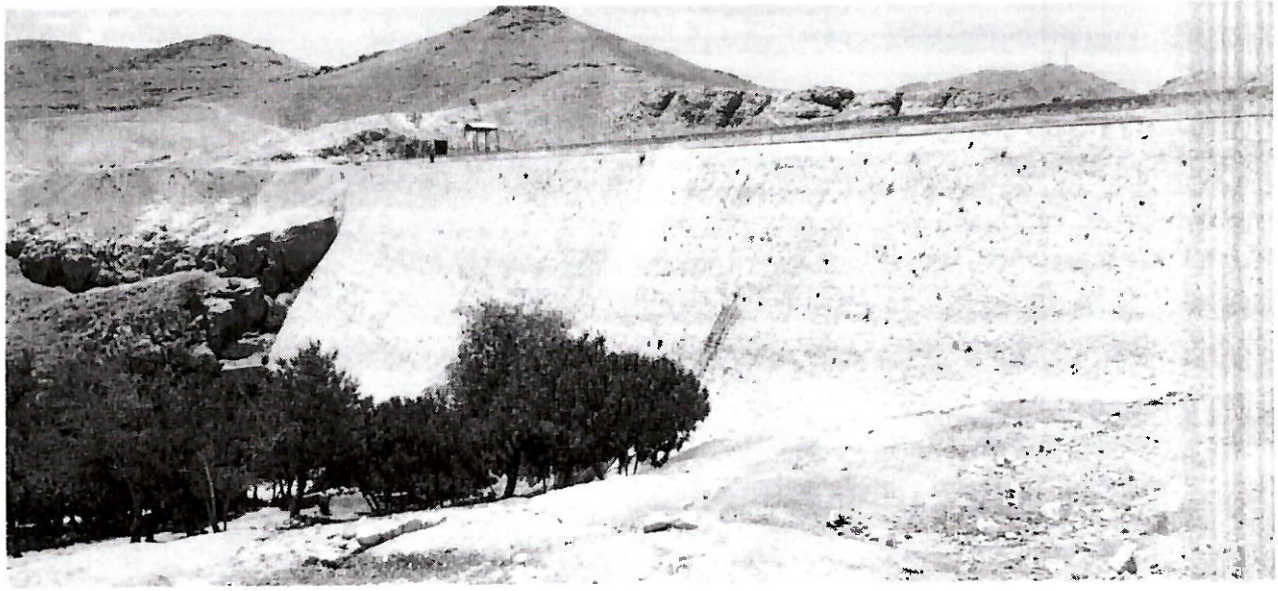
Islamic Emirate of Afghanistan

Ministry of Water and Energy

Deputy Ministry of Water

General Directorate of Engineering Services of Water Infrastructures

Technical Board



Rehabilitation of Sultan Dam			
Date		Nov 2023	General Technical specification for Civil work of Sultan Dam
Prepared by	Checked	Approved	
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SECTION-I GENERAL

1. GENERAL INFORMATION

1.1. PREAMBLE

This is the general technical specification which shall be modified based on the type of project and the type of work items included in the project, but specification for any specific work item shall remain the same. All parts of the current specification may or may not be applicable in the case of the current project (Sultan dam)

This general specification does not apply to wrong or incomplete designs and will not relieve the designer from responsibly of the deficient design and the liability of the design will be to the designer.

1.2. WORKMANSHIP AND MATERIALS

All workmanship shall be of the best quality appropriate to each category of work.

All materials used in the Works shall be of the best quality of their respective kinds as specified or described in the Specification, Drawings and Bills of Quantities and shall comply the appropriate standard published by the ASTM, ACI, USBR, USACE and AASHTO (for Roads and bridge only).

If there is a conflict among the specification, drawings and BOQs, the best and safest one shall be considered.

