent of the strands in any member shall be spliced.

(e) Tensioning Tendons

NOTE: Determination of the initial pre-stress force must consider prestress losses in accordance with ACI 318, Section 18.6.

Tensioning of stressing tendons shall be as specified and shown. The stress induced in the tendons by any method of tensioning shall be determined independently by both (1) measurement of tendon elongation and (2) direct measurement of force using a pressure gauge or load cell. If the results of these two measurements do not check each other and the theoretical values within 5 percent, the operation shall be carefully checked and the source of error determined and corrected before proceeding further. Concrete cylinder tests shall indicate a breaking strength of at least 28 MPa for Pre-tensioning and 24 for Post-tensioning before transfer of stress to ensure that the concrete strength is adequate for the requirements of the anchorages or for transfer through bond as well as meet camber or deflection requirements. The final pre-stress load in each unit after seating shall be as shown. Safety measures shall be taken by the Contractor to prevent accidental injury caused by failure of a stressing tendon or tendon component. The exposed ends of stressing tendons and anchorages shall be protected from damage during stressing operations to prevent failure.

(i) Post-Tensioning

Tensioning shall not be performed until the concrete has reached the required strength at transfer of stress. Before final tensioning of tendons, all tendons shall be brought to a uniform initial tension of approximately 10 percent of the full load. The force corresponding to the initial tension shall be measured by a dynamometer or other approved method as a starting point in determining final elongation. A temporary overstress above the final pre-stress force as approved by the Project Manager shall be used to overcome stress losses. The units shall be tensioned until the proper elongations and jacking pressures are attained and reconciled within the limits stated above. Straight tendons may be tensioned from one end. Curved or draped tendons shall be stressed by simultaneous jacking from both ends using a common pump with identical hoses and jacks, unless otherwise shown.

(ii) Grouting Post-Tensioned Tendons

Grouting between each tendon and its enclosing duct shall be performed within 5 days after completion of the tensioning operation. Grouting shall not be performed if air temperature below 7.2 degrees C is anticipated within 48 hours after grouting unless an approved method of temperature control is used. The grout shall be mixed in a mechanical mixer of a type that will produce uniformly and thoroughly mixed grout. First water shall be placed in the mixer followed by cement and admixture. Grout shall be continuously agitated until it is pumped. Grout that has begun to set shall be discarded. Just before grouting, the ducts shall be flushed with clean water and then blown clear by compressed air to removed excess water. With the grout vent open at one end of duct, grout shall be applied continuously under moderate pressure at the other end until all entrapped air is forced out as indicated by a uniform flow of grout from the discharge vent. The discharge vent shall then be closed and the pressure rose to 340 MPa minimum and held for at least 1 minute. The injection point shall then be closed by an approved means to prevent any loss of grout. For a period of at least 3 days after grouting the tendons, the pre-stressed members shall not have equipment or other loads placed on them. A longer period may be required, depending upon the method of curing and magnitude of imposed stresses.

(iii) Accuracy of Stress and Elongation Measurement

(i) Stress Measurement

Hydraulic gauges, dynamometers, load cells or other devices for measuring stressing load shall have an accuracy of reading within two percent for stress measurement. Gauges are required to have been calibrated for the jacks for whom they are used within a period not exceeding 12 months. Recalibration shall be performed at any time that a gaging system shows indication of erratic results in the opinion of the Project Manager. Gauges shall indicate loads directly in kilonewtons or be accompanied by a chart which converts dial readings into kilonewtons.

(ii) Elongation Measurement

After the initial force has been applied to a tendon, reference points for measuring elongation due to additional tensioning forces shall be established. They shall be located according to the method of tensioning and type of equipment. The system used shall be capable of measuring the true elongation plus or minus 2 mm.

(f) Pre-stressing Operations Records

The Contractor shall compile and submit complete pre-stressing operations records to the Project Manager. These records shall show the manufacturer, identification and description of materials and equipment including pre-stressing tendons and jacking and load measuring equipment; location of pre-stressing tendons; initial design tensioning loads, final design tensioning loads and actual tensioning loads for tendons; dates tensioning loads applied; and theoretical and actual elongations for tendons.

(i) Inspection

The Contractor's facilities shall be open for inspection by the Project Manager at any time.

(g) Materials Disposition Record

Accurate materials disposition records identifying all materials incorporated into the work and showing the disposition of specific lots of approved tested materials shall be compiled by the Contractor.

8-3.9.4 Anchorages for Post-tensioning

Anchorages for post-tensioning tendons will not interfere with the placement of the member such that adequate compaction of the concrete in the anchorage zone is impeded.

8-3.9.5 Steel Reinforcement

Steel bars and welded wire fabric shall be placed in accordance with **Clause 8-3.3.2 – Fabrication and Placement of Reinforcement**.

8-3.9.6 Concrete Placement

Concrete placement shall be in accordance with **Clause 8-3.4.2 – Placing**, except that once placement is started in a member it shall be carried on in a continuous operation until the member is completed. Members shall be cast in a horizontal position and casting in tiers will not be permitted. Adequate vibration shall be provided with internal and form vibrators so the cast members shall be free of rock pockets or surface blemishes resulting from inadequate vibration. Cold joints shall not be permitted in pre-stressed concrete members. If delays occur that result in hardening of the concrete so it will not receive a vibrator and again become plastic, the concrete shall be removed and the forms shall be washed out and refilled, otherwise partially cast members will be rejected.

8-3.9.7 Curing and Protection

Concrete for the manufacturing of the pre-cast pre-stressed concrete members shall be cured and protected in accordance with **Clause 8-3.6 – Curing and Protection** or by other methods specified here.

(a) Curing with Steam at Atmospheric Pressure

Steam curing shall be under a suitable enclosure to retain the live steam to minimize moisture and heat losses. The enclosure shall allow free circulation of the steam around the sides and top of the beams. Steam jets shall be so positioned so they do not discharge directly on the concrete, forms, or test cylinders. The cycle of steam application shall conform to the following:

(i) Curing After Placing and Vibrating

After placing and vibrating, the concrete shall be allowed to attain its initial set before the steam is applied. During the period between placement of the concrete and application of steam, provisions shall be made to prevent surface drying by means of a coating of membrane curing compound, moist covers, or equally effective methods. Application of the steam shall be delayed not less than 2 hours and not more than 10 hours after the time of concrete placement.

(ii) Temperature Increase

The ambient temperature within the casting enclosure shall be increased at a rate not to exceed 22 degrees C per hour. Temperature increase shall be as uniform as possible.

(iii) Temperature Range

The temperature shall be increased until the ambient temperature in the casting enclosure is between 60 and 71 degrees C. Once this temperature range is reached, it shall be maintained until the concrete has reached the compressive strength necessary for stressing or destressing the tendons.

(iv) Temperature Decrease

In discontinuing the steam curing, the ambient air temperature shall decrease at a rate not to exceed 22 degrees C per hour. Temperature decrease shall be as uniform as possible.

(v) Recording Thermometers

Recording thermometers showing the time-temperature relationship through the curing period from placing concrete to transfer of pre-stress shall be provided. At least one recording thermometer per casting enclosure shall be used. The desired curing time-temperature relationship shall be placed on the recording chart of the recording thermometer to aid the personnel controlling the temperature during curing. Recording charts shall be made available upon request and shall be clearly visible during the curing process.

(b) Curing with Radiant Heat and Moisture

(i) Radiant Heat

Radiant heat may be applied to beds by means of pipe circulating steam, hot oil, or hot water or by electric blankets or heating elements on forms. Pipes, blankets, or elements shall not be in contact with concrete, form surface, or test cylinders.

(ii) Moisture Loss

During the cycle of radiant heat curing, effective means shall be provided to prevent rapid loss of moisture in any part of the member. Moisture may be applied by a covering of moist burlap or cotton matting. Moisture may be retained by covering the member with a plastic sheet in combination with an insulating cover or by applying a liquid seal coat or membrane curing compound.

(iii) Temperature Limits

Temperature limits and use of recording thermometer shall be as specified for curing with steam at atmospheric pressure.

(iv) Termination of Curing

Termination of curing shall be as specified in Clause 8-3.6 – Curing and Protection unless the concrete has been cured by one of the two methods stated above. Termination of curing for concrete cured by either the steam at atmospheric pressure method or the radiant heat with moisture shall be determined based on the compressive strength of the concrete necessary for stressing or destressing the tendons.

8-3.9.8 Repairs

All honeycombed areas, chipped corners, air pockets over 6 mm in diameter, and other minor defects shall be repaired. Form offsets of fins over 3 mm shall be ground smooth. All unsound concrete shall be removed from defective areas prior to repairing. All surfaces permanently exposed to view shall be repaired by a blend of Portland cement and white cement properly proportioned so that the final color when cured will be the same as adjacent concrete.

8-3.9.9 Finishing

(a) Unformed surfaces

Unformed surfaces shall receive a steel trowel finish.

(b) Formed Surfaces

Formed surfaces shall match the texture and color of the sample panels, Sub-Clause 8-1.7.2(d) – Pre-cast Panel.

8-3.9.10 Erection

Erection shall comply with the following.

(a) Storage Provisions

All provisions for storage and handling given in **Clause 8-1.8 - Delivery, Storage, and Handling of Pre-cast-Pre-stressed Members** shall be observed at the erection site.

(b) Seating of Pre-cast Pre-stressed Concrete Members

The pre-cast pre-stressed concrete members shall be set in place in a manner which assures full bearing. If the bearing called for in the contract drawing is not obtained, then the members shall be removed and the situation corrected.

(c) Roof and Floor

Roof and floor single or double T-beams shall be erected in an increasing or decreasing magnitude of camber to minimize differential between beams. The Contractor shall measure T-beam camber and number the beams prior to erection.

(d) Welding

Welding during erection shall be done in accordance with Section 13, Miscellaneous Metalwork. When welding or burning with a welding electrode, the ground shall be attached directly to the base metal. Under no circumstances shall the member be used as a conductor for the ground.

(e) Erection Plan

The erection plan shall be in sufficient detail so that adequacy of equipment, techniques, and accessories can be determined and comments offered. Acceptance of the Contractor's erection plan shall not relieve the Contractor of his responsibility for erecting pre-cast pre-stressed members into position as required by the drawings and specifications.

8-3.9.11 Construction Records

Complete construction records shall be kept of the manufacturing, handling, and erection of the pre-cast-pre-stressed concrete members. Records shall be kept for, but not limited to, the following items:

a. Specifications of material used in the manufacture of the members.

b. Time-temperature history of the concrete members from casting to the transfer of the pre-stress force.

c. Records of the tendon stressing operation including initial pre-stress force, measured elongation, how it was measured, and how the tendons were stressed and destressed.

d. Records of inspection of the members before and after the pre-stress force is transferred to the members.

e. Records of the inspection of the members each time they are moved.

f. Records of any defects in the member and any corrective measures taken.

8-3.10 Tests and Inspections

8-3.10.1 General

The Contractor shall perform the following inspection and tests as described, and, based upon the results of these inspections and tests, he shall take the action required and submit reports as required. When, in the opinion of the Project Manager, the concreting operation is out of control, concrete placement shall cease. The laboratory performing the tests shall be on-site and shall conform with the requirements given in ASTM C 1077. The individuals who sample and test concrete or the constituents of concrete as required in this specification shall have demonstrated a knowledge and ability to perform the necessary test procedures equivalent to the ACI minimum guidelines for certification of Concrete Field Testing Technicians, Grade I. The Project Manager will inspect the laboratory, equipment, and test procedures prior to start of concreting operations and at least once per year thereafter for conformance with ASTM C 1077. The individual who performs the inspection shall have demonstrated a knowledge and ability equivalent to the ACI minimum guidelines for certification of Concrete Transportation Construction Inspector (CTCI).

8-3.10.2 Testing and Inspection Requirements for Concrete

(a) Fine Aggregate

(i) Grading

At least once during each shift when the concrete plant is operating, there shall be one sieve analysis and fineness modulus determination in accordance with ASTM C 136 and COE CRD-C 104 for the fine aggregate or for each fine aggregate if it is batched in more than one size or classification. The location at which samples are taken may be selected by the Contractor as the most advantageous for control. However, the Contractor is responsible for delivering fine aggregate to the mixer within specification limits. The results shall be recorded on a sheet on which are also shown the specification limits applicable to the project.

(ii) Fineness Modulus Control Chart

Results for fineness modulus shall be grouped in sets of three consecutive tests, and the average and range of each group shall be plotted on a control chart. The upper and lower control limits for average shall be drawn 0.10 units above and below the target fineness modulus, and the upper control limit for range shall be 0.20 units above the target fineness modulus.

(iii) Corrective Action for Fine Aggregate Grading

When the amount passing any sieve is outside the specification limits, the fine aggregate shall be immediately re-sampled and retested. If there is another failure for any sieve, the fact shall immediately be reported. Whenever a point on the fineness modulus control chart, either for average or range, is beyond one of the control limits, the frequency of testing shall be doubled. If two consecutive points are beyond the control limits, the process shall be considered out of control and concreting shall be stopped. Notify the Project Manager, and take immediate steps to rectify the situation. After two consecutive

points have fallen within the control limits, testing at the normal frequency may be resumed.

(iv) Moisture Content Testing

When in the opinion of the Project Manager the electric moisture meter is not operating satisfactorily, there shall be at least four tests for moisture content in accordance with ASTM C 566 during each 8-hour period of mixing plant operation. The times for the tests shall be selected randomly within the 8-hour period. An additional test shall be made whenever the slump is shown to be out of control or excessive variation in workability is reported by the placing foreman. When an electric moisture meter is operating satisfactorily, at least two direct measurements of moisture content shall be made per week to check the calibration of the meter. The results of tests for moisture content shall be used to adjust the added water in the control of the batch plant.

(v) Moisture Content Corrective Action

Whenever the moisture content of the fine aggregate changes by 0.5 percent or more, the scale settings for the fine-aggregate batcher and water batcher shall be adjusted (directly or by means of a moisture compensation device).

(b) Coarse Aggregate

(i) Grading

At least once during each shift in which the concrete plant is operating, there shall be a sieve analysis in accordance with ASTM C 136 for each size of coarse aggregate. The location at which samples are taken may be selected by the Contractor as the most advantageous for production control. However, the Contractor shall be responsible for delivering the aggregate to the mixer within specification limits. A test record of samples of aggregate taken at the same locations shall show the results of the current test as well as the average results of the five most recent tests including the current test. The Contractor may adopt limits for control coarser than the specification limits for samples taken other than as delivered to the mixer to allow for degradation during handling. When facilities are available to test samples five times as large as those required in ASTM C 136, no averaging shall be done.

(ii) Corrective Action for Grading

When the amount passing any sieve is outside the specification limits, the coarse aggregate shall be immediately resampled and retested. If the second sample fails on any sieve, that fact shall be reported. Where two consecutive averages of five tests (or two consecutive tests where large samples are used) are outside specification limits, the operation shall be considered out of control, and that fact shall be reported, concreting shall be stopped, and immediate steps shall be taken to correct the grading.

(iii) Coarse Aggregate Moisture Content

A test for moisture content of each size group of coarse aggregate shall be made at least once a shift. When two consecutive readings for smallest size coarse aggregate differ by more than 1.0 percent, frequency of testing shall be increased to that specified previously for fine aggregate.

(iv) Coarse Aggregate Moisture Corrective Action

Whenever the moisture content of any size of coarse aggregate changes by 0.5 percent or more, the scale setting for the coarse aggregate batcher and the water batcher shall be adjusted to compensate for this.

(v) Particle Shape Testing

When directed, a problem exists in connection with aggregate particle shape, tests shall be made in accordance with ASTM D 4791. Testing frequency shall be not less than one per day, when directed.

(vi) Particle Shape Corrective Action

When testing for particle shape is required, two consecutive failures in the same sieve size shall be immediately reported, who shall determine what corrective action is needed.

(vii) Material Finer than the 75-m (No. 200) Sieve

When in the opinion of the Project Manager, a problem exists in connection with the cleanliness of aggregate, tests shall be made in accordance with ASTM C 117. Testing frequency shall be as directed.

(viii) Corrective Action for Material Finer than the 75-m (No. 200) Sieve

When material finer than the 75-m (No. 200) sieve exceeds 1.0 percent of the weight of the aggregate finer than 37.5 mm or 0.5 percent of the weight of the aggregate coarser than 37.5 mm, the Project Manager shall be notified and steps, such as washing or other corrective action, shall be initiated immediately.

(c) Quality of Aggregates

(i) Frequency of Quality Tests

Prior to submitting samples for mixture proportioning studies and 30 days prior to the start of concrete placement, the Contractor shall perform the tests for aggregate quality in the following list. In addition, after the start of concrete placement, the Contractor shall perform tests for aggregate quality in accordance with the following frequency schedule. Samples tested after the start of concrete placement shall be taken immediately prior to entering the concrete mixer.

Property	***Fine Aggregate***	***Frequency Coarse Aggregate***	***Tests***
Specific Gravity	Every 3 months	Every 3 months	ASTM C 127 ASTM C 128

Property	***Fine Aggregate***	***Frequency Coarse Aggregate***	***Tests***
Absorption	Every 3 months	Every 3 months	ASTM C 127 ASTM C 128
Durability (Procedure A)	Factor using Every 12 months	Every 12 months	COE CRD-C 144 ASTM C 666
Clay Lumps and Friable Particles	Every 3 months	Every 3 months	ASTM C 142
Material Finer than the 75-m (No. 200) Sieve	Every 3 months	Every 3 months	ASTM C 117
Organic Impurities	Every 3 months	Not applicable	ASTM C 40
L.A. Abrasion	Not applicable	Every 6 months	ASTM C 131 ASTM C 535
Soft and Friable (Scratch Hardness)	Not applicable	Every 6 months	COE CRD-C 130
Petrographic Examination	Every 6 months	Every 6 months	ASTM C 295
Chart, less than 2.40 specific gravity	Every 6 months	Every 6 months	ASTM C 123
Coal and Lignite, less than 2.00 specific gravity	Every 6 months	Every 6 months	ASTM C 123

(ii) Corrective Action for Aggregate Quality

If the result of a quality test fails to meet the requirements for quality during submittal of samples for mixture-proportioning studies or immediately prior to start of concrete placement, production procedures or materials shall be changed and additional tests shall be performed until the material meets the quality requirements prior to proceeding with either mixture-proportioning studies or starting concrete placement. After concrete placement commences, whenever the result of a test for quality fails the requirements, the test shall be rerun immediately. If the second test fails the quality requirement, the fact shall be reported and immediate steps taken to rectify the situation.

(d) Scales

(i) Weighing Accuracy

The accuracy of the scales shall be checked by test weights at least once a month for conformance with the applicable requirements of **Clause 8-3.1 - Equipment**. Such tests shall also be made as directed whenever there are variations in properties of the fresh concrete that could result from batching errors.

(ii) Batching and Recording Accuracy

Once a week the accuracy of each batching and recording device shall be checked during a weighing operation by noting and recording the required weight, recorded weight, and the actual weight batched. The Contractor shall confirm that the calibration devices

described in **Clause 8-3.1 - Equipment** for checking the accuracy of dispensed admixtures, are operating properly.

(iii) Scales Corrective Action

When either the weighing accuracy or batching accuracy does not comply with specification requirements, the plant shall not be operated until necessary adjustments or repairs have been made. Discrepancies in recording accuracies shall be corrected immediately.

(e) Batch-Plant Control

The measurement of all constituent materials including cementitious materials, each size of aggregate, water, and admixtures shall be continuously controlled. The aggregate weights and amount of added water shall be adjusted as necessary to compensate for free moisture in the aggregates. The amount of air-entraining agent shall be adjusted to control air content within specified limits. A report shall be prepared indicating type and source of cement used, type and source of pozzolan or slag used, amount and source of admixtures used, aggregate source, the required aggregate and water weights per cubic meter, amount of water as free moisture in each size of aggregate, and the batch aggregate and water weights per cubic meter for each class of concrete batched during plant operation.

(f) Concrete

(i) Air Content

At least two tests for air content shall be made on randomly selected batches of each concrete mixture produced during each 8 hour period of concrete production. Additional tests shall be made when excessive variation in workability is reported. Tests shall be made in accordance with ASTM C 231. The average of each set of two tests for each mixture shall be plotted on control charts on which the average percent and upper and lower limits are set in accordance with **Clause 8-2.12 – Concrete Mix Proportioning** for each NMSA. The range between two consecutive tests for each mixture shall be plotted on a control chart on which the upper control limit is 3.0 percent. Samples for air content shall normally be taken at the mixer; however the Contractor is responsible for delivering the concrete to the forms at the proper air content. Samples shall be taken at the placement site as often as required, depending on the Contractors delivery method, to determine any air loss.

(ii) Air Content Corrective Action

Whenever points on the control chart approach the upper or lower control limits, an adjustment should be made in the amount of air-entraining admixture batched. If a single test result is outside the specification limit, immediate adjustment is mandatory. As soon as practical after each adjustment, another test shall be made to verify the correction of the adjustment. Whenever a point falls above the upper control for range, the dispenser shall be calibrated to ensure that it is operating correctly and with good reproducibility.

Whenever two consecutive points either for average or range are outside the control limits, the Project Manager shall be notified.

(iii) Slump Testing

At least two slump tests shall be made in accordance with ASTM C 143/C 143M on each concrete mixture produced during each 8-hour period or less of concrete production each day. Additional tests shall be conducted when excessive variation in workability is reported. The result of each test for each mixture shall be plotted on a control chart on which the upper and lower limits are set as specified in Mixture Proportioning. The range shall be plotted on a control chart on which the upper control limit is 50 mm. Samples for slump shall be taken at the mixer, however the Contractor is responsible for delivering the concrete to the placement site at the stipulated slump. If the Contractor's materials or transportation methods cause slump loss between the mixer and the placement, samples shall be taken at the placement site as often as required by the Project Manager.