1.3. SUPPLIERS OF MATERIALS

Before ordering a material of any description intended for the Permanent Works, the Contractor shall submit for the approval of the Engineer a comprehensive submittal included (manufacturer or supplier, details of the place of origin and specification of the material. If requested by the Engineer, the Contractor shall supply to the Engineer for his retention a copy of any such order placed.

Approval of a source does not imply that all materials in that source are approved.

1.4. TEMPORARY WORKS AND CARE DURING CONSTRUCTION

The contractor shall construct and maintain all necessary channels, diversions and other temporary works necessary to ensure that irrigation water supplies are not interrupted during rehabilitation construction works; shall furnish all materials required therefore, and

shall furnish, install, maintain and operate all necessary pumping and other equipment (if necessary) for maintaining water supplies around the rehabilitation works.

After having served their purpose, all temporary works at the construction site shall be removed in a manner approved by the Engineer, and such areas after those are removed shall be levelled and graded to the extent required to prevent obstruction in any degree whatever and maintaining the designed function of the structure.

The contractor shall be responsible for and shall repair at his expense any damage to the foundations, structures, or any other part of the works caused by floods, water or failure of any part of the temporary diversion or protective works.

1.5. SURVEY DATUM, TOPOGRAPHIC SURVEY AND CONSTRUCTION SURVEY

The levels shown on the Drawings are with reference to a specific benchmark in the project area, and whose location and value are shown on the Drawings. It shall be the Contractor's responsibility before commencing the construction to confirm with the Engineer, the location and value of the established benchmarks. The Contractor shall establish within the project area benchmark and reference points for use during the construction work. The Engineer shall approve the location of each benchmark and reference point.

The Contractor shall supply to the Engineer, in duplicate, maps and records in an approved form giving details of the location (including co-ordinates) and level of each bench-mark used or established by the Contractor. The field unit bench-marks shall be marked with a suitable system of identification and their levels submitted to the Engineer.

Where required, the Contractor shall submit to the Engineer lists of original ground surface levels for the purposes of measurement of earthworks.

The method of surveying shall be to the approval of the Engineer. Field books and tabulated data shall be well maintained and made available for inspection and checking by the Engineer when ordered.

The contractor shall be responsible for the true and proper setting out of the works, for correctness of positions, levels, dimensions and alignments of all parts the works and for the provision of all the necessary instruments, appliances, such as dumpy levels, total station, etc. and the labour in connection therewith. If at any time during the progress of works any error shall appear in the position, levels, dimensions or alignments of any parts of works, the contractor being required to do so, shall at own expenses rectify such work.

Checking of any setting out or any line or level by the Engineer representative shall not relieve the contractor of his responsibility for ensuring correctness thereof at his own cost.

For preparing exact digital surface model (DSM) the topography survey applied in high accuracy for existing dam body, Spillway, power house , bottom outlet and others appurtenant structures.

Cross sections should be perpendicular to the dam Axis and spillway at appropriate distance.

1.6. SETTING OUT OF THE WORK

The contractor shall be entirely responsible for accurate setting out of the works and reference pegs based on the information supplied from the drawings and verified by the contractor. For such parts of the Works where no setting out details are given in the drawings, the contractor will supply setting out data under the supervision of the Engineer or show the exact location on site during the course of the Contract.

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1.7. WORK PROGRAM OR PROJECT SCHEDULE

The Contractor shall submit to the Engineer approval/no objection a work program/project schedule in primavera P6, showing how he proposes to carry out the Works by the intended Completion Date. The program shall show the start and completion dates of the various activities, in order to complete the entire project by the Intended Completion Date. Once the project schedule is approve/issued no objection by the engineer, then the work can be started.

If the Contractor falls behind the Contractual Program he shall, within 14 days of the date of such default, submit for approval a revision of the program or recovery schedule showing the proposed measures, including plant, labor and material resources, to complete the Permanent Works on time.

1.8. MEDICAL ARRANGEMENTS

The Contractor shall make arrangements for treatment on the Site of casualties and sick persons of both the contractor and client in first-aid units or in such other wards as may be necessary in accordance with the appropriate Regulations.