(iv) Slump Corrective Action

Whenever points on the control chart approach the upper or lower control limits, an adjustment shall be made in the batch weights of water and fine aggregate. The adjustments are to be made so that the total water content does not exceed that amount specified in the mixture proportions provided based on the free water available with the aggregates and that amount of water batched. If the adjustments to the batch weights of water and aggregates do not satisfactorily produce the required slump, the Project Manager may adjust the mixture proportions if the fine-aggregate moisture content is stable and within the required limits. When a single slump is outside the control limits, such adjustment is mandatory. As soon as practical after each adjustment, another test shall be made to verify the correctness of the adjustment. Whenever two consecutive individual slump tests, made during a period when there was no adjustment of batch weights, produce a point on the control chart for range above the upper control limits, the slump shall be considered to be out of control, the concreting operation halted, and the additional testing for aggregate moisture content required shall be undertaken, and action taken immediately to correct the problem.

(v) Compression Test Cylinders

At least one set of test cylinders shall be made each shift on each different concrete mixture placed during the shift. Additional sets of test cylinders shall be made, as directed, when the mixture proportions are changed or when low strengths have been detected. A random sampling plan shall be developed by the Contractor and approved by the Project Manager prior to start of construction. The plan should ensure that sampling is done in a completely random and unbiased, not just haphazard, manner. A set of test cylinders for structural concrete containing Type I or Type II Portland cement only shall consist of six cylinders, two to be tested 24 hours, two at 7 days, and two at 28 days. A set of test cylinders for all other concrete shall consist of six cylinders, two to be tested at 24 hours, one at 7 days, one at 28 days, and two at 90 days. In addition, for all concrete except that

containing Type I or Type II Portland cement only, every 2 months four additional cylinders shall be made and two tested at 6 months of age and two tested at 12 months of age. The 24-hour test cylinders shall be molded, cured, and tested in accordance with ASTM C 684, Method A. All other test specimens shall be molded and cured in accordance with ASTM C 31/C 31M and tested in accordance with ASTM C 39/C 39M. All compressive strength tests shall be reported immediately. Quality control charts shall be kept for individual strength tests, moving average for strength and moving average for range for each mixture. The charts shall be similar to those found in ACI 214R.

(g) Inspection before Placing

Foundation or construction joints, forms, and embedded items shall be inspected by the Contractor in sufficient time prior to each concrete placement in order to certify that they are ready to receive concrete. The results of each inspection shall be reported in writing.

(h) Concrete Placement

(i) Placing Inspection

The placing foreman shall supervise all placing operations, shall determine that the correct quality of concrete or grout is placed in each location as directed, and shall be responsible for measuring and recording concrete temperatures and ambient temperature hourly during placing operations, weather conditions, time of placement, volume placed, and method of placement.

(ii) Placing Corrective Action

The placing foreman shall not permit placing to begin until he has verified that an adequate number of vibrators in working order and with competent operators are available. Placing shall not be continued if any pile of concrete is inadequately consolidated. If any batch of concrete fails to meet the temperature requirements, immediate steps shall be taken to improve temperature controls.

(I) Vibrators

(i) Vibrator Testing and Use

The frequency and amplitude of each vibrator shall be determined in accordance with COE CRD-C 521prior to initial use and at least once a month when concrete is being placed. Additional tests shall be made as directed when a vibrator does not appear to be adequately consolidating the concrete. The frequency shall be determined while the vibrator is operating in concrete with the tachometer being held against the upper end of the vibrator head while almost submerged and just before the vibrator is withdrawn from the concrete. The amplitude shall be determined with the head vibrating in air. Two measurements shall be taken, one near the tip and another near the upper end of the vibrator head, and these results averaged. The make, model, type, and size of the vibrator and frequency and amplitude results shall be reported in writing.

(ii) Vibrator Corrective Action

Any vibrator does not meet the requirements of **Clause 8-3.3 - Preparation for Placing** shall be immediately removed from service and repaired or replaced.

(j) Curing

(i) Moist Curing Inspections

At least twice each shift, and twice per day on nonwork days an inspection shall be made of all areas subject to moist curing. The surface moisture condition shall be noted and recorded.

(ii) Moist Curing Corrective Action

When a daily inspection report lists an area of inadequate moistness, immediate corrective action shall be taken, and the required curing period for those areas shall be extended by one (1) day.

(iii) Membrane Curing Inspection

No curing compound shall be applied until the Contractor's authorized representative has verified that the compound is properly mixed and ready for spraying. At the end of each operation, he shall estimate the quantity of compound used by measurement of the container and the areas of concrete surface covered and compute the rate of coverage in square meters/L. He shall note whether or not coverage is uniform.

(iv) Membrane Curing Corrective Action

When the coverage rate of the curing compound is less than that specified or when the coverage is not uniform, the entire surface shall be sprayed again.

(v) Sheet Curing Inspection

At least once every shift and once per day on nonworking days, an inspection shall be made of all areas being cured using sheets. The condition of the covering and the tightness of the laps and tapes shall be noted and recorded.

(j) Sheet Curing Corrective Action

When a daily inspection report lists any tears, holes, or laps or joints that are not completely closed, the tears and holes shall promptly be repaired or the sheets replaced, the joints closed, and the required curing period for those areas shall be extended by one (1) day.

(k) Cold Weather Protection and Sealed Insulation Curing

At least once each shift and once per day on nonworking days an inspection shall be made of all areas subject to cold weather protection. The protection system shall be inspected for holes, tears, unsealed joints, or other incongruities which could result in damage to the concrete. Special attention shall be taken at edges, corners, and thin sections. Any deficiencies shall be noted, corrected, and reported.

(l) Cold Weather Protection Corrective Action

When a daily inspection report lists any holes, tears, unsealed joints, or other incongruities, the deficiency shall be corrected immediately and the period of protection extended for one (1) day.

(m) Mixer Uniformity

(i) Stationary Mixers

Prior to the start of concrete placing and once every 3 months when concrete is being placed, or once for every 57,000 cubic meters of concrete placed, whichever results in the longest time, interval uniformity of concrete mixing shall be determined in accordance with **Clause 8-3.1-Equipment**. The initial and every fourth set of tests shall be regular tests performed on three batches of concrete. Intermediate uniformity tests shall be abbreviated tests performed on a single batch of concrete. If the mixer fails the abbreviated test, a regular test shall be immediately performed. Whenever adjustments in a mixer or increased mixing time are required because of failure of a uniformity test, the mixer shall be reevaluated by a regular test after the adjustments have been completed. If the Contractor proposes to reduce a mixing time, a regular test shall be performed to evaluate the proposed time. Additional testing shall be performed when directed when there is visible evidence of possible improper mixer performance. Results of all uniformity tests shall be reported in writing.

(ii) Truck Mixers

Prior to the start of concrete placing and at least once every 6 months when concrete is being placed, uniformity of concrete shall be determined in accordance with ASTM C 94/C 94M. The truck mixers shall be selected randomly for testing. When satisfactory performance is found in one truck mixer, the performance of mixers of substantially the same design and condition of the blades may be regarded as satisfactory. Results of tests shall be reported in writing.

(n) Mixer Uniformity Corrective Action

When a mixer fails to meet mixer uniformity requirements, either the mixing time shall be increased, batching sequence changed, batch size reduced, or adjustments shall be made to the mixer until compliance is achieved.

8-3.10.3 Tests, Inspections, and Verifications for Reinforcement

The Contractor shall have material tests required by applicable standards and specified performed by an approved laboratory and certified to demonstrate that the materials are in conformance with the specifications. Tests, inspections, and verifications shall be performed and certified at the Contractor's expense.

(a) Reinforcement Steel Tests

Mechanical testing of steel shall be in accordance with ASTM A 370 except as otherwise specified or required by the material specifications. Tension tests shall be performed on

full cross-section specimens using a gauge length that spans the extremities of specimens with welds or sleeves included. Chemical analyses of steel heats shall show the percentages of carbon, phosphorous, manganese, Sulphur and silicon present in the steel.

(b) Radiographic Examination of Welds

Radiographic examination of welds shall be in accordance with ASTM E 94 and shall be performed and evaluated by an approved testing agency adequately equipped to perform such services. Radiographs of welds and evaluations of the radiographs submitted for approval shall become the property of the Employer.

8-3.10.4 Test for Field-Molded Sealants

Samples of sealant and primer, when use of primer is recommended by the manufacturer, as required in Field Molded Sealants and Primer, shall be tested by and at the expense of the Contractor for compliance with **Sub-clause 8-2.10.1 - Field Molded Sealants and Primer**. If the sample fails to meet specification requirements, new samples shall be provided and rested.

8-3.10.5 Test for Non-Metallic Water stops

Samples of materials and splices as required in **Clause 8-2.10 - Water stops** shall be visually inspected and tested by and at the expense of the Contractor for compliance with COE CRD-C 513 or COE CRD-C 572 as applicable. If a sample fails to meet the specification requirements, new samples shall be provided and rested.

8-3.10.6 Splicing Water stops

(a) Procedure and Performance Qualifications

Procedure and performance qualifications for splicing water stops shall be demonstrated in the presence of the Project Manager.

(b) Non-Metallic Water stops

Procedure and performance qualifications for splicing non-metallic water stops shall be demonstrated by the manufacturer at the factory and the Contractor at the job site by each making three spliced samples of each size and type of finished waterstop.

8-3.10.7 Reports

All results of tests or inspections conducted shall be reported informally as they are completed and in writing daily. A weekly report shall be prepared for the updating of control charts covering the entire period from the start of the construction season through the current week. During periods of cold weather protection, reports of pertinent temperatures shall be made daily. These requirements do not relieve the Contractor of the obligation to report certain failures immediately as required in preceding paragraphs. Such

reports of failures and the action taken shall be confirmed in writing in the routine reports. The Contracting Officer has the right to examine all contractor quality control records.

PART 4 MEASUREMENT AND PAYMENT

8-4.1 Concrete

8-4.1.1 Measurement

(a) Measurement, for payment, of concrete required to be placed directly upon or against surfaces of excavation will be made to the lines for which payment for excavation is made.

(b) Measurement, for payment, of all other concrete will be neat lines of the structures as shown on the Drawings unless otherwise prescribed in this Specification.

(c) In measuring concrete for payment, deductions will be made for the volume of all ducts, embedded pipes, surface conduits and drains, recesses for rails and gate guides in first stage concrete, embedded metalwork and other blockouts having a cross-sectional area larger than 0.10 m^2 as measured at right angles to their longitudinal axis. Deductions will also be made for all openings, recesses and blockouts with cross-sectional areas less than 0.10 m^2 but which have an individual volume larger than 0.5 m^3.

(d) Measurement, for payment, for concrete required for treatment of defects outside the excavation pay lines other than in excavation for underground works will be made for the actual volume of concrete directed to be placed in these locations.

(e) Measurement, for payment, of backfill / dental concrete will be made of the actual volume of concrete placed as directed by the Project Manager.

8-4.1.2 Payment

(a) Payment for concrete in the various parts of the Works will be made at the applicable rates per cubic meter tendered therefore in the priced Bill of Quantities. These rates shall cover all costs of workmanship, material and equipment for in-situ concrete including furnishing all ingredients, admixtures, batching, mixing, cooling, transporting, placing, curing and protecting, formwork, finishing and repairing, testing and all other work related to the item for which separate payment is not provided. The measurement and payment for providing and placing or installing reinforcing bars and fabric, water stops, forming of expansion joints, providing and laying of joint sealing compound will be made in accordance with **Clauses 8-4.2, 8-4.5, 8-4.6 and 8-4.7** respectively.

(b) Except as provided in **Sub-Clause 8-4.1.1(e)**, payment will not be made for concrete required to be placed outside specified or approved excavation pay lines due to over-breakage, excess excavation or wasted concrete, or for any other reason.

(c) Direct payment will not be made for cement used in concrete, mortar, shotcrete, dry-pack or grout other than cement in pressure grouting. Payment for furnishing and handling cement for pressure grouting will be made as provided in Section 10, Foundation Grouting.

(d) The cost of producing or providing aggregates required under this Specification shall be included in the rates tendered in the priced Bill of Quantities for the various grades of concrete construction in which the aggregate is used.

(e) The Contractor will not be entitled to any additional payment for materials wasted from deposits, including crusher fines, excess material of any of the sizes into which the aggregates are required to be separated by the Contractor and materials which have been discarded by reason of being above the maximum sizes specified for use.

(f) The cost of contraction joints shall be included in the rate tendered in the priced Bill of Quantities for the concrete in which the joints are required except that payment for water stops if required will be made as provided in Clause 8-4.5-Water stops.

(g) The cost of expansion joints shall be included in the rate tendered in the priced Bill of Quantities for the concrete in which the joints are required except that payment for water stops, forming of expansion joints, providing and laying of joint sealing compound will be made in accordance with **Clauses 8-4.2, 8-4.5, 8-4.6 and 8-4.7** respectively.

(h) The cost of all labour and materials for forms and for any necessary treatment or coating of forms shall be included in the rates tendered in the priced Bill of Quantities for concrete for which the forms are used.

(i) All materials, labour and construction plant required for the repair of concrete shall be provided at the expense of the Contractor.

(j) No payment will be made for the backfill / dental concrete to fill the over excavation due to negligence and fault of Contractor.

(k) The cost of placing concrete in blockouts, and dry pack and grout under base plates of metalwork supplied and installed by the Contractor shall be deemed to be included in the rates tendered in the priced Bill of Quantities.

(l) No separate payment will be made for injection of cement grout or epoxy grout for filling the gap or cavity within hardened concrete.

(L) The cost of installation of steel parts to be embedded in concrete, supplied by the Contractor, or for leaving block-outs in concrete for such parts, is considered to be included in the unit prices. No separate payment shall be made for such work. No separate payment shall be made either for the constraints related to the installation of steel parts to be embedded in concrete.

(M) No adjustment shall be made in concrete placing unit prices wherever there is a need for change of cement type or dosage or of aggregate source or proportions or type of admixtures.

(N) Shear keys shown on the Drawings or for joints which the Contractor adds for his own convenience shall not be measured for payment.

(O) No separate payment shall be made for furnishing and applying coating for breaking bond in joints as shown on the drawings or as per Engineer’s instructions.

8-4.1.3 Unit of Measure

Unit of measure: Cubic Meter

8-4.2 Reinforcing bars and fabric

8-4.2.1 Measurement

Measurement, for payment, of providing and placing reinforcing bars and fabric will be made only of the calculated mass of the bars placed in the concrete in accordance with the Drawings or as directed. The calculated mass for reinforcing bars and fabric shall be determined as follows:

(a) Reinforcing bars – The calculated mass shall be based on the mass per meter calculated from nominal diameter of the reinforcing bar and the mass density of steel of 7,850 kg per cubic meter.

(b) Reinforcing Fabric – The calculated mass shall be based on the mass per unit area of the fabric based on the theoretical area of the bars and spacing and the mass density of steel of 7,880 kg per cubic meter.

(c) All joints or splices shown on the Drawings or directed will be measured for payment as laps. Mechanical coupling approved by the Project Manager, will be measured for payment in terms of length of equivalent lap joint. Additional joints or splices will not be measured for payment.

(d) Tie wire, chairs, spacers, supports, bracing and other means of holding reinforcement in position shall not be measured.

8-4.2.2 Payment

(a) Payment for providing and placing high tensile Grade 60 reinforcing bars will be made at the rate per ton tendered therefor in the priced Bill of Quantities.

(b) Payment for providing and placing reinforcing steel fabric mesh-Grade 40 will be made at the rate per ton tendered therefor in priced Bill of Quantities.

(c) These rates shall include the cost of preparing reinforcement detail drawings, scheduling reinforcement and of furnishing and attaching wire ties and metal, concrete of other supports, of cutting, bending, cleaning, wastages, securing and maintaining in position all reinforcing bars. Payment will not be made for joints or splices except as provided **Sub-Clause 8-3.3.2(d) – Splicing** of this Clause, nor for reinforcement used in miscellaneous pre-cast concrete units.

8-4.2.3 Unit of Measure

Unit of measure: Ton

8-4.3 Pre-cast Pre-stressed Concrete Members

8-4.3.1 Measurement

Measurement of pre-cast pre-stressed concrete member Grade C-33 shall be made as per dimensions shown on drawings.

8-4.3.2 Payment

Payment for providing and installing various Pre-cast Pre-stressed Concrete members will be made at the rate per cubic meter tendered thereof in the priced Bill of Quantities. The rate includes all reinforcement strands etc. required as per drawings and all associated works required for completion of the item.

8-4.3.3 Unit of Measure

Unit of measure: Cubic Meter

8-4.4 Mortar and Concrete for Foundation Preparation

8-4.4.1 Measurement

Mortar and concrete used in foundation and abutment preparation will be measured for payment in place based upon the established limit lines and the payment lines indicated on the cross sections shown or as otherwise established. Limit lines will be established by the volume between the foundation lines as determined on the basis of a survey made from excavation including the cut-off trench and accomplishment of foundation preparation (except scarifying) and the lines, grades and slopes of the accepted embankment. Mortar and concrete used in filling spaces beneath rock overhangs and around protrusions as specified in Clause 7-3.1.2 -Rock, will be measured for payment as the actual volumes of such mortar and concrete as determined by field surveys made before and after placement of the mortar and concrete.

8-4.4.2 Payment

Payment will be made for costs associated with manufacturing, furnishing, delivering, placing, finishing, and curing of mortar and concrete for foundation and abutment preparation,

8-4.4.3 Unit of Measure

Unit of measure: Cubic Meter.

8-4.5 Water stops

8-4.5.1 Measurement

Measurement, for payment, of providing and placing PVC water stops will be made only of the lengths placed in accordance with the Drawings or as directed. No allowance will be made for laps at joints. Water stops installed by the Contractor in construction joints in locations other than those shown on the Drawings or directed will not be measured for payment.

8-4.5.2 Payment

Payment for providing and placing PVC water stops will be made at the applicable rate per linear meter tendered therefore in the priced Bill of Quantities.

8-4.5.3 Unit of Measure

Unit of measure: Linear Meter

8-4.6 Expansion Joints

Measurement for forming of expansion joints shall be made of the surface area of the joints in square meter formed according to the specifications and as shown on drawings.

Payment shall be made at the unit rate tendered per square -meter in the BOQ for forming of expansion joints and shall constitute full compensation for preparation of surfaces for the expansion joints, providing and applying of bitumen, providing and placement of rubber joint sealant, including material, labour, equipment, etc., complete in all respects.

8-4.7 Proving and Laying of Joint Sealing Compound

Measurement for payment of providing and laying of joint sealing compound shall be made in Gallons. The unit rate shall cover all cost of supply and laying of the joint sealing compound.

CHAPTER 9 – MANUALLY OPERATED GATES

PART 1 GENERAL

9-1.1 Scope

The Contractor shall design, furnish, install and commission the vertical slide gates assemblies and their operating system at locations as shown on drawings.

The slide gates system shall include the wheels, frame, fabricated channel and liner sections, bush with washer, wheel pin locking arrangement, skin plate, hoisting system with hoisting deck, transportation to the site, drawings, installation procedures, operating and maintenance manuals, and all other necessary appurtenances to provide a complete operating system.

The gates and their operating systems may be designed, fabricated, supplied by a sub-contractor appointed by the Contractor and approved by the Project Manager. Manufacturers shall have a minimum of 10 years experience in the design and manufacture of equipment of this type. Manufacturer shall submit as a minimum a list of 10 projects with slide gate installations. The list shall include project name, contact, telephone number, years of service, size and method of operation.

The design, fabrication drawings and specifications shall be submitted to the Project Manager for approval 90 days before fabrication. The contractor shall be responsible for ordering such material and equipments from sub-contractor; however, the Project Manager shall be kept informed by sending a copy of correspondence with the selected sub-contractor.

The tender drawings and specification indicate the type of equipment required together with the leading dimensions. The sub-contractor shall design and submit detail specifications and calculations along with fabrication drawings to the Project Manager. Manufacturer shall commence after the written approval of the Project Manager.

Installations drawings and method statement of installation shall be submitted by the sub-contractor for approval of the Project Manager. The erection of all the equipments shall be in the supervision of Manufacturer's Site Project Manager.

The Contractor is responsible for the coordination and proper relation of his work to the civil structures and to the work of all trades. The Contractor shall verify all dimensions of the Civil Structures related to fabrication of the gates, and other equipments and shall notify the Project Manager of any discrepancy before the order for the gates is finalized.

9-1.2 References

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)	
ASTM A36	Specification for Components of Gate Structural Steel
ASTM A583	Specification for Cast Steel Wheels for Railway Service
ASTM A21	Specification for Carbon Steel Axles, Non-Heat-Treated
	for Railway use.
ASTM A492	Specification for Stainless and Heat-Resisting Steel Wire
	Rope and U.S. Fed. Spec. RR-W-410b. “Wire Rope and Strand,”
ASTM B-22	Specification for Bronze Castings for Bridges and Turntables, “Lubrite” A cast bronze alloy.
AMERICAN WELDING SOCIETY (AWS)	
AWS D1.1/D1.1M	
	(2002) Structural Welding Code - Steel
BRITISH STANDARD (BS)	
BS 639	Specification for Covered Carbon and Carbon Manganese Steel Electrodes for Manual Metal-Arc Welding
BS 4360	Specification for Weldable Structural Steels
U.S STEEL STRUCTURE PAINTING COUNCIL (SSPC)	
SSPC SP-10	Specification for Surface Preparation (Near-White Blast Cleaning)
NATIONAL ASSOCIATION OF CORROSION ENGINEERS (NACE)	
NACE 2	Specification for Surface Preparation (Near-White Blast Cleaning)

9-1.3 Submittals

The following shall be submitted for Project Manager’s review and approval in accordance with **Sub-Clause 1-1.4, Submittal Procedures**.