Notwithstanding the minimum requirements prescribed above, the Contractor shall be responsible for the adequacy of all the arrangements made.

1.9. TRANSPORTATION OF PLANT AND EQUIPMENT

All cost incurred by the Contractor of transportation and subsequent removal of the construction plant and equipment shall be deemed to be included in the unit prices.

The Contractor shall submit the planned list of plants and equipment to be supplied at each site during tendering. Plants and equipment shall be available at site at any time during the execution of the Contract and there shall not be shortages of the plants and equipment at site. The Contractor shall not be allowed to take out any plants and equipment from the site without approval of the Engineer.

1.10. REPORTS AND PHOTOGRAPHS

No separate payment shall be made for preparation of all documents, correspondence, returns and reports, geo-referenced photographs, etc. to be prepared by the Contractor and submitted to the Engineer in accordance with the provisions of the contract. The Contractor will be required to provide the Engineer with photographs of the various stages of the work, particularly those relating to approval of the works on monthly basis. These photographs should be taken at the same location and from the same angle for different stages of the same work and scale rules (staff gauge) should be used to indicate depths where required.

1.11. MAINTENANCE OF FLOW

The Contractor shall at his own expense maintain the flow in all canals, drains, streams, water courses and rivers which may be encountered during the construction of the works.

1.12. DEWATERING

The Contractor shall take all risks regarding surface and sub soil water from whatever source and shall so deal with and dispose of such water in a manner approved by the Engineer to ensure that the excavations are kept dry. The Contractor shall provide all necessary plant, labor and materials required and all costs incurred shall be deemed to be included in his rates.

The Contractor shall be responsible for damage to the Works or other property arising from insufficient or excessive dewatering and shall make good the same as soon as possible to

the complete satisfaction of the Engineer and other relevant authorities at his own expense.

1.13. UNITS OF MEASUREMENT

Unless specifically stated to the contrary, the units of measurement to be used throughout the Contract shall be based on the SI System. Abbreviations, whether singular or plural, shall be as follows:

Kilometer	km		
Meter	m		
Millimeter	mm		
Hectare	ha		
Square meter	m2		
Cubic metre	m3		
Litre	l		
Millilitre	ml		
Tonne	t		
Kilogram	kg	Gram	g

1.14. METHOD OF MEASUREMENT

All measurements shall be made according to the description of the methods of measurement contained in the related sections of the current specification or BOQ whichever is applicable.

1.15. SURVEY OF COMPLETED STRUCTURES

The Contractor in conjunction with the Engineer shall carry out survey of all completed structures to determine their final location for the purpose of preparing "as-built" drawings.

1.16. CONTRACTOR'S OFFICES

The Contractor shall make his own arrangements, for all local accommodation and offices of the contractor and client he or client may require for offices, yards stores labor camps

etc. and all buildings and all services in connection therewith which are required for the efficient execution of the Works.

1.17. "AS-BUILT" DRAWINGS

The Contractor shall submit four copies of whole sets of clearly printed "As-Built" Drawings of the completed Works along with a set in CD (not rewritable CD), to the Engineer before issuance of Completion Certificate. Failure by the Contractor to submit the "As Built" Drawing(s) to the Engineer will mean non-approval and non-acceptance of the works by the Engineer even though the physical construction works are completed and as per the Technical Specifications, Scope of Work and Bill of Quantity.

The "As-Built" Drawings shall clearly show the lines and dimensions of the permanent construction actually made based on the original design and/or change of design from time to time ordered by the Engineer or proposed by the Contractor and approved by the Engineer.

No separate payment shall be made for preparation of all construction drawings, reinforcement drawings, working drawings and shop drawings, drawing details, As-built drawings etc., to be prepared by the Contractor for submission to the Engineer and/or the Employer in accordance with the provisions of the Contract.