SD-02 Shop Drawings
Detail Drawings

Drawings showing dimensions and essential details required to locate and install the gates, hoist and their accessories shall be submitted for the Project Manager’s approval.

Detail drawings, including general arrangement drawings, fabrication drawings, shop assembly drawings, delivery drawings, and field installation drawings, shall conform to the requirements specified below:

General Arrangement Drawings

General arrangement drawings shall show the setup of various components of equipment, their working and operation system, parts embedded in civil works, layout of electrical installations, conduits and pipes etc.

Fabrication Drawings

Fabrication drawings shall show complete details of materials, tolerances, connections, machined surface finishes, and proposed welding sequences which clearly differentiate shop welds and field welds.

Shop Assembly Drawings

Shop assembly drawings shall provide details for connecting the adjoining fabricated components in the shop to assure satisfactory field installation.

Delivery Drawings

Delivery drawings shall provide descriptions of methods of delivering components to the site, including details for supporting fabricated components during shipping to prevent distortion or other damages.

Field Installation Drawings

Field installation drawings shall provide a detailed description of the field installation procedures. The description shall include the location and method of support of installation and handling equipment; provisions to be taken to protect concrete and other work during installation; method of maintaining components in correct alignment; descriptions of connections, riggings, anchorages, and measuring equipment; methods for checking and maintaining alignment of the blocks during concreting; and methods of installing other appurtenant items.

SD-03 Product Data
Materials

Submit system of identification which shows the disposition of specific lots of approved materials and fabricated items in the work before completion of the Contract.

Welding

Submit schedules of welding procedures for structural steel.

Materials

Submit material orders, material lists, and material shipping bills.

SD-05 Design Data
Gates

Design criteria for each component shall be submitted to the Project Manager for approval prior to product computation and drawing submittal. These criteria shall be established and verified from previously designed and manufactured gates by that manufacturer.

Design computations shall be performed in sufficient detail to verify that all of the above criteria are complied with. The design computations shall be made part of the submittal data. Acceptance of the design criteria and computations shall not relieve the manufacturer of the responsibility for the adequacy of the design.

SD-06 Test Reports
Tests, Inspections, and Verifications

Submit certified material test reports with all material delivered to the site.

Acceptance Trial Operation and Test

Submit operation and test results before completion of the Contract.

SD-10 Operation and Maintenance Data

Manuals about operation and maintenance of hoist or lifting arrangement and gate.

PART 2 PRODUCTS

9.2.1 Slide / Radial Gates

9-2.1.1 Description

The gate equipment shall be arranged as shown on the contract drawings.

9-2.1.2 Operating and Loading Conditions

(i) The gate shall be designed for combined normal static and dynamic design of head of 3.2 m / 3.0m design head for Under Sluice & Head Regulator Respectively.

(ii) The gate hoisting system shall have sufficient thrust capacity to open and close the gate against a static head of 3.2 /3.0 meter respectively for Under Sluice & Head Regulator Gates. The hoist sizing computations shall conservatively consider: the weight of the disc, rod, and piston; the friction of the gate seats and rod stuffing box; and the hydrodynamic down-pull forces during operation. An allowance of 20% shall be added to the sum of the above.

(iv) The gate structure and leaf shall be designed to withstand in an overloading condition the combined forces of a normal water level and a seismic acceleration of 0.25 g. The effects of increased pressure head shall be considered in the seismic computations.

(v) The gate structure shall be designed to withstand a flood condition equivalent to 3.2 & 3.0 meter of head respectively for Under Sluice & Head Regulator .

9-2.1.3 Gate Components

(a) Seat Facing

Seat facing materials shall be selected in accordance with the design section. Bronze seat facings shall be cast or extruded, leaded, low zinc bronze. Stainless steel seat facings shall be ASTM Type 344.

The top horizontal seat facings shall be radiused to facilitate engagement.

The contact surfaces of the seat facings shall have a surface finish smoother than 1.5mm. After installation onto the disc and frame, the seats shall be machined to a true plane, to obtain the tolerances specified under the assembly and testing section.

(b) Gate Frame

The guide slot shall be of a design to minimize cavitation. All sliding surfaces contacting the disc shall be of corrosion resistant materials. A bronze bar shall be provided at the inert to contact the disc bottom. Frame shall be flanged, bolted, pinned and gasketed in the manufacturer's shop.

9-2.1.4 Materials

The slide gate manufacturer shall be responsible for the selection of materials except as otherwise noted. Materials shall be used that have provided satisfactory service in past installations.

9.2.2. Stoplogs

Not Used.

PART 3 EXECUTION

9-3.1 Shop Assembly and Testing

Each gate shall be assembled in the shop complete with all accessories. Flange bolts shall be snug but not torqued. The stuffing box gland shall be left loose without compressing the packing. The following checks shall be made and discrepancies rectified:

(i) The liner, transition and frame sections shall be checked for mismatch offsets.

(ii) The gate shall be stroked through several operating cycles to assure smooth, non-binding operation.

(iii) An operation test of the system shall be made to demonstrate proper functioning of the system including the functioning and sequencing of all control and alarm devices.

9-3.2 Painting

The gate and all exposed steel surfaces shall be blasted to SSPC SP-10 and in accordance with Section 14 - Painting.

9-3.3 Welding

All welding will be done in accordance with AWS D1.1.

9-3.4 Installation

All parts shall be installed and adjusted by the contractor in a workmanlike manner. The manufacturer shall furnish necessary drawings and detailed installation, operation and maintenance instructions for all components. It shall be the contractor’s responsibility to handle, store, and install all parts and adjust switches and controls in accordance with the manufacturer’s detailed written recommendations. Stem threads shall be lubricated prior to operation of the gate.

9-3.5 Acceptance Trial Operation and Test

After the gate assembly has been installed, including operating machinery, the Project Manager will examine the complete system for final acceptance. Operation and test results shall be furnished to the Project Manager. The assembly will be examined first to determine whether or not the workmanship conforms to the specification requirements. The Contractor shall operate the gate throughout its full operating range a sufficient number of times to demonstrate proper operation. The initial operation of the gate assembly shall be conducted in the dry. The second trial operation and testing of the gate assembly shall be conducted with the reservoir normal operating pool hydrostatic pressure. The workmanship in the fabrication and installation of the gate assembly shall be such that the gate leaf shall form a watertight barrier when lowered to the seated position. Adjustments shall be made to the operation and control apparatus until all components function as required. The lifting sling, dogging devices, and other appurtenances will be inspected to assure proper operation. Required repairs or replacements to correct defects, as determined by the Project Manager, shall be made at no additional cost to the Employer. The trial operation and testing shall be repeated after defects are corrected.

9-3.6 Leakage

After installation and before the gates are put into operation, a leakage test shall be performed on all cast iron slide gates in accordance with AWWA C560. Excess leakage shall be reduced to this maximum by adjusting the gate and its wedges.

9.3.7 Fabrication of Stop logs

Not Used.

PART 4 MEASUREMENT AND PAYMENT

9-4.1 Gates and Appurtenant Items

9-4.1.1 Measurement

Measurement for payment will be made for area of the slide gates installed satisfactorily. This item includes appurtenant items, guides, embedded metal, operating system and ancillaries designed, fabricated, painted with protective coating delivered at site, stored, installed, tested and commissioned under the supervision of manufacture's representative and maintained in good condition during the Defects Notification Period of one year after award of completion certificate by the Project Manager.

9-4.1.2 Payment

Payment will be made at the corresponding tendered rate for the different types of gates in the priced Bill of Quantities. The rate covers all costs associated with designing, furnishing and installing slide gate and appurtenant items, operating system and ancillaries which includes full compensation for the materials, fabrication, delivery, storage if required, installation, and testing and commissioning under the supervision of

manufacturer's erection supervisor, maintenance during Defects Notification Period of one year of operating system and appurtenant items for complete installations.

Payment shall be made according to the Schedule of Payment given below.

9-4.1.3 Unit of Measure

Unit of measure: Square meters

9-4.1.4 Schedule of Payment

The payment for design, furnishing and installing the gates shall be made according to the following Schedule:

(i) Design, manufacture, delivered to site all material and ancillaries 50%

(ii) Installation
20%

(iii) Testing and commissioning
30%

(iv) Retention in each progress payment

7%

9.4.2 Stop Log

Not Used.

CHAPTER 10 - MISCELLANEOUS METAL WORKS

PART 1 GENERAL

10-1.1 References

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION (AISC)	
AISC 303	(2000) Code of Standard Practice for Steel Buildings and Bridges
AMERICAN NATIONAL STANDARDS INSTITUTE (ANSI)	
ANSI A10.3	(1995) Operations -- Safety Requirements for Powder Actuated Fastening Systems
ANSI B18.2.1	(1996; Errata 2003) Square and Hex Bolts and Screws Inch Series
ANSI B18.6.2	(1972; R 1993) Slotted Head Cap Screws, Square Head Set Screws, and Slotted Headless Set Screws
ANSI B18.6.3	(1972; R 1997) Machine Screws and Machine Screw Nuts
AMERICAN WELDING SOCIETY (AWS)	
AWS D1.1/D1.1M	(2002) Structural Welding Code - Steel
ASME INTERNATIONAL (ASME)	
ASME B18.2.2	(1987; R 1999) Square and Hex Nuts
ASME B18.21.2M	(1999) Lock Washers (Metric Series)
ASME B18.22M	(1981; R 2000) Metric Plain Washers
ASTM INTERNATIONAL (ASTM)	
ASTM A 123/A 123M	(2002) Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 153/A 153M	(2003) Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 307	(2002) Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
ASTM A 36/A 36M	(2003a) Carbon Structural Steel
ASTM A 500	(2003) Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes
ASTM A 53	(1999b) Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless

ASTM A 653/A 653M, Z275	(2003) Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process
ASTM A 687	(1993) High-Strength Nonheaded Steel Bolts and Studs
ASTM A 780	(2001) Repair of Damaged and Uncoated Areas of Hot-Dipped Galvanized Coatings
ASTM D 1187	(1997; R 2002e1) Asphalt-Base Emulsions for Use as Protective Coatings for Metal
THE SOCIETY FOR PROTECTIVE COATINGS (SSPC)	
SSPC SP 3	(1982; R 2000) Power Tool Cleaning
SSPC SP 6	(2000) Commercial Blast Cleaning
U.S. GENERAL SERVICES ADMINISTRATION (GSA)	
FS TT-P-664	(Rev D) Primer Coating, Alkyd, Corrosion-Inhibiting, Lead and Chromate Free, VOC-Compliant
U.S. NATIONAL ARCHIVES AND RECORDS ADMINISTRATION (NARA)	
29 CFR 1910.27	Fixed Ladders

10-1.2 Submittals

The following shall be submitted for Project Manager's review and approval in accordance with **Clause 1-1.4 - Submittal Procedures**:

SD-02 Shop Drawings

- Handrails, installation drawings
- Ladders, installation drawings
- Embedded angles and plates, installation drawings

Submit fabrication drawings showing layout(s), connections to structural system, and anchoring details as specified in AISC 303.

Submit templates, erection and installation drawings indicating thickness, type, grade, class of metal, and dimensions. Show construction details, reinforcement, anchorage, and installation with relation to the building construction.

SD-03 Product Data

- Handrails
- Ladders

SD-04 Samples

- Control-joint covers

Samples may be installed in the work, provided each sample is clearly identified and its location recorded.

10-1.3 Qualification of Welders

Qualify welders in accordance with AWS D1.1/D1.1M. Use procedures, materials, and equipment of the type required for the work.

10-1.4 Delivery, Storage, and Protection

Protect from corrosion, deformation, and other types of damage. Store items in an enclosed area free from contact with soil and weather. Remove and replace damaged items with new items.

PART 2 PRODUCTS

10-2.1 Materials

10-2.1.1 Structural Carbon Steel

ASTM A 36/A 36M.

10-2.1.2 Structural Tubing

ASTM A 500.

10-2.1.3 Steel Pipe

ASTM A 53, Type E or S, Grade B.

10-2.1.4 Fittings for Steel Pipe

Standard malleable iron fittings ASTM A 47M.

10-2.1.5 Anchor Bolts

ASTM A 307. Where exposed, shall be of the same material, color, and finish as the metal to which applied.

(a) Lag Screws and Bolts
ANSI B18.2.1, type and grade best suited for the purpose.

(b) Toggle Bolts
ANSI B18.2.1.

(c) Bolts, Nuts, Studs and Rivets
ASME B18.2.2 and ASTM A 687 or ASTM A 307.

(d) Powder Driven Fasteners
Follow safety provisions of ANSI A10.3.

(e) Screws
ANSI B18.2.1, ANSI B18.6.2, and ANSI B18.6.3.

(f) Washers

Provide plain washers to conform to ASME B18.22M. Provide beveled washers for American Standard beams and channels, square or rectangular, tapered in thickness, and smooth. Provide lock washers to conform to ASME B18.21.2M.

10-2.2 Fabrication Finishes

10-2.2.1 Galvanizing

Hot-dip galvanize items specified to be zinc-coated, after fabrication where practicable. Galvanizing: ASTM A 123/A 123M, ASTM A 153/A 153M or ASTM A 653/A 653M, Z275, as applicable.

10-2.2.2 Galvanize

Anchor bolts, grating fasteners, washers, and parts or devices necessary for proper installation, unless indicated otherwise.

10-2.2.3 Repair of Zinc-Coated Surfaces

Repair damaged surfaces with galvanizing repair method and paint conforming to ASTM A 780 or by application of sticky or thick paste material specifically designed for repair of galvanizing, as approved by Contracting Officer. Clean areas to be repaired and remove slag from welds. Heat surfaces to which sticky or paste material is applied, with a torch to a temperature sufficient to melt the metallics in stick or paste; spread molten material uniformly over surfaces to be coated and wipe off excess material.

10-2.2.4 Shop Cleaning and Painting

(a) Surface Preparation

Blast clean surfaces in accordance with SSPC SP 6. Surfaces that will be exposed in spaces above ceiling or in attic spaces, crawl spaces, furred spaces, and chases may be cleaned in accordance with SSPC SP 3 in lieu of being blast cleaned. Wash cleaned surfaces which become contaminated with rust, dirt, oil, grease, or other contaminants with solvents until thoroughly clean. Steel to be embedded in concrete shall be free of dirt and grease. Do not paint or galvanize bearing surfaces, including contact surfaces within slip critical joints, but coat with rust preventative applied in the shop.

(b) Pretreatment, Priming and Painting

Apply pretreatment, primer, and paint in accordance with manufacturer's printed instructions. On surfaces concealed in the finished construction or not accessible for finish painting, apply an additional prime coat to a minimum dry film thickness of 0.03 mm. Tint additional prime coat with a small amount of tinting pigment.

10-2.2.5 Non-Ferrous Metal Surfaces

Protect by plating, anodic, or organic coatings.

10-2.3 Manhole Cover and Frame

Provide a heavy-duty type made of ductile cast-iron with bolted lid, machined bearing surfaces Provide frame with a 760 mm diameter clear opening. Maximum weight of frame and cover together to be 240 kg.

10-2.4 Steel Handrails / Guard Rails for Roads

Supply and install Steel Handrails / Guard Rails for Road and bridge decks as shown in Drawings.

10-2.4.1 Steel Handrails, Including Carbon Steel Inserts

Provide steel handrails, including inserts in concrete, steel pipe conforming to ASTM A 53 or structural tubing conforming to ASTM A 500, Grade A or B of equivalent strength. Provide steel railings of nominal size shown in Drawings. Railings to be hot-dip galvanized and shop painted.

(a) Fabrication: Joint posts, rail, and corners by one of the following methods:

(1) Flush-type rail fittings of commercial standard welded and ground smooth with railing splice locks secured with 10 mm hexagonal-recessed-head setscrews.

(2) Mitered and welded joints made by fitting post to top rail and intermediate rail to post, mitering corners, groove welding joints, and grinding smooth. Butt railing splices and reinforce them by a tight fitting interior sleeve not less than 150 mm long.

(3) Railings may be bent at corners in lieu of jointing, provided bends are made in suitable jigs and the pipe is not crushed.

(b) Provide removable sections as indicated.

10-2.5 Ladders

Fabricate vertical ladders conforming to Section 7 of 29 CFR 1910.27. Use 65 by 10 mm steel flats for stringers and 20 mm diameter steel rods for rungs. Rungs to be not less than 400 mm wide, spaced one foot apart, plug welded or shouldered and headed into stringers. Install ladders so that the distance from the rungs to the finished wall surface will not be less than 175 mm. Provide heavy clip angles riveted or bolted to the stringer and drilled as indicated. Provide intermediate clip angles not over 1200 mm on centers.

PART 3 EXECUTION

10-3.1 Installation

Install items at locations indicated, according to manufacturer's instructions. Items listed below require additional procedures.

10-3.2 Anchorage, Fastenings, and Connections

Provide anchorage where necessary for fastening miscellaneous metal items securely in place. Include for anchorage not otherwise specified or indicated slotted inserts, expansion shields, and powder-driven fasteners, when approved for concrete; toggle bolts and through bolts for masonry; machine and carriage bolts for steel; through bolts, lag bolts, and screws for wood. Do not use wood plugs in any material. Provide non-ferrous attachments for non-ferrous metal. Make exposed fastenings of compatible materials, generally matching in color and finish, to which fastenings are applied. Conceal fastenings where practicable.

10-3.3 Built-in Work

Form for anchorage metal work built-in with concrete or masonry, or provide with suitable anchoring devices as indicated or as required. Furnish metal work in ample time for securing in place as the work progresses.

10-3.4 Welding

Perform welding, welding inspection, and corrective welding, in accordance with AWS D1.1/D1.1M. Use continuous welds on all exposed connections. Grind visible welds smooth in the finished installation.

10-3.5 Finishes

10-3.5.1 Dissimilar Materials

Where dissimilar metals are in contact, protect surfaces with a coat conforming to FS TT-P-664 to prevent galvanic or corrosive action. Where aluminum is in contact with concrete,

mortar, masonry, wood, or absorptive materials subject to wetting, protect with ASTM D 1187, asphalt-base emulsion.

10-3.5.2 Field Preparation

Remove rust preventive coating just prior to field erection, using a remover approved by the rust preventive manufacturer. Surfaces, when assembled, shall be free of rust, grease, dirt and other foreign matter.

10-3.5.3 Environmental Conditions

Do not clean or paint surface when damp or exposed to foggy or rainy weather, when metallic surface temperature is less than -15 degrees C above the dew point of the surrounding air, or when surface temperature is below 7 degrees C or over 35 degrees C, unless approved by the Contracting Officer.

10-3.6 Steel Handrails / Guard Rails for Roads

10-3.6.1 Steel Handrail

Install handrails as shown in Drawings.

10-3.6.2 Guard Rails for Roads

Install Guard Rails as shown in Drawings

10-3.7 Ladders

Secure to the adjacent construction with the clip angles attached to the stringer where approved by the Project Manager. Install intermediate clip angles not over1200 mm on center. Install brackets as required for securing of ladders welded or bolted to structural steel or built into the masonry or concrete. In no case shall ends of ladders rest upon finished roof or floor.

PART 4 MEASUREMENT AND PAYMENT

10-4.1 Metalwork Fabrication and installation

10-4.1.1 Measurement

Metalwork fabrication and machine work for which payment is not otherwise specifically provided in these specifications, will be measured for payment based upon computed weights per fabricated piece, assembly or cast piece for the various metals as classified on the approved detail drawings except as indicated below. Computed weights shall be indicated on the detail drawings submitted for approval. Approval of the detail drawings will constitute acceptance of the computed weights shown thereon. When measurement of complicated shapes can be determined more readily by scale weights per fabricated piece, cast piece or assembly the use of certified scale weights will be approved as the basis for measurement.

(a) Computed Weights

Weights for payment shall be the net calculated weights based on the dimensions indicated on the detail drawings. The weight of rolled shapes and plates shall be computed on the basis of their nominal weights and dimensions. In calculating the net weights all copes, cuts and open holes except rivet and bolt holes shall be deducted. No additional weight shall be calculated for overweight allowance, protective coatings, and

allowance for milling, grip length of rivets and bolts and butt and groove welds. The weight of castings including fillets shall be computed on the basis of the dimensions shown on the detail drawings with deductions for all openings and cuts in the finished casting. Computed weights for fillet welds, rivets, bolts and cut washers shall be included in accordance with the following:

ALLOWANCES FOR WEIGHT OF EQUAL-LEG FILLET WELDS

Leg of weld in Millimeters	*Kilograms per meter Length of weld*
3	0.045
5	0.089
6	0.160
8	0.250
10	0.360
11	0.490
13	0.630
16	0.980
19	1.400
22	1.900
25	2.500

Note: For unequal-leg fillet welds the weight corresponding to the smaller leg in the above listing shall be multiplied by the ratio of the longer leg to the smaller leg.

ALLOWANCES FOR WEIGHT OF RIVET HEADS

Diameter in Millimeters	*Kilograms per 100 heads*
13	1.8
16	3.2
19	5.4
22	8.2
25	12.0
29	16.0
32	22.0
35	27.0
38	37.0

ALLOWANCES FOR WEIGHT OF BOLTS - REGULAR SIZE

Diameter in Millimeters	*Kilograms per 100 units*
13	6.12
16	12.20
19	20.00
22	31.30
25	46.70
29	68.50
32	92.10

ALLOWANCES FOR WEIGHT OF BOLTS - HEAVY SIZE

Diameter in Millimeters	*Kilograms in 100 units*
13	9.1
16	16.3
19	27.7
22	41.7
25	61.2
29	86.2
32	113.0
38	195.0
44	311.0
50	454.0
57	635.0
64	855.0
70	1100.0
75	1460.0

Note: Allowances for bolts are based on weight data given in AISC manual. Allowances consist of weight of square head, bolt shank (in and projecting beyond nut) and hexagonal nut and shall apply to all type bolts without modification. Projections beyond nuts are assumed equal to 1/2 the bolt diameter up to M50 size bolts and 25 mm for bolt sizes M50 and above. Where the number and size of another type of bolt would result in a significant difference in a pay item the allowances given above should be supplemented to include the additional type of bolt.