1.18. MINIMUM SAFETY REQUIREMENTS

At a minimum, the Contractor must provide at his own cost safety equipment for his employees and ensure that the equipment is used appropriately. He shall require and ensure that his sub-contractors also comply with the requirements of this section. Minimum safety equipment includes the following:

- Hard hats must be provided for and worn by all employees and site visitors when in the vicinity of overhead, falling or other related hazards.
- Close-toed shoes must be worn by all construction workers when the potential for injury to feet or toes is present. This includes but may not be limited to workers in trenches, where tools or materials can fall from above them, workers operating any equipment, workers carrying materials or supplies at the job site.
- Eye protection must be worn during all cutting, grinding and welding processes or any construction process where the potential for air-borne particulates or flash from a welding operation could injure a worker's eyes.

- Hearing protection must be worn by workers engaged in very loud activities such as metal grinding or cutting, operating an electric saw, or operating loud machinery
- Gloves

The Contractor shall take all necessary measures to protect the work and prevent accidents during the construction. He shall provide and maintain sufficient night-lights, barricades, guards, temporary sidewalks, temporary bridges, danger signals, watchmen and necessary alliances and safeguards to properly protect life and property. He shall also protect all excavations, equipment and materials so that the public are not be endangered.

1.19. ASSISTANCE TO ENGINEER'S STAFF

The Contractor shall render and provide all necessary accommodation, food, offices, internet and assistance to the Engineer's staff and shall provide and maintain sufficient number of pegs, poles, paints, survey equipment and tools, staff, ranging rods, moulds, templates, profiles and all other requisites for checking the Contractor's setting-out and the measurement of the Works as well as field tests.

1.20. PLAQUES AND SIGN BOARDS

The Contractor shall erect plaques and sign boards on all the structures giving the location and name of the structure. The location, dimensions and style of the sign boards and plaques shall be as per the approval of the Engine

1.21. SCOPE OF WORK

This document covers the General Technical Specifications for earth work, Concrete Work, stone masonry work, Rock filled concrete, , brick work, plaster work in Sultan dam in Ghazni province of Afghanistan.

The document covers following items but not limited to these items:

Section I General

Section-II Earth work (Excavation and embankment)

Section III concrete work.

Section IV Rock stone masonry

Section V Rock filled concrete work

Section VI Brick work

Section VII Plaster work

1.22. SUBMITTAL BY CONTRACTOR

(a) CVC Concrete mix design along with all the required quality tests for coarse aggregate, fine aggregate, cement and water.

(b) Rock filled concrete (RFC) mix design along with all the required quality tests per the specification.

(c) Mix designs of mortar and grout (if any)

(d) Stone and Brick quality control tests.

(e) Routine quality control tests results for CVC concrete, Rock-filled concrete, Embankment construction, mortar, Grout and steel.

(f) Mill certificates/catalogues of the admixture

and water stopper.

(g) Shop drawings.

(h) Method statements

(i) Shop drawings

(j) Any other document needed but not

Mentioned here.

1.23. APPLICABLE STANDARDS

Following codes will be applicable. If in some cases, the reference codes and standards are not included in the below list, the related ACI, ASTM, USBR, USACE and AASHTO (for Bridge and culverts) codes and standards are applicable.

Standard	Subject
ASTM A36	Standard Specification for Carbon Structural Steel
ASTM A615	Standard Specification for Deformed and Plain Carbon-Steel Bars for concrete Reinforcement
ASTM C33	Standard Specification for Concrete Aggregates
ASTM C67	Sampling and Testing Brick
ASTM C90	Building brick (solid masonry units made from clay or shale) and Hollow load-bearing concrete masonry units
ASTM C144	Aggregate for masonry mortar
ASTM C150	Standard Specification for Portland Cement
ASTM C 270	Standard Specification for Mortar for Unit Masonry
ASTM C476	grout for common brick and concrete masonry
ACI- 207.1R	Mass concrete
ACI-211.1	Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
ACI 224.1R	Causes, Evaluation and Repair of Reapproved 1998Cracks in Concrete Structures
224.3R	Joints in Concrete Construction ACI
ACI 301	Specifications for Structural Concrete
ACI 304R	Guide for Measuring, Mixing, Transporting, and Placing Concrete
ACI 305	Hot Weather Concreting
ACI 306	Cold Weather Concreting

ACI 318	Building code requirement for structural concrete
ACI 347	Guide to Formwork for Concrete
ACI 350	CODE REQUIREMENTS FORENVIRONMENTAL ENGINEERINGCONCRETE STRUCTURES
ACI 504R-90	Guide to Sealing Joints in Concrete Structures

2. SECTION-II-EARTH WORK

2.1. Excavation

2.1.1 General

Excavation includes provision of all the needed material, personal and equipment and conducting the excavation to the specified levels, grades and dimension shown on the design drawings, loading, transporting and unloading of the excavated material in the specified location.

2.1.2 Surface preparation for excavation

Before starting the excavation, a joint topographic survey of the natural ground surface (NGS) shall be conducted for estimation of the quantities of excavation.

2.1.3. Excavation

2.1.3.1. Soil Excavation

After conducting clearing, grabbing and stripping activities, the main excavation a long with cut-off trench excavation will be conducted which includes excavation to the specified level, grade and dimension, loading, transporting and unloading of the excavated material in the specified location. Excavation for structures shall be made to the foundation of the structures and to lateral dimensions one foot outside the structure outline and to the slopes shown on the Drawings or as directed by the Engineer.

The additional excavation for placing and removal of forms, installation of services, for inspection and generally for working area on slopes for stability shall not be measured for payment and shall be deemed to be included in the rates for excavation as measured net.

There will be no any additional payment for the excess excavation of soil and rock and the excess excavated portion shall be backfilled with lean concrete with the contractor's expense.

The Contractor shall also take and record such other levels and dimensions as are necessary during the progress of the excavation to allow accurate measurement of the different categories of excavation (soil excavation, Soft rock excavation and hard rock excavation.

The Contractor shall preserve the completed excavation from damage due to slips and earth movements, ingress of water from any source whatsoever and deterioration by exposure to the sun and the effects of the weather. All excavations shall be kept free of water and shall be maintained dry to the satisfaction of the Engineer. Prevent surface water and sub-surface water from flowing into the excavation and flooding the project site and surroundings.

Shoring, where required during excavation, shall be installed to protect workmen and the bank, adjacent paving, structures and utilities. The term shoring shall also be deemed to cover whatever methods the Contractor elects to adopt, with prior approval of the Engineer, for upholding the sides of excavation and also for planking and strutting to excavation against the side of roadways and adjoining properties in existing hardcore of any other material. The Contractor will be held responsible for upholding the sides of all excavations and no claim for additional excavation, concrete or other material will be considered in this respect.

2.1.3.2. Rock excavation (If any)

Any material in the excavations, which the Contractor considers, may be classified, as Rock as defined herein will be notified to the Engineer before excavation of the material is begun. The quantities of Rock or material alleged to be Rock excavated from within the nominal limits of excavation shall be recorded and the agreed record shall be signed by the Engineer and the Contractor each day or at such shorter intervals as the Engineer may require. Only such material so notified and agreed by the Engineer as Rock shall qualify for payment as Rock. Over break (that is excavation in Rock outside the nominal limits of excavation) shall be kept to a minimum and shall be held to be Excess Excavation.

Soft Rock to be excavated shall be loosened by large dozer(s) equipped with one or more rippers, the number of rippers being varied as necessary to suit the prevailing conditions. Thereafter, the loosened material shall be excavated using machinery and methods selected by the Contractor.

Hard Rock to be excavated may be fractured and loosened by systematic drilling and blasting or by drilling and presplitting. Thereafter, the rock shall be excavated by dozers, with or without rippers, and other plant, as necessary.