ALLOWANCES FOR WEIGHT OF CUT WASHERS

Bolt Diameter in Millimeters	***Kilograms of 100 units***
13	2.02
16	4.04
19	5.94
22	7.21
25	9.71
29	11.70
32	15.20
35	20.10
38	22.00
44	28.80
50	35.90
57	48.50
64	57.60

70	68.90
75	84.40

Note: Each unit comprise cut washer and bolt shank in depth of washer.

The following weights, per cubic millimeter, will be used in computing weights of metalwork:

Iron Castings	7.20 mg
Steel (All Compositions)	7.83 mg
Copper, Bronze, Brass; Nickel-Copper Alloy	8.61 mg
Lead	11.30 mg
Aluminum	2.77 mg
All Other Metals	7.83 mg

(b) Scale Weights

Shop scale weight measurements shall be made in the presence of the Contracting Officer unless otherwise specifically authorized. The weight of erection bolts, nuts and washers boxes, crates and other containers used for packing and the materials used for supporting members during transportation shall not be included in the scale weights. It shall be the responsibility of the Contractor to prepare the shipping lists required in **Clause 13-1.2 - Submittals** in a format to allow the correct allocation of the scale weights of individual metal parts and members to the applicable payment classifications. Failure to comply with this requirement to the satisfaction of the Contracting Officer will necessitate measurement of computed weights. The weight of shop applied permanent protective coatings shall not be deducted from scale weights.

10-4.1.2 Payment

Payment will be made for costs associated with metalwork fabrication and machine work not specifically provided for elsewhere, which includes costs for materials, fabricating work, shop and field painting, galvanizing or other metallic coatings and the installation of metal items shown or required by these specifications unless otherwise specified. No separate payment will be made for bolts, nuts, pins, washers, studs and strap hangers and the cost of such items shall be included in the unit prices of items on which they are used. No separate payment will be made for the inspection of welds.

10-4.1.3 Unit of Measure

Unit of measure: Kilogram.

10-4.2 Ladders

10-4.2.1 Measurement

Measurement for payment will be made on number of Ladders of given lengths installed and will cover all associated cost for the same.

10-4.2.2 Payment

Payment will be made for the number of Ladders of given length installed & at the respective rate tendered in Bill of quantities and will cover all associated cost for the same.

10-4.2.3 Unit of Measure

Unit of measure: Each

10-4.3 Hand (Terrace) Rails

10-4.3.1 Measurement

Measurement for payment will be made as linear meter length of acceptably furnished and installed different types of hand (terrace) rails as shown in the drawings and shall cover all associated cost for completing the items of work as shown in the drawings.

10-4.3.2 Payment

Payment will be made for the length of different types of hand (terrace) rails as measured above at the respective rates tendered therefor in the priced Bill of Quantities and shall cover all associated cost for completing the different items of work.

10-4.3.3 Unit of Measure

Unit of measure: Linear Meter.

CHAPTER 11 – ROAD WORK

PART 1 GENERAL

11-1.1 Scope

This Section contains requirements for construction of roads, and road safety works.

11-1.2 References

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M180	Standard specifications for corrugated sheet steel beams for highway guardrails
AASHTO T11	
Amount of material finer than 0.075 mm sieve in aggregates	
AASHTO T27	
Sieve analysis of fine and coarse aggregates	
AASHTO T96	Resistance to abrasion of coarse aggregate by use of Los Angeles machine
AASHTO T104	Soundness of aggregates by use of sodium sulphate or magnesium sulphate
AASHTO T112	Clay lumps and friable particles in aggregates
AASHTO T166	Bulk specific gravity of compacted bituminous mixtures**
AASHTO T182	Coating and stripping of bitumen aggregate mixtures
AASHTO T209	Maximum specific gravity of bituminous paving mixtures**
AASHTO T90	
Determining the Plastic Limit and Plasticity index of Soils	
AASHTO T176	Method of Test for Sand Equivalent
AASHTO T193	The California Bearing Ratio (CBR)
AASHTO T180	“Moisture Density Relations of Soils”
AASHTO M17	Mineral Filler for Bituminous Paving Mixtures

BRITISH STANDARDS (BS)

BS 340 Precast concrete kerbs, channel, edgings and quadrants

BS 873 Road traffic signs and internally illuminated bollards

** Bituminous mixtures prepared in accordance with Marshall Method of mix design as mentioned in Asphalt Institute Manual series No. 2 (MS-2) Fourth Edition - March 1974;

"Mix Design Methods for Asphalt Concrete and Other Hot-mix Types".

11-1.3 Submittals

The following shall be submitted in accordance with **Clause 1-1.4 - Submittal Procedures** for Project Manager's review and approval:

SD-04 Samples

The Contractor shall provide samples of all materials used in the Permanent Works covered by this Section and as may be required by the Project Manager at no additional cost to the Employer. Samples of materials shall be submitted for approval 63 days prior to starting the Permanent Works, and thereafter at regular intervals during production, as required by the Project Manager. The samples shall be obtained at the source, from test pits, stockpiles, at the place of use during construction or from other locations designated by the Project Manager.

Reference samples shall be kept in suitable containers properly labelled and stored on Site. The Contractor may also be required to furnish certificates from an independent reputable testing laboratory acceptable to the Project Manager certifying that the materials comply with these Specifications or with manufacturers' specifications.

SD-06 Tests Performed by Contractor

The Contractor shall furnish:

- Daily reports and monthly summaries of aggregate plant gradation test results on aggregates produced for roadwork.
- Calibration certificates for the weighing and dispensing devices on bitumen concrete batching plant - once every month with an interval of not less than three weeks between two calibrations.
- Monthly summary of tests conducted on precast concrete pipes, i.e. physical dimensions, 3-point load bearing test and determination of uniformly distributed load-bearing capacity.

SD-07 Certificates

Before delivery of materials to the Site, the Contractor shall submit to the Project Manager, for his approval, certificates of origin specifying physical and/or chemical characteristics of each material, and each constituent, which shall conform with those contained in the Specifications or other Standards acceptable to the Project Manager. All such certificates of compliance with relevant standards shall accompany each shipment of all materials to be used in the Permanent Works.

Before delivery to the Site, or during the course of work, the Project Manager may call for any test considered necessary for acceptance of the materials or for control of their use. All such tests shall be performed at the expense of the Contractor. The materials that will be used in the Permanent Works include:

- Asphalts
- Grade 60-70 penetration for pavement
- Medium Curing (MC) Grade MC-1

- Rapid Curing (RC) Grade RC-2 or RC-4
- Precast concrete pipes
- Unplasticised polyvinyl chloride (uPVC) cable ducts

SD-11 Bituminous Concreting Records

The Contractor shall submit daily returns in respect of bitumen concrete placed during the previous day.

The returns shall detail:

- In respect of each concrete mix design (base coarse or wearing course):
  - Number of batches mixed,
  - Number of batches wasted or rejected, and
  - Total volume of concrete placed.
- In respect of location in the Permanent Works:
  - The position of placement,
  - The concrete mixes placed, and
  - Total volume of bitumen concrete placed and number of batches of each mixture used.

In addition, the Contractor shall maintain an accurate and up-to-date record showing dates, times, weather and temperature conditions when each location of road/drainage was completed. These records shall be available for inspection by the Project Manager at all times.

PART 2 PRODUCTS

11-2.1 Roadway Fill

Material for roadway fill shall conform to the requirements specified in Section 5, Excavation and Miscellaneous Earthwork.

The Contractor shall be responsible for carrying out all field and laboratory testing of fill materials in accordance with provisions of Section 5, Excavation and Miscellaneous Earthwork. In addition, the Contractor shall also be responsible for carrying out CBR tests on every 2500 cubic meter of fill or a fraction thereof, and submit these results to the Project Manager. CBR tests shall be in accordance with AASHTO T193.

11-2.2 Asphalt

Asphalt for Bituminous Base Course or Bituminous Wearing Course shall be petroleum asphalt, Grade 60-70 penetration, conforming to all applicable standards.

Liquid asphalt for prime coat shall be medium curing cutback asphalt and shall consist of an asphaltic base fluxed with suitable petroleum distillates. The product shall show no separation prior to use and shall conform to standard requirements of Grade MC-1.

Liquid asphalt for tack coat shall be rapid-curing type cutback Grade RC-2 or RC-4, as may be directed by the Project Manager.

11-2.3 Aggregate

11-2.3.1 Aggregate for Aggregate Base Course

Coarse material for aggregates for base course shall consist of clean, tough, durable, sharp angle fragments, free of any excess of thin or elongated pieces, and free of soft, disintegrated or decomposed stone, dirt or other deleterious matter.

Crushed gravel or stone fragments for base course shall consist of the product obtained by crushing gravel that, if directed by the Project Manager, has first been screened in such a manner that not less than 90% of the material to be crushed is retained on 5 mm sieve.

All base course aggregates shall conform to the following physical requirements:

- Loss of sodium sulphate soundness
- test (AASHTO T104) 10% maximum
- Loss of magnesium sulphate soundness
- test (AASHTO T104) 12% maximum
- Loss by abrasion (AASHTO T96) 40% maximum
- Thin and elongated pieces, by weight,
- (larger than 25 mm thickness less
- than 1/5 length) 5% maximum

- Friable particles (AASHTO T112) 0.25% maximum

Coarse materials for aggregate base course shall be crushed rock or crushed gravel conforming to the following grading requirement:

Sieve Designation		*Percent Passing by Weight*
63.5 mm	(2.5 inch)	100
50.8 mm	(2 inch)	90-100
38.1 mm	(1.5 inch)	35-70
25.4 mm	(1 inch)	0-15
12.7 mm	(0.5 inch)	0-5

Fine materials for the aggregate base course shall be quarry screenings or natural material and of suitable binding quality as approved by the Project Manager. The material shall be free from foreign or organic matter, dirt, shale, clay and clay lumps or other deleterious matter and shall conform to the following requirements when sieved in accordance with AASHTOT27:

Sieve Designation		*Percent Passing by Weight*
9.52 mm	(0.375 inch)	100

4.76 mm	(No. 4)	85-100
0.148 mm	(No. 100)	10-30

- Plasticity index (AASHTO T90) 6 maximum
- Sand equivalent (AASHTO T176) 30 minimum

The combined material shall consist of a mixture of all aggregate well graded from coarse to fine to conform to the following gradation requirements:

Sieve		*Percent Passing*
63.5 mm	(2.5 inch)	100
50.8 mm	(2 inch)	90-100
38.1 mm	(1.5 inch)	60-90
25.4 mm	(1 inch)	45-80
19.1 mm	(0.75 inch)	35-70
12.7 mm	(0.5 inch)	25-60
4.76 mm	(No. 4)	15-40
2.00 mm	(No. 10)	10-25
0.425 mm	(No. 40)	5-15
0.075 mm	(No. 200)	2-10

- Plasticity index (AASHTO T90) 6 maximum
- Sand equivalent (AASHTO T176) 50 minimum

During construction, the following testing shall be carried out:

- When a stationary plant is used, the aggregates shall be tested immediately following mixing based on periodic samples taken from the pugmill.
- When a roadside mix method is used, the aggregates will be accepted after necessary blending and before laying, based on samples taken from the combined windows for each layer of the aggregate base course in case the same is to be constructed in more than one layer.
- When the aggregate is total aggregate, it may be accepted at the crusher plant.

Acceptance of the material by the Project Manager does not constitute acceptance of the aggregate base course.

11-2.3.2 Aggregate for Bituminous Base Course

Mineral aggregates for bituminous base course shall consist of coarse aggregates, fine aggregates, and filler, if required, all complying with the requirements given below.

Coarse aggregate, which is the material retained on a 5 mm sieve, shall consist of crushed rock or crushed gravel. It shall be clean, hard, tough, durable and sound, and shall be of uniform quality and free from decomposed stone, organic matter, shale, clay, lumps and other deleterious substances.

The coarse aggregate shall be free from excess of flat elongated pieces, in no case more than 10%, and shall be of such character that when coated with asphalt shall pass a stripping test performed in accordance with AASHTO T182.

Fine aggregate material shall be that material which passes a 5 mm sieve. Fine aggregate shall be obtained by crushing gravel. The Project Manager may allow use of natural material passing a 5 mm sieve provided this material is fed separately to the drier and the amount used shall be so limited that the mixture of the fine aggregate will contain not less than 25% by weight of the crushed aggregate.

The combined mineral aggregates shall meet the quality requirements specified for material for aggregate base course and, in addition, shall conform to the following physical requirements:

- Sand equivalent (AASHTO T176) determined after all processing except for addition of asphalt binder — 45 minimum
- Plasticity index (AASHTO T90) — 6 maximum
- Loss of Marshall Stability by submerging specimens in water at 60øC (140øF) for 24 hours as compared to stability measured in water at 60øC (140øF) for 30 to 40 minutes — 25% maximum

The Contractor shall determine the absorption of asphalt by the aggregates by measuring the maximum specific gravity of the loose paving mixture (AASHTO T209) and then calculating the effective specific gravity.

When tested according to AASHTO T11 and AASHTO T27, the combined mineral aggregates shall conform to the following gradings:

Sieve		*Percent Passing*
38.1 mm	(1.5 inch)	100
25.4 mm	(1 inch)	80-100
19.1 mm	(0.75 inch)	70-90
9.5 mm	(0.375 inch)	55-75
4.76 mm	(No. 4)	45-60
2.00 mm	(No. 10)	35-50
0.425 mm	(No. 40)	15-25
0.075 mm	(No. 200)	3-10

The grading limits specified are based on materials having uniform specific gravity and shall be adjusted for any variations in specific gravity of the individual sizes. Also the gradings may be revised by the Project Manager on the basis of Marshall tests to obtain optimum stability and life of the bitumen base course mix.

When the combined grading of coarse and fine aggregates is found deficient in material passing a 0.063 mm sieve, approved mineral filler may be added to make up the deficiency. This mineral filler shall consist of rock dust, limestone dust, slag dust, hydrated lime, hydraulic cement or other approved material. It shall be dry and free from

agglomerations at the time of its use. This filler material shall conform to the requirements of AASHTO M17 gradation as follows:

Sieve		*Percent Passing*
0.60 mm	(No. 30)	100
0.30 mm	(No. 50)	95-100
0.075 mm	(No. 200)	70-100

11-2.3.3 Aggregate for Bitumen Wearing Course

Mineral aggregate for bitumen wearing course shall consist of coarse aggregate, fine aggregate, and mineral filler, if required, all complying with the requirements given below.

Coarse aggregate shall be the same as specified in **Sub-Clause 11-2.3.2 - Aggregate for Bituminous Base Coarse**.

Fine aggregate shall be the same as specified in **Sub-Clause 11-2.3.2 - Aggregate for Bituminous Base Coarse**.

The combined mineral aggregate shall have physical requirements as specified in **Sub-Clause 11-2.3.2 - Aggregate for Bituminous Base Coarse**

- The plasticity index shall be maximum 3.
- When tested according to AASHTO T11 and AASHTO T27, the combined mineral aggregates shall conform to the following requirements:

Sieve Designation		*Percent Passing by Weight*
19.1 mm	(0.75 inch)	100
12.7 mm	(0.5 inch)	80-100
4.76 mm	(No. 4)	50-70
2.00 mm	(No. 10)	30-45
0.425 mm	(No. 40)	15-25
0.177 mm	(No. 80)	10-20
0.075 mm	(No. 200)	4-10

11-2.4 Road Safety Works

11-2.4.1 Corrugated Guard Rails

Steel Guard Rails shall be manufactured from rolled steel as shown on the Drawings or as directed by the Project Manager.

11-2.4.2 Pre-cast Concrete Kerb Stone

Pre-cast concrete kerb stones shall comply with BS 340 and shall be hydraulically pressed or machine extruded in situ. They shall be manufactured in accordance with all applicable requirements specified in Section 8, Concrete Work.

11-2.4.3 Road Signs

Road signs shall be in accordance with BS 873.

11-2.4.4 Road-Marking Paint

Road- marking paint shall be chlorinated rubber, one-pack epoxy, or alkyd based, and shall be supplied by an approved manufacturer. It shall be suitable for applying by brush or mechanical means to concrete or bituminous pavement and to concrete block paving so as to give a chemically stable film of uniform thickness.

White paint shall contain not less than 6% by mass of titanium dioxide as a pigment, conforming to type A (anatase) or type R (rutile) specified in BS 1851. Yellow paint shall be standard colour BS 381C No. 355, and shall contain not less than 6% by mass of a suitable yellow pigment.

The paint shall be supplied fresh and ready for use in sealed containers.

11-2.4.5 Right of Way (ROW) Markers and Delineators

The markers and delineators shall conform to the details shown on the plans drawings.

(a) Concrete Post

The Concrete post markers and delineators shall conform to the material requirements as indicated in Section 8, Concrete work.

(b) Reflectorization

The white part of a delineator shall be illuminated with white retroreflecting material and the red part may be illuminated with red retroreflecting material.

Reflex reflectors or retroreflective sheeting may be used for object markers and delineators with rigid posts. Retroreflective sheeting shall be used for delineators with concrete posts.

The instrumental method of determining color shall conform to the requirements of Yemeni Standards. In the event of any dispute concerning the test results of instrumental testing, the visual test shall prevail.

A significant difference between day and night reflective color shall be grounds for rejection.

11-2.5 Equipment

11-2.5.1 General

Plant and equipment shall be sufficient to meet the requirements of both the Specifications and the Construction Program. This chapter describes special requirements for plant and equipment for roadway construction. Alternative equipment capable of producing the specified results may be proposed by the Contractor for the approval by the Project Manager.

11-2.5.2 Two-Axle Tandem Steel Rollers

The two-axle tandem steel rollers shall be self-propelled and shall not weigh less than 7 tons nor more than 11 tons. The power mechanism shall be capable of propelling the roller smoothly and without jerking when starting, stopping or reversing, free from backlash, loose link motions, faulty steering mechanism and worn king bolts. The steering

mechanism shall not have any lost motion, shall operate readily and permit the roller to be directed on the alignment desired.

The faces of all drums shall be smooth and free from defects which mar the finished road surface. The roller shall be equipped with water tanks and sprinkling devices which shall be used for wetting the drums to prevent adherence of placed material.

The equipment shall be equipped with independent vibratory mechanism capable of producing 1500 to 2000 vibrations per minute in three different amplitudes to act as an additional tamping force.

11-2.5.3 Heavy-Weight Self-Propelled Pneumatic-Tired Rollers

Heavy self-propelled pneumatic-tired rollers shall be so constructed that they can be loaded to provide a gross weight of not less than 15 tons and up to 23 tons. The tires of the front and rear axle shall have wide smooth treads and shall be staggered to provide complete coverage of the entire area over which the rollers travels. The tires shall be inflated to a pressure that has been approved by the Project Manager and the pressure shall be uniform in all tires.

11-2.5.4 Aggregate Mixing Plant

The mixing plant shall be capable of mixing the specified grades of the aggregate and water into a mixture of uniform consistency and of discharging the mix directly through a hopper into the transporting equipment without segregation.

11-2.5.5 Self-Propelled Aggregate Spreader

The aggregate spreader shall be a self-propelled, self-contained unit provided with manually controlled screed and capable of spreading the mixed aggregates uniformly in lane width and thickness as shown on the Drawings.

The equipment shall have mechanical devices capable of guiding the spreader along the route and adjustable device to maintain the design grade of the aggregate base course and confine the edges of the mixture to true lines without use of stationary side forms.

The screed shall effectively produce a finished surface of the required evenness and texture without tearing or shoving the material. The spreader must be capable of paving the desired width and thickness of the aggregate base course without segregation and defects in workmanship. The Project Manager can order the Contractor to remove any equipment that fails to produce work within specified limits and acceptable workmanship.

11-2.5.6 Bitumen Distributor

This equipment shall be used to spray bituminous materials, Prime Coat Grade MC-1 and Tack Coat Grade RC-2 or RC-4, on prepared and approved surfaces at approved rates of spraying and in accordance with the requirements of these Specifications.

11-2.5.7 Hot-Mix Plant for Bitumen Mixes

The plant shall be capable of producing asphalt concrete for bituminous base course and bituminous wearing course in accordance with the requirements of these Specifications and in such a quantity that can meet the demands of the construction program.

11-2.5.8 Self-Propelled Bituminous Paver

The bituminous paver shall be a self-contained, power-propelled unit provided with automatically controlled activated screed or strike-off assembly, capable of spreading and finishing courses of bituminous plant- mixed material in lane widths to the specified sections and thickness shown on the Drawings. Pavers used for shoulders and similar construction shall be capable of spreading and finishing courses of bituminous plant mixed material in widths as shown on the Drawings.

The machine shall employ mechanical devices such as equalizing runners, straight-edge runners, evener arms or other compensating devices to adjust the grades and confine the edges of the mixture to true lines without the use of stationary side forms.

The screed or the strike-off assembly shall effectively produce a finished surface of the required evenness and texture without tearing, shoving or gouging the mixture.

The controls for the paver shall be an automatic linkage arrangement so that through the process of adjusting the screed thickness controls, asphalt mixture can be placed and finished to a predetermined grade and a uniform transverse slope.