Precautions shall be taken to preserve the material outside the line of excavation in an undisturbed condition. All cavities in rock excavations upon or against which concrete is to be placed shall be filled with concrete; those cavities caused by careless excavation as determined by the Engineer, or by removal of rock or other materials needlessly damaged by the Contractor's operations as determined by the Engineer, shall be filled with concrete at the Contractor's expense. The Contractor shall clean rock slope benches and shall maintain an inspection system in regard to rock slopes as necessary to provide safe working conditions.

Explosives shall be transported, stored and used in accordance with BS-5607.

The blasting methods used shall initially be based on the results of a blasting test program carried out at the Site by the Contractor at his expense and as approved by the Engineer and the contractor shall submit the blasting plan for approval of the Engineer. The depth and spacing of holes for blasting shall be determined by the Contractor, based on observation of the manner in which the rock breaks as blasting operations progress, and additional testing as shown to be necessary, subject to the approval of the Engineer. Near residential areas (powerhouse) and as excavation approaches its final grade, control blasting shall be used and the depth of holes for blasting and the amount of explosives used per hole shall be reduced sufficiently to prevent disturbance and damage.

2.2. EMBANKMENT & OTHER FILLS

2.2.1. General

Embankment includes Material excavation from the approved barrow area or stockpile, loading, transporting, unloading, spreading, watering, compacting and testing of the material to the specified level and grades

The work covered by this Section consists of the construction of the Embankment Dam, any backfill for structures, stone pitching and other miscellaneous fills including the preparation of the foundations. Any reference to embankment or fill materials shall be considered as applying equally to both except where the context clearly implies the contrary. Applicable standards to construction of Embankment Dam are USBR DS-13-(chapter 3), USBR DS-13(chapter 10) , USBR Earth Manual (Part 1) , EM 1110-2-1911 and EM1110-2-2300 whichever is applicable.

2.2.2. DEFINITIONS

Fill

The term "Fill" as used in these Specifications is defined as the earth fill portion of the dam including all other fills, riprap and downstream slope protection, filters and drain materials for the dam and as used in connection with other works.

Formation

"Formation" is a surface of in situ undisturbed soil and/or rock on which fill is placed.

Zone

The term "Zone" is that part of an embankment or fill, the material for which has specified characteristics such as particle size, moisture content, density and method of placing. Only those zones will be applicable which is mentioned in the drawings and BOQ of the project.

2.2.3. GENERAL PROVISIONS

2.2.3.1 Reference Standards

The numbers and subjects of reference standards are listed below:

Standard	Subject
USBR	Earth Manual-part-I, Second Edition
USBR DS-13 chapters 3, 10	Foundation surface treatment for embankment dams, Embankment construction.
EM 1110-2-1911	CONSTRUCTION CONTROL FOR EARTHAND ROCK-FILL DAMS
EM 1110-2-2300	GENERAL DESIGN AND CONSTRUCTION CONSIDERATIONS FOR EARTH AND ROCK-FILL DAMS
ASTMD 422-63	Standard Test method for particle size analysis of soils
ASTM D4318	Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D698	Standard Test Methods for Laboratory Compaction Characteristics

	of Soil Using Standard Effort
ASTM D1556	Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method
ASTM D2049	Standard Test Method for Minimum and Maximum Densities of Granular Materials
ASTM D6539-13	Standard Test Method for Measurement of the Permeability of Unsaturated Porous Materials by Flowing Air
ASTM D4647	Standard Test Methods for Identification and Classification of Dispersive Clay Soils by the Pinhole Test
BS 1377:1967	Methods of testing soils for civil engineering purposes
ASTM C535	Test for resistance to abrasion for large size coarse aggregate by use of the Los Angeles machine
ASTM C88	Test for soundness of aggregates by use of Sodium Sulphate or Magnesium Sulphate
ASTM C97	Standard Test Methods for Absorption and Bulk Specific Gravity of Dimension Stone
ASTM C131	Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C127	Standard Test Method for Relative Density (Specific Gravity) and Absorption of Coarse Aggregate
ASTM D4791	Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM C295	Standard Guide for Petrographic Examination of Aggregates for Concrete

2.2.3.2 Submissions by the Contractor

Submission which the Contractor is required to make in relation to embankment other fills include the following:

(a). Drawings:

Contractor's topographic survey of the natural ground surface and shop drawings of the agreed foundation level survey prior to the placement of fill in those areas.