11-2.5.9 Broom Drags

Broom drags shall consist of brooms mounted on a frame in such manner as to spread the aggregate uniformly over the surface of the area to be treated. The drags shall be equipped with tow plates. Towing equipment shall be equipped with pneumatic tires.

11-2.5.10 Power Brooms and Power Blowers

Power brooms and power blowers shall be suitable for cleaning the surfaces to be treated.

PART 3 EXECUTION

11-3.1 Control of Work

11-3.1.1 Construction Stakes, Lines and Grades

The Project Manager will furnish the Contractor with the locations of beginning point and end point of each road, the points of horizontal intersection of tangents and primary bench marks. The Drawings will indicate the properties of horizontal and vertical curves, together with rates of super elevation where required and elevations of the top of the finished road surface. The Contractor shall set construction stakes establishing lines, slopes and continuous profile grade in road work, and centre lines and bench marks for drainage and culvert works and embankment slope protection works. These stakes and marks shall constitute the field control by and in accordance with which the Contractor shall establish other necessary controls and perform the work.

The Contractor shall, prior to any stake-out work, submit to the Project Manager, for his approval, a planned method of staking-out of the roads, covering accuracy, the position of the various types of stakes, the method of marking stakes, the method to be used for

protecting stakes, etc. No staking shall proceed prior to the Project Manager's approval of the Contractor's staking plan.

At least twenty-four hours before he intends to stake-out any portion of the work, the Contractor shall submit written notice to the Project Manager. Such notice shall include the time, location and type of work to be staked.

The Contractor shall stake-out the work and secure the Project Manager's approval of his stake-out before proceeding with construction. If, in the opinion of the Project Manager, modification of the line or grade is advisable, before or after stake-out, the Project Manager will issue instructions to the Contractor for such modification and the Contractor shall revise the stake-out for further approval at no extra cost to the Employer.

11-3.1.2 Templates and Straightedges

The Contractor shall provide a sufficient number of metal templates to be used by the Contractor and the Project Manager to control and check the correct shaping of finished surfaces of the work.

In addition, the Contractor shall provide sufficient number of metal straight edges, as required by the Specifications and the Project Manager, for control of the longitudinal dimensions of work.

Samples of templates and straight edges shall be submitted to the Project Manager for approval.

No separate payment for templates and straightedges will be made. The cost of these items is deemed to be included in other items in the Bill of Quantities.

11-3.1.3 Tolerances

All slopes, lines and grades shall be true, correct, and accurate and according to those shown on the Drawings or as directed and approved by the Project Manager. The subgrade and the finished surface of unpaved shoulders shall be accurate to the authorised levels plus or minus 25 mm, with a maximum deviation from a 3 m straightedge of 25 mm. Where discrepancies are found in the work, the Contractor shall make the necessary corrections.

11-3.2 Earthwork

11-3.2.1 Clearing and Grubbing

Clearing and grubbing shall conform to the requirements of Section 5, ‘Excavation and Miscellaneous Earthwork.

11-3.2.2 Excavations

All excavations including borrow excavation, if any, for roadways, road drainage culverts, berm drains and stream channels adjacent to drainage culverts shall conform to the requirements of Section 5, Excavation and Miscellaneous Earthwork.

11-3.2.3 Roadway Fill

The work of constructing roadway fill including preparation of the areas upon which they are to be placed; placing and compacting of approved materials within roadway areas where unsuitable material has been removed ; and placing and compacting of fill material in pits and other depressions within the roadway area shall be carried out in accordance with Section 5, Excavation and Miscellaneous Earthwork, and in conformity with the lines, grades, thickness and typical cross sections shown on the Drawings or established by the Project Manager.

The work shall comply with Section 5, Excavation and Miscellaneous Earthwork, except that:

- The subgrade shall be compacted so that the dry density of the upper 150 mm is nowhere less then 95% of the maximum density as determined in accordance with AASHTO T180 method D or AASHTO T181.
- Pieces of rock projecting more than 75 mm from the surface of the foundation shall be cut down.
- In order that the roadway embankment, subbase and/or base course may not be subject to standing water, during or after construction, the Contractor shall at all times provide adequate drainage so as to prevent standing water. The Contractor shall clean and trim all such drainage ditches from time to time during the work and/or when directed by the Project Manager. Damage to the work attributable to wetting through failure to provide such adequate drainage shall be immediately repaired by the Contractor at no additional cost to the Employer. No separate payment will be made for cleaning and trimming drainage.

11-3.2.4 Compaction of Roadway Fill

Compaction of roadway fill shall be in accordance with the requirements of Section 5, Excavation and Miscellaneous Earthwork.

11-3.3 Aggregate Base Course

11-3.3.1 Description

This work shall consist of furnishing and placing a layer of aggregate, including additive if required, on a prepared surface in accordance with these Specifications and in conformity with the lines, grades, thickness and typical cross sections shown on the Drawings or as established by the Project Manager.

Prior to placing the aggregate base course, the Contractor shall provide adequate edge kerbs on both edges of the roadway width to be paved. Edge kerbs shall be subject to the approval of the Project Manager.

11-3.3.2 Maintenance of Subgrade

The roadway fill and subgrade shall be maintained true to cross section and grade until the aggregate base course is completed. The Contractor shall make all the necessary arrangements to prevent ponding of water on or along the roadway fill. It shall be the sole responsibility of the Contractor to maintain the subgrade as prepared and approved, and any defects which may develop shall be corrected at no additional cost to the Employer.

11-3.3.3 Combining Aggregates and Water

Aggregate for the base course shall be combined into a uniform mixture and water added in a central mixing plant. When a binder is to be added, it shall also be combined in the central mixing plant.

11-3.3.4 Placing Combined Aggregates

Aggregates for aggregate base course shall be delivered to the Site as a uniform mixture and shall be placed in a single layer of uniform thickness as shown on the Drawings. Aggregates shall be placed using a mechanical spreader capable of working to control guide wires.

The material shall be so handled as to avoid segregation. If the spreader causes segregation, or leaves ridges or other objectionable marks on the surface which cannot be readily eliminated or prevented by adjustment of the spreader operation, the use of such spreader shall be discontinued and it shall be replaced. All segregated material shall be removed and replaced with properly graded material. Surface patching shall not be permitted after compaction has commenced. Local pockets or depressions may be patched up with aggregates before compaction commences.

Hauling and placement of material will not be permitted when, in the opinion of the Project Manager, the weather or the road conditions are such that hauling operations will cause damage to the road surface or contamination of the aggregates.

11-3.3.5 Compaction

Immediately after placing the material shall be compacted to 100% of the maximum density as determined according to AASHTO T180 method D or determined in accordance with ASTM D2049. The field determination of density shall be made in accordance with AASHTO T 181. The percent of maximum density may be adjusted by the Project Manager if, in his opinion, the weight and volume of the aggregate is larger than the aggregate used in the compaction control test.

Rolling shall be done with self-propelled steel drum rollers to insure a smooth surface free from ruts or ridges and having the proper cross slope and longitudinal grade.

The surface of the finished aggregate base course will be tested with a 3 m straightedge at selected locations. The variation of the surface from the testing edge of the straightedge between any two contacts with the surface shall not exceed 6 mm when placed parallel or perpendicular to the center line of the roadway. The base course shall be compacted to the thickness and cross section as shown on the Drawings and shall not vary more than 6 mm from the required elevation. All humps shall be cut down to correct elevations within permissible tolerance limits mentioned before and compacted as specified. Skin patching shall not be allowed to make good thickness deficiencies. If the thickness deficiencies are more than the specified tolerances, these deficiencies shall be corrected by removing the defective work or by adding new material as directed by the Project Manager.

11-3.3.6 Maintenance of Aggregate Base Course

The approved aggregate base course shall be maintained by the Contractor at his expense until such time as the bitumen base course (the upper layer) or the prime coat Grade MC-1 is allowed to be placed.

The Project Manager shall determine when the surface of the base course is in the proper condition to permit the bituminous prime coat to be applied. When such a permission is extended to the Contractor who chooses not to apply the prime coat or is not in a position to apply the prime coat, he must continue to maintain the approved surface of the aggregate base course, including necessary application of water, brooming, etc. at his expense until such time as the bituminous prime coat is applied.

11-3.4 Bituminous Prime Coat

11-3.4.1 Description

This work shall consist of applying a liquid asphalt prime coat on previously constructed aggregate base course in accordance with these Specifications and in conformity with the lines shown on the Drawings or established by the Project Manager.

11-3.4.2 Preparation of Surface

It shall be the sole responsibility of the Contractor to maintain the surface in an approved condition conforming to required grades and sections. Any and all defects that may have developed shall be corrected at no extra cost to the Employer.

Prior to the application of the bituminous prime coat, all loose material shall be removed by mechanical sweepers, hand brooms or power blowers until the surface is as free from dust as is deemed practicable. If permitted by the Project Manager, the cleaned surface shall be given a light spray of water and allowed to dry to surface-dry condition before the prime coat is applied. No traffic shall be permitted on the surface after it has been prepared to receive the prime coat.

11-3.4.3 Temperature of Bituminous Prime Coat Application

Cutback medium-curing asphalt of Grade MC-1, shall be heated to a temperature range of 50 ºC to 80 ºC. Material heated to temperatures higher than 80 ºC shall be considered as overheated and shall not be applied. Over- heated material shall be retested before it may be allowed to be used as bituminous prime coat. The reacceptance or final rejection will be made by the Project Manager on the same requirements under which the material was originally tested.

11-3.4.4 Areas to be Primed

The top of aggregate base course from a point 200 mm outside the edge of the pavement line to the like point on the opposite side of the pavement.

- The top of the shoulders from the intersection of the embankment slope and top of subgrade to the edge of the pavement line.

- The bridge deck surface from kerb to kerb and end to end of the bridge wearing surface.

- Other surfaces as shown on the Drawings or as directed by the Project Manager.

11-3.4.5 Application of the Prime Coat

Medium-curing cutback asphalt of Grade MC-1 shall be applied mechanically. The spray nozzles and the spray bar shall be adjusted and frequently checked so that uniform distribution is ensured. Spraying shall cease immediately upon any clogging or interference of any nozzle, and corrective measures taken before spraying is resumed. Hand sprays will be approved only for priming small patches or areas inaccessible to the normal distributor. Care shall be taken to avoid excessive overlapping of earlier spreads to avoid exceeding the specified amount. Any such excess shall be blotted from the surface when directed by the Project Manager. Any missed areas or recognized deficiencies shall be corrected by means approved by the Project Manager.

11-3.4.6 Test Section and Rate of Application

The rate of application shall be approved by the Project Manager within the limits shown below as determined from field trials conducted on a test section. The Contractor shall prepare a test section for determination of the rate of application for the prime coat for a given type of soil.

The test methods shall be determined by the Project Manager and performed by the Contractor in his presence.

The Project Manager may order subsequent test sections and/or alter the previously established rate of application when he deems it necessary.

Application Rates		
Type of Surface	*Grade MC-1 (litres sq m)*	
	Minimum	*Maximum*
Earth surface, shoulders, aggregate base course	0.50	1.40
Bridge decks	0.075	0.25
Other surfaces	As determined from field tests	

11-3.4.7 Protection of Adjacent Structures

When bituminous materials are being applied, the surfaces of all structures, wheel guards, guard rails, kerbs, gutters, and other roadway appurtenances shall be protected from being splattered with bituminous material or marred by construction equipment. In the event any appurtenances become splattered or marred, the Contractor shall remove all traces of bituminous materials and repair all damage at no extra cost to the Employer.

11-3.4.8 Blotting

If the bituminous prime coat has been applied for 48 hours and has not dried under favourable conditions, the Project Manager either may allow blotting of undried bitumen by

clean fine sand or any other approved material or may extend extra time for drying out of the bituminous prime coat. Care shall be taken to protect the surface during stripping and removal of bitumen- mixed blotting sand.

11-3.4.9 Protection of Prime Coat

The Contractor shall maintain the prime-coated surface until it has been covered by the subsequent layer. Any area where the prime-coated surface has been damaged shall be cleaned of all loose material, the defective aggregate base course or subgrade repaired to the satisfaction of the Project Manager and the prime coat reapplied. The maintenance and repairs to defective areas shall be done at no extra cost to the Employer.

11-3.4.10 Weather and Temperature Limitations

Application of the prime coat shall be performed only when the surface is dry, when the atmospheric temperature is above 15 ºC and when the weather is not foggy or rainy.

11-3.5 Bituminous Base Course (BBC)

11-3.5.1 Description

This work shall consist of aggregates and bituminous material mixed in a central plant and spread and compacted on an approved and primed aggregate base course in accordance with these Specifications and in conformity with the lines, grades, thicknesses and typical cross sections shown on the Drawings or established by the Project Manager.

11-3.5.2 BBC Mixture Proportions

At least 28 days prior to the date the Contractor intends to begin production of plant-mix bituminous base course and after receiving approval of the aggregate and after the delivery on Site of the asphalt specified for the bituminous base course, the Contractor shall submit, for approval by the Project Manager, the job-mix formula for bituminous base course prepared by the Contractor. The job-mix formula, prepared in accordance with the Marshall Method of Mix Design, shall combine the mineral aggregates and asphalt in such proportions as to produce a mixture conforming to the following composition limits by weight:

- Total mineral aggregates 96-93%
- Asphalt binder 4-7%

When tested according to the Marshall Method (75 blows), the bituminous mixture shall conform to the following requirements:

- Stability (kg) 800 minimum
- Flow (mm) 2-5
- Voids in total mix (percent) 4-7
- Voids filled with asphalt (percent) 60-75

All mixes to be used in the Works shall be prepared by the Contractor and submitted to the Project Manager for his approval.

The mix will be densely graded and on the high side in fine materials. The mix formula shall have as high asphalt content as possible. The formula shall also take into consideration the absorption of asphalt into the aggregates. Thus for calculations for voids, the bulk specific gravity of the Marshall specimens, adjusted for the portion of asphalt lost by absorption, shall be used.

The gradation of the combined aggregate, including the mineral filler, shall be within the limits specified in **Sub-Clause 13-2.3.1 – Aggregate for Aggregate Base Coarse**. The Project Manager may vary the specified limits where he deems it necessary, on the basis of the Marshall Method, to obtain optimum stability and life of the completed mix.

Upon receiving approval for the Bitumen Base Course mix by the Project Manager, the Contractor shall adjust his plant to proportion the individual aggregates, mineral filler and asphalt to produce a final mix that, when compared to the job-mix formula, shall be within the following limits:

Maximum Variations of Percentage of Materials

Retained on sieve No. 4	5%
Passing sieve No. 4 and retained on sieve No. 200	5%
Passing sieve No. 200	1.5%
Asphalt content	0.3%

The Project Manager will test the mix periodically and, if necessary, direct the Contractor to readjust the plant to maintain conformity with the design proportions of all ingredients of the mix.

11-3.5.3 Construction Requirements

Asphalt shall be heated within a temperature range of 135 ºC to 165 ºC at the time of mixing with heated aggregates. Asphalt heated more than 40 ºC above the maximum shown shall be considered overheated and shall be rejected until the material can be resampled and tested.

Each aggregate ingredient shall be heated and dried so that the temperature when recorded in the bins for hot fines after screening does not exceed 165 ºC. If the aggregates contain sufficient hot water vapours to cause foaming in the mix or their temperature is in excess of 165 ºC, they shall be removed from the bins and returned to their respective stockpiles for reprocessing.

Immediately after heating, the aggregates shall be screened into at least 3 sizes and conveyed into separate bins ready for batching and mixing with asphalt. The efficiency of the screening operations shall be sufficient to produce, at plant operating capacity, gradations in each of the sizes of heated and dried aggregates which when mixed shall result in production of a mixture complying with the limits specified for the aggregates.

Dried and heated aggregates and bitumen shall be combined in the plant in the approved proportions.

The mixing time shall be enough to obtain a homogeneous mixture and satisfactory coating of each and every particle of the aggregates.

11-3.5.4 Placing of the Mixture

The bituminous mixture shall be spread and finished true to crown and grade by an automatically-controlled paver. Where pavers cannot be used, the Project Manager may allow manual operations or other means.

The automatically-controlled paver shall spread the bituminous mixtures without tearing the surface and shall strike a finish which is smooth, uniform in density and texture and free from hollows, transverse corrugations and other physical irregularities.

The paver shall be operated at a speed which will give the best results for the type of paver being used and which coordinates satisfactorily with the rate of delivery of the mixture to the paver so as to provide a uniform rate of placement without intermittent operations of the paver. The delivery of the mixture to the paver shall be arranged to allow the paver enough time to complete spreading, finishing and compaction.

All mixtures shall be delivered to the paver at a temperature between 140øC and 165øC. Mixtures delivered at lower temperatures shall be discarded.

If the Contractor paves for the full width of each carriageway in two or more operations, he shall take all care to minimize the effects of cold joints as mentioned hereinafter.

The inner edge of the previously paved lane shall be blown clean of all loose material, and the improperly compacted bituminous mixture shall be removed by means approved by the Project Manager. The final surface shall then be heated and a thin coat of Grade RC-2 asphalt applied using a brush before the new pavement is laid against it.

The use of an automatically controlled paver to provide both longitudinal and transverse control shall include the furnishing and maintaining of a reference string line, whether it be erected or mobile, by the Contractor. The reference string line shall be taut and free from sags.

After spreading and strike-off, and as soon as the mix conditions permit the rolling to be performed without excessive shoving or tearing, the mixture shall be uniformly compacted, without the appearance of any cracks due to over-rolling.

Compaction shall be done by steel wheel and pneumatic rollers which 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 uniformly and to the specified density while it is still in a workable condition. A minimum of three rollers, two steel wheel type and one pneumatic-tyre type, shall be used with each spreading operation.

Initial or break-down rolling shall be done by a tandem power steel roller and shall begin when the mixture will bear the roller without undue displacement. Rolling shall be longitudinal, beginning at the low side of the spread of material and proceeding toward the high side, overlapping on successive trips by at least a half width of the rear wheel.

To prevent adhesion of the mixture to the roller, the wheels shall be kept constantly moistened with water but an excess of water will not be allowed.

The initial or breakdown rolling shall be followed by rolling with a pneumatic-tyre roller for kneading action to effect maximum compaction. Final compaction and finish rolling shall be done by tandem power steel rollers. The Contractor shall protect all sections of the newly-compacted mixture from traffic until the surface has hardened properly.

The road compaction density requirement shall be equal to or greater than 96% of the Marshall Density of each day's production.

Joints between old and new pavement or between successive day's work shall be made so as to ensure thorough and continuous bond between old and new mixtures. Transverse joints in previously laid material shall be constructed by cutting the material vertically with a power saw for the full depth of pavement so as to expose a fresh contact surface.

Before placing the fresh mixture against a cut joint or against an old pavement, the contact surfaces shall be painted with a thin uniform coat of Grade RC-2 asphalt. Where a finishing machine is used, the longitudinal joint shall be made by overlapping the screed on the previously laid material for a width of at least 20 mm and depositing a sufficient amount of mixture so that the joint formed shall be smooth and tight.

11-3.5.5 Thickness Cores

The depth of the compacted base course shall be measured in two separate operations by extracting a minimum of two cores per lane per km at locations designated by the Project Manager. The first core shall be taken when the layer has been laid and cooled. The second core will be taken when the wearing course is laid and at a location adjacent to the first core.

The Contractor shall furnish and operate an approved core drill for cutting samples from the compacted mixture. The equipment shall be capable of cutting the mixture without shattering the edges of the specimen. The core shall have a nominal diameter of 100 mm.

Unless otherwise permitted, core extracted for thickness measurement shall not be used for density determination and density samples shall not be used for thickness measurements.

11-3.5.6 Tolerances in Construction

The surface will be tested with a 4 meter long straightedge by the Project Manager at selected locations. The variations of the surface from the testing edge of the straightedge between any two contacts with the surface shall at no point exceed 6 mm when placed

parallel or perpendicular to the center line of the roadway. The top of the base course shall not vary from the required elevation by more than 6 mm.

The thickness of the base course shall be determined by average caliper measurement of cores.

When a core is deficient by less than 6mm, the thickness of the base course will be acceptable. When such measurement is deficient by more than 10mm, the Contractor shall remove such deficient areas and replace them. When such measurement is deficient by more than 6mm but less than 10mm, two additional cores at intervals of not less than 100m, at locations directed by the Project Manager, shall be taken and used in determining the average thickness. If the average of the three cores is deficient by less than 6mm, Project Manager will accept the work in the area represented by these cores.

In calculating the average thickness of the bituminous base course, measurements which are in excess of the specified thickness will be considered as specified thickness. When the measurement of any pavement is shown to be deficient but within the acceptable limits given above, the Contractor shall make up the deficiency while paving the bituminous wearing course.

11-3.5.7 Compaction, Sampling and Testing

The field density of the paved layer of bitumen base course shall be determined in accordance with AASHTO T166. The briquettes used in this ascertainment shall be made of the material used in construction, taken from samples of freshly mixed bituminous mixture at the plant. Reheating of the sample mixture will not be permitted.

The density of the mixture as placed and as compacted on the road shall be determined from samples cut from the compacted course on the road at locations specified by the Project Manager. Samples shall be taken in sets of two cut from the same location on the road. The frequency of testing shall be one set of samples per traffic lane every 500 linear meter per layer or a minimum of one set per day for shorter runs, as well as additional tests to determine limits of areas deficient in density or for rechecking.

The Contractor shall cut the samples with an approved saw or core drill in the presence of the Project Manager. The equipment shall be capable of cutting the mixture without shattering the edges of the specimen. Samples shall be 100 mm square or 100 mm in diameter (nominal).

11-3.5.8 Weather Limitations

Hot asphalt mixtures shall be placed only when the air temperature is 5øC or above and when the weather is not windy or rainy and when the surface is not affected by moisture.