Contractor's as built drawings of all agreed level surveys taken for the purpose of measurement of quantities of fill.

Survey records as specified above shall be submitted to the Engineer within 7 days of the completion of the survey work recorded on them.

(b). Test Results:

Laboratory tests and field tests results on agreed format-s and shall be submitted the review and approval of the Engineer.

(C)Samples:

Materials proposed for use as fill, where specifically required by the Engineer.

2.2.4. Method Statement and Equipment

Before proceeding with any of the work specified in this section, the Contractor shall furnish the method statement with equipment details, to the Engineer as further information for approval. The method statement to be submitted by contractor will include the following details:

- Proposed method and sequence of placing and compacting fill including a schedule of plant and equipment to be used.
- Programme for quality control of earthworks.
- Proposed sources of all embankment and fill materials including riprap and downstream slope protection and method of selective excavation and processing
- Proposed programme/schedule of embankment construction

2.2.5. Test Fills for Embankment

Test fill will be constructed for each embankment zone for the approval of method statement, equipment and material as directed by Engineer. No separate payment will be made for these test fills, and if approved, will form part of the permanent works.

2.2.6. Lines and Grades

Fills shall be constructed to the lines, grades, and cross-sections indicated on the approved Drawings. Materials conforming to the requirements specified in Clause 2.2.10 Materials, shall be placed and compacted within the indicated zone limits. The Engineer reserves the right to increase or decrease the foundation widths, the

embankment slopes or the zone limits or to make such other changes in the embankment sections as may be deemed necessary as per site condition to produce safe structures, or for efficient utilization of materials from required excavations upon approval of the designer. Settlements of foundation and dam for the post construction period will be provided for increasing the height of the sections. Required height increases will be determined and specified by the designer from settlement observations made as the work progresses.

2.2.7. Placing of Fill on a Formation

Before the placing of any fill on a Formation all shattered loose and weathered material shall be removed from the excavation so as to ensure that the work rests on a sound, water tight, well-shaped, treated (if required) and clean foundation having enough bearing capacity to support the structure with adequate factor of safety and minimum allowable settlement or, where appropriate, abuts against undisturbed ground. The methods of cleaning the foundation for the impervious core of embankment shall include the use of compressed air jets where necessary, and the Engineer will inspect and record the geology of these parts of the formation before approving them.

No additional payment will be made for cleaning of the foundation or undisturbed ground as specified above.

2.2.8. Conduct of Work

(a). Maintenance, Protection and Tests

The contractor shall maintain and protect the Dam structure in a satisfactory condition at all times until final completion of all work under the Contract including period of maintenance. Any approved fill material which is diverted from its use in construction of the dam, or rendered unsuitable after being placed in the dam before final acceptance of the work, shall be replaced by the Contractor in a satisfactory manner and no additional payment will be made thereof. The contractor will submit a CQC plan to the approval of engineer and establish a programme of testing of in-place fill to ensure that the work is being performed in conformity with the requirements of these Specifications. The Engineer will also perform/advise tests on material at their source and during their processing and handling as necessary for quality control and the Contractor shall adjust his methods as per Specification requirements. Tests of material and embankment construction will be made at regular intervals and Engineer will notify Contractor of any deficiencies in materials and/or construction when results of tests are known. Deficiencies shall be remedied by such measures as the Engineer may direct. Remedies shall include the complete removal of portions of the fill if so directed by the Engineer. The contractor shall dispose of any unsuitable materials and refill the excavated area with suitable material as directed, at no cost to the Employer. The Contractor may be required to remove/ at his own expense, any fill placed outside of the prescribed slope lines where such placement is not authorized by the Engineer.