11-3.6 Bituminous Tack Coat

Prior to placing a bituminous layer on the approved bituminous base course, a tack coat, as specified in **Clause 11-2.2 - Asphalt**, shall be applied to the base course at a rate of application not exceeding 0.2 liters per sq m or as otherwise directed by the Project Manager.

Before application of the tack coat, the surface of the bitumen base course shall be thoroughly cleaned of all loose materials and all mud sticking to the base course shall be washed and the surface allowed to dry naturally.

The application of the tack coat shall be uniform throughout and as specified or directed by the Project Manager. If any area is left uncoated, the Contractor shall not apply a second coat throughout but will be allowed to do hand-coating.

The Contractor shall protect the tack-coated surface from traffic and if any damage does occur, the damaged surface shall be recoated at no extra cost to the Employer.

The bituminous wearing course shall be placed as soon as possible after the surface dries.

11-3.7 Bituminous Wearing Course (BWC)

11-3.7.1 Description

This work shall consist of construction of one course of hot-mixed and hot- laid bituminous mixture conforming to the requirements of this Section, spread and compacted on a layer of existing bituminous base course in conformity with the lines, grades and typical cross sections shown on the Drawings.

11-3.7.2 BWC Mixture Proportions

The requirements for the BWC mixture shall be the same as given in **Sub-Clause 11-3.5.2 – BBC Mixture Proportion** except that, when tested according to the Marshall Method (75 blows), the bituminous mixture shall conform to the following requirements:

- Stability (kg) 900
- Flow (mm) 2.4-4
- Voids in total mix (percent) 3-5
- Voids filled with asphalt (percent) 70-80

11-3.7.3 Construction Requirements

The requirements for preparation of the asphalt, the mineral aggregates and the bituminous mixture shall be the same as specified **in Sub-Clause 16-3.5.3 - Construction Requirements**.

11-3.7.4 Placing of the Mixture

The requirements for placing of the mixture shall be the same as specified in **Sub-Clause**

11-3.5.4 Placing of the Mixture

11-3.7.5 Thickness Cores

The requirements for thickness cores shall be the same as specified in **Sub-Clause 11-3.5.5 – Thickness Cores**

11-3.7.6 Tolerance in Construction

The requirements for tolerance shall be the same as specified in **Sub-Clause 11-3.5.6 - Tolerance in Construction**, except that, when the measurement of any unit of pavement is shown to be deficient, the bituminous wearing course shall be rejected and the Contractor shall replace it with a layer of acceptable thickness.

11-3.3.7 Compaction Sampling and Testing

The requirements for compaction sampling and testing shall be the same as specified in **Sub-Clause 11-3.5.7 - Compaction Sampling and Testing**.

11-3.3.8 Weather Limitations

The requirements for weather limitations shall be the same as specified for BBC in **Sub-Clause 11-3.5.8 - Weather Limitations**.

11-3.8 Road Safety Works

11-3.8.1 Steel Crash Barriers

Rails shall be made in standard lengths of 3200 mm effective centre-to-centre of post fixing bolts. They shall be formed from 3 mm (nominal) sheet steel to AASHTO M180, at least 300 mm in depth and corrugated in cross-section to produce a central trough having a depth of at least 75 mm.

They shall be shaped so as to produce no sharp edges to traffic and except where otherwise required shall be straight and of uniform cross-section.

A single length, when freely supported on knife edges placed 3000 mm apart, shall be capable of supporting a load of 1 tons when applied vertically to the traffic face, without deflecting more than 40 mm. The tensile strength of any rail and its lap joint shall be not less than 330 kN.

Adjacent rails shall be connected by lap joints each using 8 No. M 16 bolts. Lap joints shall be made in the direction of the adjacent flow of traffic.

Curved rails shall be supplied as necessary without any lessening of the strength of the barrier, for radii up to 45 m internal or external. For radii greater than 45 m, the individual rails shall not be curved.

Rails shall be mounted on steel posts of 150x75 mm channel section with hardwood pads 150x150x350 mm setting the rail clear of the post. The connection of the rail to the post, through the pad, shall be with a single M16 bolt with a lock nut and two washers. Each post shall be 1800 mm long and set in concrete minimum 350 mm diameter in plan and 1300 mm deep.

The end of each length of railing shall end in a standard wing terminal as shown on the Drawings.

The upper edge of the rail shall be 700 mm above the edge of the carriageway or hard surface.

All steel parts shall be galvanized after fabrication.

11-3.8.2 Pre-cast Concrete Kerbs

Pre-cast concrete kerbs shall be provided at locations shown on the Drawings or as directed by the Project Manager. Kerbs shall be laid on a foundation 400 mm wide and 150 mm thick of 21 MPa concrete mixed with only enough water to hydrate the cement, and shall be backed up with additional concrete finishing 50 m below the top of the kerb. Thereafter, the gap between kerb units shall be pointed with cement/sand mortar.

Kerbs shall be laid true to line and level, with no more than 3 mm steps between adjacent units. Curved kerbs shall be used to form radii of 8 m or less.

11-3.9 Row Markers and Delineators

Posts may be cast in place. Posts shall be cast in the ground to the depth shown on the plans. After the posts have been set in position, any space around them shall be filled with earth free from rock. The filling material shall be thoroughly watered and tamped into place in such a manner as to hold the post securely in position.

Surplus excavated material remaining after the posts have been installed shall be disposed of in a uniform manner along the adjacent roadway as directed by the Project Manager.

11-3.10 Testing

Testing shall be carried out in accordance with the applicable provisions given earlier in this Section.

PART 4 MEASUREMENT AND PAYMENT

11-4.1 General

Excavation for roadway shall be measured and paid for in accordance with the provisions of Section 5, Excavation and Miscellaneous Earthwork.

Roadway fills shall be measured and paid in accordance with the provisions of Section 5, Excavation and Miscellaneous Earthwork.

Edge kerbs shall be measured under Section 8, Concrete work.

Steel Guard Rails shall conform with Section 10, Miscellaneous Metalwork but shall be paid as item of work under this Section.

Provision and application/installation of road- marking paint and road signs shall be paid as items of work under this Section.

11-4.2 Aggregate Base Course

11-4.2.1 Measurement

The volume of aggregate base course acceptably constructed as shown on the Drawings or directed by the Project Manager shall be measured as the product of its nominal width, its nominal thickness and its length measured along the center line of the roadway at the finished roadway surface.

11-4.2.2 Payment

Payment will be made for the number of cubic meter measured as above at the unit price for the Item.

The unit price shall be deemed to cover all costs of constructing the aggregate base course including furnishing, mixing, spreading, compacting, maintaining as specified, testing and reporting and all other work related to the Item.

11-4.2.3 Unit of Measure

Unit of measure: Cubic Meter

11-4.3 Bituminous Prime Coat, Grade MC-1 and Bituminous Tack Coat Grade RC-2

11-4.3.1 Measurement

The volume of bituminous coating material applied shall be measured in liters as the product of the area in square meters acceptably coated at the application rate in Kilogram per square meter as directed by the Project Manager.

11-4.3.2 Payment

Payment will be made for the number of liters measured as above at the corresponding rate for the respective item.

The rate shall be deemed to cover all costs of furnishing, applying and protecting the bituminous coat, including the cost of field trials to determine appropriate rates of application, protection of adjacent structures, blotting, testing and reporting and all other work related to the Item.

11-4.3.3 Unit of Measure

Unit of measure: Liter

11-4.4 Bituminous Wearing Course

11-4.4.1 Measurement

The volume of bituminous wearing course acceptably placed shall be measured as the product of the nominal width of wearing course, its length measured along the center line of the roadway and the compacted nominal thickness of the finished wearing course.

11-4.4.2 Payment

Payment will be made for the number of cubic meter measured as above at the unit rate tendered in the priced Bill of Quantities. The unit rate shall be deemed to include cost of furnishing, mixing, spreading, compacting, testing and reporting and maintaining as specified and all other associated works related to the Item.

11-4.4.3 Unit of Measure

Unit of measure: Cubic Meter

11-4.5 Corrugated Galvanized Steel Guard Rails

11-4.5.1 Measurement

The measurement of Guard Rail in linear meter will be made from end to end length of the Guard Rail acceptably installed.

11-4.5.2 Payment

Payment will be made at the rate quoted on the priced Bill of Quantities. The rate includes cost of providing installing, maintaining as specified and cost of all associated works related to the item.

11-4.5.3 Unit of Measure

Unit of measure: Linear meter

11-4.6 Delineators

11-4.6.1 Measurement

Quantities of Delineators to be paid for will be determined as units from actual count in place.

A delineator post equipped with reflectorized red & white paint will be considered a single delineator.

11-4.6.2 Payment

Payment for measurement will be paid at the tendered rate for delineators of the designated class.

The above rate shall include full compensation for furnishing all labor, materials, tools, equipment and incidentals, and for doing all the work involved in installing delineators, complete in place, as specified and shown on the drawings and as directed by the Project Manager.

11-4.6.3 Unit of Measure

Unit of measure: Each

11-4.7 Road Marking

11-4.7.1 Measurement

Measurement for payment shall be made for full lengths

11-4.7.2 Payment

Payment shall be made at the rate per linear meter tendered in the Bill of Quantities for the lengths measured.

11-4.7.3 Unit of Measure

Unit of measure: Linear Meter

11-4.8 Arrow Marking

11-4.8.1 Measurement

Measurement for payment shall be made for the numbers of Arrows Marked of different types

11-4.8.2 Payment

Payment shall be made at the rate per number tendered in the Bill of Quantities for different types for the total numbers of each type.

11-4.8.3 Unit of Measure

Unit of measure: Number

11-4.9 Regulatory, Warning and Guide Signs

11-4.9.1 Measurement

Measurement for payment shall be made for the numbers of each type of sign installed

11-4.9.2 Payment

Payment shall be made at the rate per number tendered in the Bill of Quantities for each type of sign installed for the total numbers of each type.

11-4.9.3 Unit of Measure

Unit of measure: Number

11-4.10 Kilometer Post

11-4.10.1 Measurement

Measurement for payment shall be made for the numbers of Kilometer Posts installed

11-4.10.2 Payment

Payment shall be made at the rate per post tendered in the Bill of Quantities for the total number of posts installed.

11-4.10.3 Unit of Measure

Unit of measure: Number

11-4.11 Convex Mirror Post

11-4.11.1 Measurement

Measurement for payment shall be made for the numbers of Convex Mirror Posts installed

11-4.11.2 Payment

Payment shall be made at the rate per number tendered in the Bill of Quantities for the total number of Convex Mirror Posts installed.

11-4.11.3 Unit of Measure

Unit of measure: Number

CHAPTER 12 – PAINTING

PART 1 GENERAL

12-1.1 Scope

12-1.1.1 General

In accordance with the Specification contained in this Section and as shown on the Drawings, or as directed, the Contractor shall furnish all plant, Labour, equipment and materials required for the work of painting.

This includes painting of the equipment and appurtenant works for the gates, hoists, stoplogs and miscellaneous metalwork. It also includes painting of exterior, interior walls and ceilings of the buildings.

12-1.1.2 Definitions

In this Section, the following terms shall have the meanings hereby assigned to them:

Paint emulsions, enamels, paints, stains, varnishes, sealers and other coatings, organic or inorganic, whether they be used as primer, intermediate or finish coats. This definition does not include trowelled or sprayed metal coatings.

Shop painting	cleaning and painting operations conducted in or at a shop, mill or plant before shipment of the equipment or material to the Site.
Field painting	application of paint coats at the Site.
Touch-up painting	application of paint on small areas of painted surfaces to repair marks and scratches in order to restore the coating to an unbroken condition.

Repainting cleaning and recoating, with the same materials originally used, of extensive areas on which the existing coatings have been damaged, have deteriorated or otherwise do not provide adequate protection.

12-1.1.3 General Requirements

Surfaces to be painted shall receive the preparatory treatment and number of coats prescribed in the Painting Schedule at the end of this Section, unless specifically exempted elsewhere. The applicable provisions of the US Steel Structures Painting Council (SSPC) Manual shall apply for all metalwork unless specifically stated otherwise.

12-1.1.4 Delivery and Storage

All materials shall be delivered to the Site in original, new, unopened packages and containers bearing the manufacturer's name and label and the following information:

j. Name or title of material;

k. Specification designation, if applicable;

l. Manufacturer's stock numbers and date of manufacture;

m. Manufacturer's name;

n. Contents by volume, for major pigment and vehicle constituent;

o. Thinning instructions;

p. Application instructions, and

q. Colour name and numbers.

Materials shall be stored in accordance with the manufacturer's instructions and protected from moisture, direct sunlight and adverse temperatures. Paint shall be used within the pot life recommended by the manufacturer.

12-1.1.5 Project Conditions

The conditions at the Site as regards painting vary over a wide range. Shade temperatures can be high in the summer months. Winds are generally light, but strong dust-laden winds occur particularly during the hot weather. The Contractor shall plan his painting operations accordingly.

12-1.2 References

12-1.2.1 Agencies

Paint specifications, standards and methods referred to herein, with their abbreviations, are as follows:

Agency	***Abbreviation***
American Society for Testing and Materials	ASTM
US Federal Specification	FS
US Steel Structures Painting Council	SSPC
National Association of Corrosion Engineers	NACE

12-1.2.2 References

The following publications of the titles listed below, but referred to hereinafter by basic designation only, form a part of these Specifications to the extent indicated by the references thereto:

Standard	**Subject**
SSPC-PS 1.04	Three-coat alkyd (lead and chromate-free) painting system for galvanized or non-galvanized steel (with zinc dust- zinc oxide linseed oil primer)
SSPC-Paint 2	Red lead, iron oxide, raw linseed oil and alkyd primer
SSPC-Paint 8	Aluminum vinyl paint
SSPC-Paint 9	White (or colored) vinyl paint
SSPC-Paint 22	Epoxy-polyamide paint

SSPC-Paint 104	White or tinted alkyd paint

U.S. GENERAL SERVICES ADMINISTRATION (GSA)

FS TT-E-489	(Rev J; Notice 1)) Enamel, Alkyd, Gloss, Low Voc Content
FS TT-P-29	(Rev K; Notice 1) Paint, Latex
FS TT-F-1098D	Filler, Block, Solvent-Thinned for Porous Surfaces (Concrete Block, Cinder Block, Stucco, etc.)
FS TT-P-636	Primer Coating, Alkyd, Wood and Ferrous Metal

12-1.3 Submittals

The following shall be submitted for Project Manager's review and approach in accordance with **Sub-Clause 1-1.4 - Submittal Procedures**:

SD 03 Product Data

The Contractor shall submit each manufacturer's product data and recommended work procedures for the application of each system to be exposed to immersion or severe exposure conditions, including procedures to be used for surface preparation, application, inspection and quality verification reporting, and samples of all paints and painting systems utilized.

Complete data on standard products, substitute paints and/or end products shall be submitted to the Project Manager. Submission of insufficient data could constitute a reason for rejection.

SD 04 Samples

Where specifically indicated herein or where indicated in a standard specification for a finished paint product, separate samples of ingredient materials shall be furnished. The ingredient samples shall be clearly identified by commercial name, trade designation, manufacture, batch number and such other data as may be required. Testing of paint for compliance with the Specifications will be performed in an Employer-designated laboratory at no expense to the Contractor except that the cost of testing any sample representing material which replaces material previously rejected will be at the Contractor's expense.

SD 06 Test Reports

Two one-liter samples of each batch of every type and colour of paint and a one- liter sample of each thinner or solvent intended for field thinning shall be submitted to the Project Manager for testing. Each sample shall be clearly labeled to indicate the batch number, batch quantity, type of material, date of production, shelf life, colour, applicable contract number and intended application and shall be submitted not less than 91 days in advance of the date of use of the represented paint. The manufacturer's technical literature shall be submitted with all samples.

PART 2 PRODUCTS

12-2.1 Standard Products

All materials, supplies and articles furnished shall be standard products of recognized reputable manufacturers, shall comply with these Specifications and shall be subject to the Project Manager's approval.

12-2.2 Substitutions

Substitute components may be used provided that, in the opinion of the Project Manager, the end products will be at least equal in application characteristics, durability and all other qualities which had influence on the selection of the specified paint. If substitute components are proposed for use, the Contractor shall obtain and furnish to the Project Manager, prior to purchase, the paint manufacturer's certification, in acceptable form, that the paint produced using the substitute components will be of the same type and at least equal to the paint specified insofar as the quality and performance are concerned and will be compatible with paints required to be used therewith. The Contractor shall also obtain from the manufacturer and furnish to the Project Manager such other substantiating data as the Project Manager may require. Only paints and ingredients specified or approved by the Project Manager in writing shall be used.

12-2.3 Paint Materials

Paint materials used shall conform to the following specifications:

j. Vinyl paints shall conform to SSPC-Paint 8, or SSPC-Paint 9.

k. Epoxy-polyamide shall conform to SSPC-Paint 22 (primer, intermediate and topcoat).

l. Primer shall conform to SSPC-Paint 2.

m. Intermediate and finish coats shall conform to SSPC-Paint 104, Type I, II, III or IV.

n. Machinery enamel shall conform to FS TT-E-489, Class A, air drying.

o. Solvent cleaner for galvanized surfaces shall consist of diluted (about 5% strength) muriatic (hydrochloric), phosphoric or acetic acid. A proprietary treating agent, approved by the Project Manager and applied in accordance with the manufacturer's instructions, may also be used.

p. Solvent cleaner for other than galvanized surfaces shall be in accordance with the recommendations of the paint manufacturer.

q. Interior latex-base paint shall be in accordance with FS TT-P-29.

r. Filler shall be in accordance with FS TT-F-1098, solvent type.

s. Colour pigments for latex base paint shall conform to the applicable ASTM Specifications.

t. For equipment for temporary use, alkyd priming paint conforming to FS TT-P-86, Type 1 or FS TT-P-636.

PART 3 EXECUTION

12-3.1 General

Containers of coatings or components shall not be opened unless for immediate use. Containers shall be kept closed when not in use. Paint shall be applied only when the temperature of the surface to be painted and the surrounding air temperatures are between 10 ºC and 30 ºC, unless otherwise permitted by the paint manufacturer's printed instructions.

Paint shall not be applied in rain or mist, or when the relative humidity exceeds 85%, or when the surface temperature drops to within 4 ºC of the dew point, or to damp or wet surfaces. Painting may be continued during inclement weather only if the areas and surfaces to be painted are enclosed and maintained within the temperature limits specified by the paint manufacturer during the application and drying periods.

Paint shall not be applied when dust is present. Surface preparation and painting shall be programmed so that dust and other contaminants from the surface preparation process and other work performed will not fall or settle on wet, newly painted surfaces. Paint shall not be applied to interior surfaces unless the area is enclosed. Surfaces which will be inaccessible shall be painted before they are enclosed. Other work shall be protected, whether to be painted or not, against defacement or damage by painting. Masking materials shall be used to protect adjacent surfaces.

Time periods between surface preparation and initial paint application and time periods between coats shall be in accordance with the requirements and recommended practices of the SSPC and in accordance with the relevant manufacturer's instructions.

Paint curing temperatures, humidity and time periods shall be in accordance with the manufacturer's instructions.

12-3.2 Surface Preparation

12-3.2.1 General

Preparation and cleaning procedures shall be performed in accordance with the paint manufacturer's instructions and as specified below for each substrate condition.

Surfaces to be coated shall be clean before applying any coating or surface treatment. All oil, grease, dirt, rust, loose mill scale, weld spatter, slag or flux deposit, old weathered coating or other foreign substances shall be removed as hereinafter specified. Welds shall be dressed as necessary for proper adhesion and to prevent excessive thinning of the coating as can occur at sharp edges. Oil and grease shall, in general, be removed before mechanical cleaning is started. Cleaning shall be done as stated in the Painting Schedule at the end of this Section. For surfaces cleaned by blast-cleaning, the anchor pattern shall be as recommended by the coating manufacturer.

Dusty, dirty and greasy surfaces shall be washed with a solution of tri-sodium phosphate and water and rinsed with clean water and allowed to dry. Penetrated oil and grease shall be removed with cleaning solvents. Damaged or loose paint and adhering scaly or blistered paint shall be removed.

Edge breaks in existing paint shall be feathered. Dents, cracks, hollow places, open joints and other irregularities shall be filled with filler suitable for the purpose. Where required, imperfections and holes in surfaces and open joints between matching surfaces shall be filled or obliterated in a manner approved by the Project Manager.

Cleaning and coating shall be programmed so that dust or spray from the cleaning process will not fall on wet, newly coated surfaces. Any wash treatment required by a coating material shall be done in accordance with the coating manufacturer's instructions. Blast cleaning shall be planned and carried out in a manner to prevent blasting materials from damaging machined surfaces and precision parts.

All hardware, hardware accessories, machined surfaces, plates, lighting fixtures and similar items shall not be finish-painted. They shall either be removed or surface-applied protection shall be provided prior to surface preparation and painting operations. Removal of these items for painting and their replacement shall be by workers skilled in the trades involved.

12-3.2.2 Cementitious Materials

Cementitious surfaces of concrete and plaster shall be prepared by removing all efflorescence, chalk, dust, dirt, grease, and oils and by roughening as required to remove glaze.

The alkalinity and moisture content of the surfaces to be painted shall be determined by performing appropriate tests. If the surfaces are found to be sufficiently alkaline to cause blistering and burning of the finish paint, this condition shall be corrected before application of paint. No paint shall be applied over surfaces where the moisture content exceeds that permitted in the manufacturer's printed directions.

12-3.2.3 Ferrous Metals

Ferrous surfaces which are not galvanized or shop-coated shall be cleaned of oil, grease, dirt, loose mill scale, loose rust, weld spatter, flux and other foreign substances by the cleaning process described in the Painting Schedule at the end of this Section.

Uninsulated interior ferrous conduit, piping and ductwork shall be painted in accordance with SSPC-PS 1.04 using alkyd eggshell enamel.

Uninsulated interior galvanized conduit, piping and ductwork shall be painted in accordance with SSPC-PS 1.04 with zinc dust-zinc oxide primer and alkyd eggshell enamel.

12-3.3 Coating Application

12-3.3.1 General

Paint application shall be performed in accordance with the paint manufacturer's instructions and as specified herein. Application shall conform with the methods recommended in SSPC - PA 1.

12-3.3.2 Brush Application

All prime coats shall be brush-applied unless the use of roller or mechanical applicators is approved.

Brush coats shall be brushed-out and worked onto the surfaces in both directions in a uniform film of the thickness required to achieve the specified dry film thickness. Brushes best suited for the type of material being applied shall be used. Cloudiness, spotting, holidays, laps, brush marks, runs, sags, droopiness and other surface imperfections will not be acceptable. All glass and colour break lines shall be neatly drawn.

12-3.3.3 Roller Application

Roller coats shall be rolled-out and worked onto the surfaces in both directions in a uniform film of the thickness required to achieve the specified dry film thickness. Sleeves used on the rollers shall be clean, full clipped pile or as recommended by the paint manufacturer for the material used and the texture required. Cloudiness, spotting, holidays, laps, marks, runs, sags and other surface imperfections will not be acceptable.

Brushes shall be used at corners, fasteners, irregular surfaces and other like conditions.

12-3.3.4 Spray Application

The use of spray methods of paint application shall be subject to approval by the Project Manager.

Spraying equipment shall be suitable for the specific paint application and shall maintain paint ingredients uniformly mixed in the spray pots or containers.

The manufacturer's recommendations shall be closely observed regarding the use of thinners, spray operating techniques, etc.

Paint shall not be double-backed with spray equipment for the purpose of building up a film thickness of 2 coats in one pass.

12-3.3.5 Air Supply

Compressed air shall be used to blow off all blasting residue.

Compressed air shall be checked for the presence of oil and water by wiping a clean white cloth over a clean, smooth, metal surface upon which the air stream has been impinged for a period of not less than two minutes, the orifice being held not more than 500 mm away from the surface. Alternately, the air stream may be projected against a square of

white blotter paper taped around its complete periphery to a substantial surface. Sufficient freedom from oil and water is confirmed if no soiling or discolouration is visible.

If air contamination is evidenced, the filters shall be changed or cleaned, traps emptied, after-coolers, moisture separators or filters added, the equipment maintained, or such adjustments made as may otherwise be required to achieve clean air. This test shall be performed for each compressor used during a given shift, no sooner than 1/2 hour after starting the compressor.

12-3.3.6 Inaccessible Parts

All cleaning, surface preparation and coating application work shall be done after the parts are completely finished and checked in the shop. The parts shall be disassembled to the extent necessary to enable cleaning and coating those surfaces which are inaccessible when assembled. After finish coating and curing, parts shall be reassembled as required for shipment, and coatings on those bolts and other connections that will not be removed in erection shall be touched-up.

12-3.3.7 Protection of Coated Surfaces

Where shelter and/or heating or cooling are provided for paint surfaces during inclement weather, such protective measures shall be maintained until the paint film has dried and discontinuance of the measures is authorized. Items, which have been painted, shall not be handled, worked on or otherwise disturbed until the paint coat is fully dry and hard. All metalwork coated in the shop or field prior to final erection shall be stored out of contact with the ground and damp surfaces in such manner and location as will prevent the trapping of water in pockets, soiling, contamination and deterioration of the paint film. Such metalwork shall be cleaned and repainted or touched-up from time to time, with the specified paint, whenever it becomes necessary to maintain the integrity of the film.

12-3.3.8 Time between Surface Preparation and Coating

Surfaces which have been cleaned, pretreated, blasted or otherwise prepared for coating shall be primed within four hours after such preparation has been completed and prior to visible deterioration of the prepared surface.

12-3.3.9 Method of Coating Application

Application of the coating system shall be in accordance with the recommendations of the coating manufacturer, and the coating application procedure to be used shall be submitted for review and approval by the Project Manager prior to the initiation of coating operations. These application instructions will be used by the Project Manager for inspection and shall specify the following information:

j. Ambient temperature and humidity requirements for application of coating materials;

k. Criteria for curing time, as a function of temperature;

l. The minimum and maximum dry film thickness of each coat; and

m. A repair procedure for any areas, which have been damaged.

12-3.3.10 Coating Progress

Where field painting on any type of surface has commenced, the complete painting operation, including priming and finishing coats, on that portion of the work, shall be completed as soon as practicable, without prolonged delays. Sufficient time shall be allowed to elapse between successive coats to permit them to dry properly for recoating and this period shall be modified as necessary to suit adverse weather conditions. Paint shall be considered dry for recoating when it feels firm, does not deform or feel sticky under moderate pressure of the finger and the application of another coat of paint does not cause such film irregularities as lifting or loss of adhesion of the undercoat.

All coats of all painted surfaces shall be unscarred and completely integral at the time of application of all succeeding coats. Repairs to damaged areas of coatings shall be carried out as directed by the Project Manager.

At the time of application of each successive coat, undercoats shall be cleaned of dust, grease or foreign matter by means of air blast, solvent cleaning or other means. Cement and mortar deposits on painted steel surfaces, not satisfactorily removed by ordinary cleaning methods, shall be brushed-off blast-cleaned and the steel completely repainted as required. Enamel undercoats shall, if necessary, be scuff-sanded or otherwise treated to decrease objectionable gloss and to provide a satisfactory bond prior to application of a succeeding coat. Field coats on metal shall be applied after erection except as otherwise specified or directed by the Project Manager and excepting surfaces to be painted which will become inaccessible after erection.

12-3.3.11 Curing

Curing of coating materials shall be performed in strict accordance with the coating manufacturer's recommendations.

12-3.4 Colors

Colors shall be as directed. Alternate coats of paints having the same colour shall be tinted to ensure that all surfaces are properly coated with the specified number of paint coats.

12-3.5 Field Touch-up Material

For shop-painted equipment, coating materials for field touch- up work shall be stored by the Contractor at the Works in containers showing the designated name, formula or specification number, colour, manufacturer and date of manufacture.

12-3.6 Protection of Unpainted Surfaces

12-3.6.1 Mating Machined Surfaces

Mating machine-finished surfaces including bored and reamed holes shall be thoroughly cleaned of foreign matter and coated with a suitable rust-resisting compound which can

be easily removed by a commercially available petroleum solvent. Finished surfaces of large parts shall be further protected with polyethylene covered wooden pads or by other suitable means. Unassembled fittings, pins, bolts and nuts shall be oiled and wrapped with moisture-resistant paper or protected by other means as approved by the Project Manager.

12-3.6.2 Other Surfaces

Corrosion-resisting surfaces shall not be coated. The corrosion-resisting surfaces shall be thoroughly cleaned of coating splashes and foreign matter and suitably protected from damage during handling and shipment. Surfaces not intended to be painted shall be suitably protected from the effects of cleaning and painting operations. Machinery and equipment shall be protected against entry of blast abrasive and dust into the working parts.

Surfaces already painted which are adjacent to surfaces to be painted shall be protected by covering or masking against splashes or accidental overlap.

12-3.7 Painting of Contractor-Furnished Equipment

Contractor-furnished equipment may be shop painted or field painted as selected by the Contractor, except as otherwise specified. Shop painting may consist of the specified surface preparation and prime coats with the remainder of the finish coats applied in the field or may consist of the specified surface preparation and the specified total number of coats, except that epoxy resin systems shall be applied in the field.

Surfaces requiring protection during shipment shall be painted in the shop with the necessary shop coats. The prime coats and the finished coats shall be touched-up as necessary in the field. Manufacturer's stock items subject to atmospheric exposure which are normally cleaned and primed or painted in accordance with the manufacturer's standard practice may be exempted from the specified requirements for surface preparation and the first coat.

The interior of pipes 600 mm diameter or smaller need not be painted except as specified otherwise.

Surfaces shop-painted with the manufacturer's standard finish shall be field-painted with finish coats compatible with the shop coats, and the paints used on ferrous metal subject to atmospheric exposure shall be compatible with later application of either alkyd or oil-base coatings if so directed. Surfaces to be coated shall receive the preparatory treatment and number of coats specified herein. The applicable provisions of the SSPC Manual, Volumes 1 and 2, shall apply unless specifically modified herein.

12-3.8 Cleaning

During the progress of the work, all discarded paint materials; rubbish, cans and rags shall be removed from the Site at the end of each workday. Upon completion of painting work, window glass and any other paint-spattered surfaces shall be cleaned. Spattered paint

shall be removed by proper methods of washing and scraping, using care not to scratch or otherwise damage finished surfaces. Scratched or damaged finished surfaces shall be replaced by the Contractor at no extra cost to the Employer.

12-3.9 Testing

12-3.9.1 General

Inspection and testing shall include, but not necessarily be limited to, the following items:

j. Temperature and humidity requirements for application and curing as set forth in approved application procedures.

k. Curing times and conditions for curing as set forth in approved application procedures.

l. Surface cleanliness and anchor profile by visual methods as specified or set forth in approved application procedures.

m. Required film thickness as specified or set forth in approved application procedures.

n. Holiday testing by wet sponge method. Coatings shall be 100% holiday free.

PART 4 MEASUREMENT AND PAYMENT

12-4.1 General

No separate payment will be made for painting. The cost of painting shall be covered by the rates specified in Bill of Quantities for various items which are required to be painted as per various Sections of the Specifications and shall include the preparation of surfaces, application of paint, and all other work related to the painting specified herein.

CHAPTER 13 - MISCELLANEOUS WORKS

PART 1 GENERAL

13-1.1 Scope

This Section covers general requirements for constructing, furnishing, installing, and testing of items of miscellaneous work not covered in other sections of the specification and includes the followings:

- Elastomeric Bearing Pads

The Contractor shall detail, furnish, fabricate, assemble, install, test and paint miscellaneous work in accordance with these Specifications as in Sections 18 and as shown on the Drawings or as directed:

13-1.2 References

The publications listed below form a part of this section to the extent referenced:

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

AASHTO M 306	(1990) Standard Specification for Drainage Structure Castings
AASHTO – ASH 106	(2003) Standard Specification for Highway Bridge- 17th Edition

ASTM INTERNATIONAL (ASTM)

ASTM A 123/A 123M	(2002) Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products
ASTM A 48M	(1994; Rev A) Standard Specification for Gray Iron Castings (Metric)
ASTM A 74	(1998) Standard Specification for Cast Iron Soil Pipe and Fittings
ASTM D 2750	(1993) Acrylonitrile-Butadiene-Styrene (ABS) Plastics Utilities Conduit and Fittings

13-1.3 Submittals

The following shall be submitted for Project Manager's review and approval in accordance with **Clause 1-1.4 - Submittal Procedures** in sufficient detail to show full compliance with the specification:

The Contractor shall submit construction programs, photographs, progress reports, test reports and drawings as applicable to the work under this Section. The applicable provisions of **Clause 13-1.3 - Submittals** shall apply to all submissions by the Contractor under this Section.

SD-01 Preconstruction Submittals

Records of Existing Conditions shall be submitted by the Contractor prior to construction.

SD-02 Shop drawings

The Contractor shall submit to the Project Manager Shop drawings of all sheet metalwork for approval, before work is fabricated and installed.

Equipment layout is to be detailed on shop drawings, showing the method of installation and clearly illustrating components to be used in making all connections.

SD-03 Product data

Manufacturers' performance data, performance curves and certified factory drawings giving full information as to capacity, dimensions, materials and all other information pertinent to the adequacy of the equipment shall be submitted to the Project Manager for approval. Manufacturers' names of equipment, sizes, catalogue numbers and samples of materials shall also be submitted as required by the Project Manager for approval.

SD-04 Samples

The Contractor shall submit samples of materials to be used by him for approval by the Project Manager including the following

- Elastomeric Bearing Pads

SD-05 Test Reports

Reports for the following shall be submitted in accordance with **Clause 13-2.4 - Reports** of this section.

- Test Reports
- Inspection Reports

SD-06 Certificates

Certificates of compliance for the following items shall be submitted in accordance with the applicable reference standards and description of this section:

- Materials for concrete according to Section 8, Concrete Work

13-1.5 Existing Conditions

Existing Conditions shall be submitted after a thorough inspection of the area by the Contractor in the presence of the Project Manager. Details should include the condition of environment and other areas adjacent to site work. Copies of the record shall be submitted and the stated conditions before starting work shall be verified.

PART 2 PRODUCTS

13-2.1 Plumbing Fixtures and Accessories

13-2.1.1 General

The plumbing fixtures specified below shall comply with the relevant Standards listed in **Clause 13-1.2 - References**. Each fixture shall be furnished and installed as shown on

the Drawings and in accordance with the manufacturer's instructions, and shall be subject to the approval of the Project Manager.

Each fixture shall be complete with all accessories, connections of cold and hot water and connections to soil, waste and vent pipes, as appropriate.

13-2.1.2 Wash basins

Each wash basin shall be of glazed vitreous china or earthenware of approved manufacture and at least 450 x 550 mm in size. It shall be provided as a complete unit including:

- 15 mm chromium plated (CP) brass taps,
- 15 mm CP stop-cocks,
- CP chain with rubber plug,
- CP bottle trap for each individual wash basin and CP P-trap for each battery of wash basins, as applicable,
- CP strainer,
- Heavy cast iron brackets with bolts, screws, etc.,
- Plastic water inlet connections and waste pipes,
- CP outlet, and
- Joints, jointing and sealing material, and all other accessories required in all respects.

13-2.1.3 Mirrors

One bevelled-edge glass mirror of first class quality securely fixed on treated hardboard packing shall be fixed on the wall for each wash basin. The glass shall be at least 6 mm thick and shall be 600 mm x 450 mm in size.

13-2.1.4 Kitchen sinks

Each kitchen sink shall be stainless steel of approved make, single bowl with integral drain board 1000 x 500 mm in size. It shall be provided as a complete unit with arrangement for both cold and hot water supplies and shall include:

- 15 mm CP stop-cocks,
- waste inlet connection,
- CP mixer tap with extended spout,
- CP strainer,
- CP chain with rubber plug,
- CP bottle trap,
- CP waste outlet and plastic waste pipe,
- heavy cast iron brackets with bolts, screws, etc., and

- Joints, jointing and sealing material, and all other accessories.

13-2.1.5 Water Closets - Squatting (or Arabic) type

Each squatting (Arabic) type water closet, of size and manufacturer as approved by the Project Manager, shall have glazed vitreous china or glazed earthenware pan. It shall be provided as a complete unit including:

- 15 mm CP bib-cock,
- 15 mm CP stop-cock,
- plastic water inlet connection pipe,
- water cistern installed at a low level including interconnecting flush piping, and
- foot-rests, cast iron P-trap, joints, jointing and sealing material, and all other
- accessories.

13-2.1.6 Water closets - European type

Each European-type water closet (WC), of size and manufacturer approved by the Project Manager, shall meet all the requirements specified for Arabic-type water closets except that the trap shall be cast integral with the pan. The WC shall be provided additionally with a seat and a toilet paper holder. The seat shall be of a smooth, non-combustible, non-absorbent material such as bakelite and of open front type fixed to the pan with CP hinges.

13-2.1.7 Toilet paper holders

Each toilet paper roll holder shall be of CP with CP brackets and screws, and shall be fixed to the wall beside the water closet.

13-2.1.8 Urinals

Urinals shall be of stall type, either with an integral water seal trap or with a separate CP brass P-trap. The complete unit shall be installed including 15 mm CP stop-cock, plastic water inlet connection pipe, white ceramic or glazed earthenware automatic flush tank of 4 liters capacity with heavy duty cast iron brackets, bolts, screws and all internal accessories, CP steel flush pipe, CP steel waste pipe, joints, jointing and sealing material, etc., complete with all other accessories. Wherever two or more urinals are located in a row one flush tank shall be provided for every pair of urinals.

13-2.1.9 Traps

Traps shall be of self-cleaning design, provided with 38 mm water seal. Traps used for underground installation shall be of cast iron. The average thickness of wall shall be 5 mm and at no point shall the thickness be less than 4 mm. All waste traps shall have a grating or cross bars formed integrally. The grating shall be designed so as not to unduly restrict the flow of waste water.

13-2.1.10 Cleanouts

All cleanouts in the sewerage system shall be closed with brass screw caps. All brass screw caps shall be not less than 3 mm thick. Each screw cap shall have a solid square or hexagonal nut not less than 25 mm high, with a minimum diameter of 38 mm. The body of the cleanout ferrule shall be at least equivalent in weight and thickness to the caulking ferrule for the same size of pipe as shown below. The engaging parts of the screw cap shall have not less than six threads and shall be of cast iron pipe size and tapered.

NOMINAL PIPE SIZE	***LENGTH***	***WEIGHT***
(mm)	***(mm)***	***(kg)***
50	113	0.45
75	113	0.79
100	113	1.14

13-2.1.11 Showers

A showerhead shall consist of a corrosion-resisting cast or fabricated sheet metal rose with perforations and shall be adjustable for angle of spray. If only cold water supply is available, each showerhead shall be controlled with a screw down stop valve. If both cold and hot water supplies are available, then the shower shall be arranged for hot and cold water supplies blended manually by means of a mixing valve, a thermostatic mixing valve or a thermostatic blender. Valves for the control of the water supply shall be within the reach of the user when tubing a bath.

13-2.1.12 Eyewash

Each eyewash shall be wall mounted with cast aluminum receptor, integral mounting brackets, twin chrome-plated brass anti-squirt, push-type ball valve that stays open until manually closed, and dual automatic pressure compensation devices that assure water flow under varying pressures. The fixture shall be Model 7300 as cp 2 manufactured by the Haws Drinking Faucet Company, Berkeley, CA, or equivalent.

13-2.1.13 Drinking water fountain

Each drinking water fountain supplied shall be of an approved make and shall operate at 230 V, 50 Hz. The drinking water fountain shall be fitted with auto thermostat, two water taps, inlet and drainage pipes, etc. The inlet and drainage pipes shall be connected to the treated water distribution system and waste water system respectively. The drinking water fountains shall be installed at the locations shown on the Drawings.

13-2.1.14 Electric water heater

Automatic electric water heaters shall be of an approved make having a steel tank factory-fitted with glass lining and tested to 150% of working pressure. Each heater shall include a thermostat and a high temperature cut-off, fibre glass insulation, safety valve, etc. Electric water heaters shall be installed at the locations shown on the Drawings and connected to the treated water distribution system.

13-2.1.15 Kitchen Unit

The Unit shall comprise a sink, electric cooking range, refrigerator and overhead cabinet, all of white enameled steel construction, together with 12 mm cold and hot water supplies and 40 mm waste connections. The power supply to the unit shall be 230 V, 50 Hz, single phase, 3-wire. The Unit shall be series E-69SC and E-84-SCR as manufactured by Dwyer Products Corporation, Michigan City, Indiana 4-6360, USA or equivalent.

13-2.2.6 Cement Mortar

Mortar shall consist of 1 part Portland Cement and 2 parts fine sand with enough water to produce mortar of the proper consistency for the type of joint. Cement, sand, water shall be according to Section 8, Concrete Work.

13-2.2.7 Manholes

(a) Construction

Manholes shall be constructed of concrete, reinforced pre-cast-concrete rings, pre-cast concrete rings, or pre-cast-concrete segmental blocks, with cast iron frames and covers. Frames and covers shall be bolted down and as necessary. Frames and covers shall be set so that the top of the cover is 100 millimeter higher than finished grade, where no pavement exists. Where pavement does exist, frames shall be flush with surface. Invert channels shall be smooth and semicircular in shape conforming to the inside of the adjacent sewer section. Changes in direction of flow shall be made with a smooth curve of as large a radius as the size of the manhole will permit. Changes in size and grade of the channels shall be made gradually and evenly.

(b) Invert Channels

Invert channels shall be formed directly in the concrete of the manhole base. Flooring of the manhole outside the channels shall be smooth and shall slope toward the channels, neither less than 25 millimeters per 300 millimeter nor more than 50 millimeter per 300 millimeter. The free drop inside the manholes shall not exceed 460 millimeter measured from the invert of the inlet pipe to the top of the floor of the manhole outside the channels. Drop manholes shall be constructed whenever the free drop would be greater than 460 millimeter.

(c) Concrete

Concrete used in manholes shall be Grade 21 as specified in Section 8, Concrete Work and shall be composed of not less than six 7-1/2 bags of Portland cement per cubic meter. Coarse aggregate shall be used maximum possible but consistent with required workability. The foregoing requirements apply to concrete in pre-cast rings, segmental blocks, and concrete poured in place. Concrete rings shall conform to ASTM C 76M, except that the length of sections may be shorter as conditions require. Wall thicknesses shall be not less than 100 millimeter nor less than 1/12 the diameter of the manhole for either vertical walls or cone sections and shall be reinforced with not less than 3 square millimeter of steel per 300 millimeter of height. Joints between pre-cast rings shall be full-bedded in cement mortar and shall be smoothed to a uniform surface on both the interior

and exterior of the manhole. Segmental blocks shall be at least 130 millimeter but not more than 200 millimeter in thickness, not less than 200 millimeter in length, and of a shape that the joints can be effectively sealed and bonded with cement mortar.

(d) Ladders

When the depth from the top of the cover to the invert of the main sewer exceeds 3700 millimeter, manholes shall be provided with a straight steel ladder not less than 400 millimeter in width with 20 millimeter diameter rungs spaced 300 millimeter on center. Ladder shall be adequately anchored to the wall by means of steel inserts spaced not more than 1830 millimeter apart vertically and installed to provide at least 170 millimeter of toe space between the wall and the inside of the rungs. Stringers shall be 15 by 40 millimeter steel bars. Ladder and inserts shall be galvanized after fabrication in accordance with ASTM A 123/A 123M. Wall along the line of the ladder shall be vertical its entire height.

(e) Jointing and Plastering

Mortar for jointing and plastering shall consist of 1 part Portland Cement and 2 parts fine sand with enough water to produce a workable consistency. Joints shall be completely filled, smooth, and free from surplus mortar on the inside of the manhole.

13-2.2.8 Septic Tank and Soak Pit

The Contractor shall provide and construct a reinforced concrete septic tank of capacity 4500 liters with inlet, outlet, vents, manhole covers and frames, sludge removal arrangement and all other related items.

The soakage pit shall be of required size but not less than 3 m diameter and 6 m depth with top slab, intermediate slab, vent, manhole covers, frames and all other related items. The Contractor shall connect the sewer with the septic tank and then to the soak pit.

13-2.3 Elastomeric bearing pads

Elastomeric bearing pads as herein specified shall include plain bearings, consisting of elastomer only, and laminated bearing pads, consisting of layers of elastomer restrained at their interfaces by bonded laminates. The elastomer portion of the elastomeric compound shall be 100% virgin chloroprene (neoprene) meeting the requirements of Section 2.25.2, Table B of the AASHTO Standard Specifications for Highway Bridges. Material having a nominal Durometer hardness of 70 shall be used for plain elastomeric bearings and a Durometer hardness of 50 for laminated bearings.

Laminates shall be rolled mild steel sheets conforming to ASTM A36 unless otherwise specified.

13-2.4 Reports

- Test Reports shall be submitted. Compaction and density test shall be in accordance with Section 5, Excavation and Miscellaneous Earthwork.

- Inspection Reports for daily activities during the installation of the sanitary system shall be submitted. Information in the report shall be detailed enough to describe location of work and amount (footage) laid.

PART 3 EXECUTION

13-3.1 Plumbing Fixtures and Accessories

All Plumbing fixtures and accessories shall be furnished and installed according to manufacturer's instructions and method approved by the Project Manager.

13-3.1.1 Plumbing Fixture Supports

All plumbing fixtures shall be supported and fastened in a satisfactory manner. Where secured to concrete or masonry, they shall be fastened with bronze or brass expansion bolts. Where fixtures are secured to partitions, they shall be fastened with brass toggle or through bolts. Where secured to partitions faced with glazed tile or mosaic, the expansion element or toggle shall be set behind the back of the tiling. Otherwise, inserts shall be installed flush with the finished wall or floor line and shall be completely concealed where the fixtures are installed. Bolt heads and nuts shall be hexagon. Exposed bolts, nuts, cap nuts, washers, and screws for fixtures shall be brass, chromium-plated.

13-3.2 Septic Tank and Soak Pits

Excavation of septic tank and soak pits shall be according to Section 5, Excavation and Miscellaneous Earthworks.

Construction of septic tank and soak pits shall be according to Section 8. Concrete Work.

13-3.3.3 Infiltration and Exfiltration

Leakage shall not exceed a rate of 18.5 liter per millimeter of pipe diameter per kilometer per day of sewer for any section between successive manholes. When infiltration appears excessive, the amount of leakage shall be measured by a suitable device. When the determination of infiltration is not practicable because of dry trench conditions, exfiltration tests shall be made by filling the sewer between successive manholes with water to the top of the outlet of the upper manholes. Amount of water required to maintain the pipe full for the required test period shall be measured and the rate of leakage determined. When leakage exceeds the maximum amount, an approved correction shall be made. Both measurement and correction shall be made at no additional cost to the Employer.

13-3.3.4 Wye Branches

Commercially manufactured wye branches shall be installed where sewer connections are necessary. Cutting into pipe for connections shall not be done except as approved. When

conditions are such that the connecting pipe cannot be adequately supported on undisturbed earth or tamped backfill, the pipe shall be encased in concrete or supported on a concrete cradle as directed. Concrete required due to faulty construction methods or negligence of the Contractor shall be installed at no additional cost to the Employer.

13-3.3.5 Acceptance

Sections of the sewer found defective in material, alignment, grade, or joints shall be corrected at no additional cost to the Employer before acceptance.

13-3.4 Elastomeric Bearing Pads

13-3.4.1 General

Elastomeric bearings, when specified, shall be furnished in assemblies, and shall be installed as shown on the Drawings. Any damaged bearing shall be replaced by the Contractor. The elastomeric bearing assemblies shall be furnished as complete units from one manufacturing source, unless otherwise approved in writing by the Project Manager.

13-3.4.2 Fabrication

Plain bearings may be moulded individually, cut from previously moulded strips or slabs, or extruded and cut to length. Cut edges of plain bearings shall be at least as smooth as ANSI 250 finish.

Laminated bearings shall have all components moulded together into an integral unit. All edges of the non-electric laminations shall be covered by a minimum 3 mm thickness of elastomer, except at laminate restraining devices and around holes that will be entirely closed on the finished surface.

Bearing assemblies, which include a top structural steel bearing plate to be bonded to the bearing, shall be furnished as a complete unit. The elastomeric bearing shall be bonded by vulcanizing to the structural steel bearing plate. Epoxy-type bonding shall not be permitted. Bonding of the structural steel bearing plate shall be done in the shop. Field bonding shall not be permitted.

13-3.4.3 Tolerances

For both plain and laminated bearings, the variation from the dimensions and configurations shown on the Drawings shall not be greater than the following:

DIMENSIONS	PERMISSIBLE VARIATION
Overall vertical dimensions	
Total thickness 32 mm or less	- 0, + 3 mm
Total thickness over 32 mm	- 0, + 6 mm
Overall horizontal dimensions	
900 mm and less	- 0, + 6 mm

over 900 mm - 0, + 12 mm

Thickness of individual layers

Thickness of individual layers of elastomer (laminated bearings only) - 0, + 3 mm

Variation from plane

Variation from a plane parallel to the theoretical surface (as determined by measurements at the edges of the bearings):

Top 3 mm

Sides 6 mm

Individual non-elastic laminates 3 mm

13-3.4.4 Construction methods

The bearings shall be attached to the structures as shown on the Drawings. Exposed edges and other exposed portions of the structural steel bearing plates shall be cleaned and painted in accordance with Section 18, Painting. During cleaning and painting, the elastomer shall be protected from abrasion and paint

PART 4 MEASUREMENT AND PAYMENT

13-4.1 General

This Clause covers measurement and payment for furnishing, installing and or constructing items of miscellaneous items of works for the project.

The unit prices for furnishing installing, and or constructing items of miscellaneous items of works shall be deemed to cover all costs of designing, detailing, furnishing and storing of such equipment and of installing, and or constructing testing, painting and commissioning it, including the supply of erection materials, all as specified and as shown on the Drawings or as directed.

13-4.2 Furnish, Install and Construct Sewer System

Different Items of Sewer System shall be measured and paid as shown on the following table and are acceptably installed in the Permanent Works:

ITEM	***UNIT***
Septic tank (4500 liters)	Each
Soak pit	Each
Manhole	Each

13-4.2.1 Measurement

Measurement shall be made in units mentioned in the table above for different items of the Sewer System.

13-4.2.2 Payment

Payment for above mentioned different items comprising the Sewer System will be made at the related tendered rates quoted in the Bill of Quantities.

The rates for providing and installing of different items of Sewer System shall be deemed to cover all costs of providing, installing, constructing with required fittings like bends etc as required and included in pipe length (with no additional payment), testing and commissioning, and all other work related to the Item.

The rates shall also be deemed to also include for weld joints, flanges, bolts, nuts, washers, lead, oakum, gaskets, sealing compounds, solder, coatings, fastenings for holding pipe in place, excavation, backfilling, wall plates or other items required.

13-4.3 Manholes of Depths more than 1.5 m

13-4.3.1 Measurement

The quantity of manholes will be measured as the total number of manholes, complete with frames and gratings or covers and, where indicated, with fixed side-rail ladders, constructed of depth more than 1.5 m in the accepted work. The depth of manholes will be measured from the top of grating or cover to invert of outlet pipe.

13-4.3.2 Payment

Manholes constructed to depths greater than the depth specified above will be paid for as units at the contract unit price for manholes upto depth of 1.5m with, an additional amount per linear meter or part of it to be paid as one linear meter for the measured depth beyond the depth of 1.5 meters.

13-4.3.3 Unit of Measure

Unit of measure: Each

Unit of measure (more than 1.5 m): Linear Meter

13-4.4 Plumbing Fixtures and Accessories

13-4.4.1 Measurement and Payment

Measurement and payment for the provision and installation of plumbing fixtures and accessories shall be made in accordance with the requirements of Sub-Clause 13.5 - Provisional Sums, of the Conditions of Contract.

13-4.5 Expansion and Fixed Elastomeric bearing pads

13-4.5.1 Measurement

Elastomeric bearing pads of types Expansion and Fixed shall be measured as the volume of elastomeric bearing pads in cubic meter as shown on the Drawings and acceptably installed in the Permanent Works.

13-4.5.2 Payment

Payment will be made for the volume of both types of bearing pads measured as above at the respective unit price for the Item. The unit rates for elastomeric bearing pads shall be deemed to cover all costs of elastomeric bearing pads including supply, installation and all other work related to the Item.

13-4.5.3 Unit of Measure

Unit of measure: Cubic Meter

CHAPTER 14 - SECURITY FENCING AND GATE

PART 1 GENERAL

14-1.1 References

The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM A 121	(1999) Zinc-Coated (Galvanized) Steel Barbed Wire
ASTM A 153/A 153M	(2003) Zinc Coating (Hot-Dip) on Iron and Steel Hardware
ASTM A 780	(2001) Repair of Damaged and Uncoated Areas of Hot-Dipped Galvanized Coatings
ASTM A 824	(2001) Metallic-Coated Steel Marcelled Tension Wire for Use with Chain Link Fence
ASTM F 1043	(2000) Strength and Protective Coatings on Metal Industrial Chain-Link Fence Framework
ASTM F 1083	(1997; R 2003) Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures
ASTM F 1184	(2003) Industrial and Commercial Horizontal Slide Gates
ASTM F 626	(1996a; R 2003) Fence Fittings
ASTM F 668	(1999a) Poly(Vinyl Chloride) (PVC) and other Organic Polymer-Coated Steel Chain-Link Fence Fabric
ASTM F 883	(1997) Padlocks
ASTM F 900	(2003) Industrial and Commercial Swing Gates

14-1.2 Submittals

The following shall be submitted in accordance with **Clause 1-1.4 - Submittal Procedures** in sufficient detail to show full compliance with the specification:

SD-07 Certificates

- Chain Link Fence

Statement, signed by an official authorized to certify on behalf of the manufacturer, attesting that the chain link fence and component materials meet the specified requirements.

14-1.3 Approval of Polyvinyl Chloride-Coated Fence Materials

Polyvinyl chloride-coated fence materials shall be thoroughly inspected for cracking, peeling, and conformance with the specifications by the Project Manager prior to installation. Any fence materials rejected by the Project Manager shall be replaced by the Contractor with approved materials at no additional cost to the Employer.

PART 2 PRODUCTS

14-2.1 Fence Fabric

Fence Fabric shall be Chain Link

Class 2b polyvinyl chloride-coated steel fabric with 92 grams of zinc coating per square meter in accordance with ASTM F 668 green in colour. Fabric shall be fabricated of 9-gauge wire woven in 50 mm mesh. Fabric height shall be as shown on drawings. Fabric shall be twisted and barbed on the top selvage and knuckled on the bottom selvage.

14-2.2 Gates

ASTM F 900 and/or ASTM F 1184. Gate shall be the type and swing shown. Gate frames shall conform to strength and coating requirements of ASTM F 1083 for Group IA, steel pipe, with external coating Type A, nominal pipe size as shown on drawings. Gate frames shall conform to strength and coating requirements of ASTM F 1043, for Group IC, steel pipe with external coating Type A or Type B, nominal pipe size as shown. Gate fabric shall be as specified for chain link fabric. Gate fabric shall be attached to the gate frame by method standard with the manufacturer except that welding will not be permitted. Latches, hinges, stops, keepers, rollers, and other hardware items shall be furnished as required for the operation of the gate. Latches shall be arranged for padlocking so that the padlock will be accessible from both sides of the gate. Stops shall be provided for holding the gates in the open position. Each end member of gate frames shall be extended sufficiently above the top member to carry three strands of barbed wire in horizontal alignment with barbed wire strands on the fence.

14-2.3 Posts and Braces for Fence

Fence posts braces shall be of pre-cast concrete having shape, dimension, reinforcement and concrete grade as shown on drawings.

14-2.4 Wire

14-2.4.1 Tension Wire

Tension wire shall be Type I or Type II, Class 4 coating, in accordance with ASTM A 824.

14-2.4.2 Barbed Wire

Barbed wire shall conform to ASTM A 121 zinc-coated, Type Z, Class 3, or aluminum-coated, Type A, with 12.5 gauge wire with 14 gauge, round, 4-point barbs spaced no more than 125 mm apart.

14-2.5 Accessories

ASTM F 626. Ferrous accessories shall be zinc or aluminum coated. Ferrous accessories shall also be polyvinyl chloride-coated, minimum thickness of 0.152 mm, maximum thickness of 0.381 mm. Color coating of fittings shall match the color coating of the fabric. Truss rods shall be furnished for each terminal post. Truss rods shall be provided with turnbuckles or other equivalent provisions for adjustment. Barbed wire support arms shall be the V arm type and of the design required for the post furnished. Tie wire for attaching fabric to rails, braces, and posts shall be 9 gauge steel wire and match the coating of the fence fabric. Tie wires for attaching fabric to tension wire on high security fences shall be 1.6 mm stainless steel. The tie wires shall be a double loop and 165 mm (6.5 inches) in length. Miscellaneous hardware coatings shall conform to ASTM A 153/A 153M unless modified. Threaded hardware shall be painted to match polyvinyl chloride coatings.

14-2.6 Concrete

Concrete grade for precast concrete post and mass concrete shall be of grade as shown on drawings. Concrete shall be constructed in accordance with provisions of Section 8,

Concrete Work. Grout shall consist of one part Portland cement to three parts clean, well-graded sand and the minimum amount of water to produce a workable mix.

PART 3 EXECUTION

14-3.1 Installation

Fence shall be installed to the lines and grades indicated. The area on either side of the fence line shall be cleared to the extent indicated. Line posts shall be spaced equidistant at intervals not exceeding as shown on drawings. Terminal (corner, gate, and pull) posts shall be set at abrupt changes in vertical and horizontal alignment. Fabric shall be continuous between terminal posts; however, runs between terminal posts shall not exceed 150 m. Any damage to galvanized surfaces, including welding, shall be repaired with paint containing zinc dust in accordance with ASTM A 780.

14-3.2 Excavation

Post holes shall be cleared of loose material. Waste material shall be spread where directed. The ground surface irregularities along the fence line shall be eliminated to the extent necessary to maintain a 50 mm clearance between the bottom of the fabric and finish grade.

14-3.3 Post Installation

14-3.3.1 Posts for Chain Link Fence

Posts shall be set plumb and in alignment. Except where solid rock is encountered, posts shall be set in concrete to the depth indicated on the drawings. Where solid rock is encountered with no overburden, posts shall be set to a minimum depth of 457 mm (18 inches) in rock. Where solid rock is covered with an overburden of soil or loose rock, posts shall be set to the minimum depth indicated on the drawing unless a penetration of 457 mm (18 inches) in solid rock is achieved before reaching the indicated depth, in which case depth of penetration shall terminate. All portions of posts set in rock shall be grouted. Portions of posts not set in rock shall be set in concrete from the rock to ground level. Posts set in concrete shall be set in holes not less than the diameter shown on the drawings. Diameters of holes in solid rock shall be at least 25 mm (1 inch) greater than the largest cross section of the post. Concrete and grout shall be thoroughly consolidated around each post, shall be free of voids and finished to form a dome. Concrete and grout shall be allowed to cure for 72 hours prior to attachment of any item to the posts. Group II line posts may be mechanically driven, for temporary fence construction only, if rock is not encountered. Driven posts shall be set to a minimum depth of 914 mm (3 feet) and shall be protected with drive caps when being set. For high security fences, fence post rigidity shall be tested by applying a 222.4 Newtons (50 pound) force on the post, perpendicular to the fabric, at 1.52 m (5 feet) above ground; post movement measured at the point where the force is applied shall be less than or equal to 19 mm (3/4 inch) from the relaxed position; every tenth post shall be tested for rigidity; when a post fails this test, further tests on the next four posts on either side of the failed post shall be made; all failed posts shall be removed, replaced, and retested at the Contractor's expense.

14-3.3.2 Bottom Kerb

The fen mesh should be tied with bottom kerb as shown in drawings. The bottom kerb shall be constructed of concrete insitu.

14-3.4 Braces and Truss Rds

Braces and truss rods shall be installed as indicated and in conformance with the standard practice for the fence furnished. Horizontal (compression) braces and diagonal truss (tension) rods shall be installed on fences over 1.83 m in height. A center brace or 2 diagonal truss rods shall be installed on 3.66 m fences. Braces and truss rods shall extend from terminal posts to line posts. Diagonal braces shall form an angle of approximately 40 to 50 degrees with the horizontal. No bracing is required on fences 1.83 m high or less if a top rail is installed.

14-3.5 Tension Wires

Tension wires shall be installed along the top and bottom of the fence line and attached to the terminal posts of each stretch of the fence. Top tension wires shall be installed within the top 102 mm of the installed fabric. Bottom tension wire shall be installed within the bottom 152 mm (6 inches) of the installed fabric. Tension wire shall be pulled taut and shall be free of sag.

14-3.6 Chain Link Fabric

Chain link fabric shall be installed on the side of the post indicated. Fabric shall be attached to terminal posts with stretcher bars and tension bands. Bands shall be spaced at approximately 381 mm (15 inch) intervals. The fabric shall be installed and pulled taut to provide a smooth and uniform appearance free from sag, without permanently distorting the fabric diamond or reducing the fabric height. Fabric shall be fastened to line posts at approximately 381 mm (15 inch) intervals and fastened to all rails and tension wires at approximately 305 mm intervals. Fabric shall be cut by untwisting and removing pickets. Splicing shall be accomplished by weaving a single picket into the ends of the rolls to be joined. The bottom of the installed fabric shall be 25 mm plus or minus 13 mm above the ground. For high security fence, after the fabric installation is complete, the fabric shall be exercised by applying a 222 Newton (50 pound) push-pull force at the center of the fabric between posts; the use of a 133 Newton (30 pound) pull at the center of the panel shall cause fabric deflection of not more than 63.5 mm (2-1/2 inches) when pulling fabric from the post side of the fence; every second fence panel shall meet this requirement; all failed panels shall be re-secured and retested at the Contractor's expense.

14-3.7 Barbed Wire Supporting Arms and Barbed Wire

Barbed wire supporting arms and barbed wire shall be installed as indicated and as recommended by the manufacturer. Barbed wire shall be pulled taut and attached to the arms with clips or other means that will prevent easy removal.

14-3.8 Gate Installation

Gates shall be installed at the locations shown. Hinged gates shall be mounted to swing as indicated. Latches, stops, and keepers shall be installed as required. Padlocks shall be

attached to gates or gate posts with chains. Hinge pins, and hardware shall be welded or otherwise secured to prevent removal.

PART 4 MEASUREMENT AND PAYMENT

14-4.1 Security Fencing

14-4.1.1 Measurement

Measurement for payment of providing and installing galvanized steel security fencing with posts will be made in linear meters as shown on drawings or as directed at site.

14-4.1.2 Payment

Payment for providing and installing security fencing will be made at the rate per linear meter tendered therefor in the priced Bill of Quantities.

14-4.1.3 Unit of Measure

Unit of measure: Linear Meter

14-4.2 Gate

14-4.2.1 Measurement

Measurement for payment shall be made for providing and installing the number of gates as shown on the drawings or as directed by the Project Manager.

14-4.2.2 Payment

Payment shall be made for the number of gates provided and installed at the rate tendered in the priced Bill of Quantities.

14-4.2.3 Unit of Measure

Unit of measure: Each

APPENDIX 1

TABLE OF TOLERANCES

The following are the tolerances within which the works are to be executed or as directed by the Project Manager

EARTHWORKS

Top level of Embankments after compaction	+100/-0 mm
Sides of Embankments over a 10m length	+75/-0 mm
Channel or Excavation cutting	+12.5/-12.5 mm
Channel Water Way Area	-0
Horizontal Alignment of Channels Maximum Over 60ft length	 300mm 75 mm
Formation Level for Structures	+0/-ve filled with concrete
Formation levels of Gabions	+0/-75 mm

CONCRETE STRUCTURES

The following tolerances shall apply to all wrought formed and fair or fine unformed finishes.

Tolerance from Specified Positions Maximum departure of plan position of structure	 150 mm
Tolerance from Specified Dimension Maximum departure in thickness, cross-sectional dimension or position of columns, beams, walls, footings and the like	 +25/-12.5 mm
Surface Tolerance on Straightness or Departure from Specified Curve General Surfaces Maximum deviation in horizontal or Vertical direction Gradual over a 30 feet length Abrupt Surfaces in contact with Flowing Water Maximum deviation in direction of flow or normal to flow Gradual over a 30 feet length Abrupt	 25 mm 12.5 mm 12.5 mm 6 mm
Reinforcement Maximum departure in required spacing	12.5 mm
Stonework Pitching and Masonry over a 6 feet length Face a gabion basket Thickness of tipped rock or filter layer	 +75/-25 mm +75/-25 mm +100/-0 mm