(b). Haul Road

Haul roads shall be located and constructed as approved by the Engineer. They shall be designed to maintain the intended degree of traffic safely, without endangering dam stability during the construction period and shall be constructed in a manner to preclude contamination or alteration of materials forming the dam section. All haul roads located on dam slopes shall be removed at the completion of dam construction. Roads on abutments, which would be unstable during reservoir operations shall be removed at the completion of the dam construction or stabilized to the satisfaction of the Engineer. Haul or construction roads shall not be measured for payments.

(c). Stockpiles

Whenever the Contractor for his own convenience excavates and stockpiles fill material for subsequent usage in the fill, no additional payment shall be made for such stockpiling nor for the reloading and hauling of this material to its final position in the embankment except where specifically provided in the Specifications and Bill of Quantities.

Each stockpile shall contain material suitable for use in one fill Zone only, unless otherwise authorized in writing by the Engineer. Due care would be taken to avoid mixing of materials and the Contractor shall advise the Engineer of the intended use of the material contained in all such stockpiles.

2.2.9. MATERIALS

Fill materials shall be obtained primarily from the designated borrow areas indicated on the Drawings and if the borrows areas are not indicted on the drawings, and then the contractor shall investigate the barrow areas and submit the test results to the approval of the Engineer. The Contractor may use the suitable materials for the fill from additional sources on any borrow areas investigated by him, with the approval of the Engineer who will satisfy himself that the material conforms to the specifications. Providing the material of the zoned embankment is mentioned in the drawings and the material with haulage is however, included in the B.O.Q. Material containing bush, roots, sod, organic material or other material not considered suitable shall be cleaned of such materials or shall be wasted in areas away from the work site, as approved by the Engineer. All materials shall not contain any clods and lumps which cannot be broken up during compaction and shall conform to the requirements of the Specifications, their dispositions in the dam shall be as directed by the Engineer.

2.2.10. Material assigned for different zones of the earth saddle dam

This specification focus on the materials of the following zones:

Zone 1: impervious Clay core Is Zone of low permeability soil that acts as the water barrier in the dam.

Zone 2A: Fine Filter/chimney filter is Zone that protects the core from internal erosion and cracking. Usually, this zone is composed of sand-size particles. normally placed on the downstream face of the clay core.

Zone 2B: Coarse Filter, normally placed on the upstream face of the clay core and also acts as a transition zone between the clay core and upstream shell.

Zone 2C: Chimney Drain (Gravel with uniform gradation) Zone that carries away seepage coming through the chimney filter and delivers it to the blanket drain. It also acts as a transition zone between the chimney filter and the downstream shell. Usually, this zone is composed of gravel-size particles.

Transition Zone – A zone on the interior side of the upstream or downstream shells. Upstream transition zones can also function as crack stoppers.

Zone 3: Upstream and downstream shell material are Zones of higher strength soil to support the upstream face of the core and the chimney and downstream slope of the core respectively. The geometry of the upstream core is sometimes dependent on the rapid drawdown loading case. In the current project, random fill is specified by the designer instead of shell material for economical purposes but still the stability and seepage criteria must meet.

Zone 4: Riprap (Stone) and bedding: Riprap is the rock layer that protects the upstream slope of the dam against erosion caused by reservoir wave action. Bedding under riprap protects against particle movement of the protected zone after reservoir drawdown.

Impervious Blanket – Extends the seepage path and increases the head loss zone for dams on pervious foundations when a cutoff under the dam is not practical. Upstream blankets are integrated into the core of the dam.

Cutoff Trench – A cutoff trench to rock or other low permeability strata that is integrated with the overlying core.

All of the above zones and component may or may not be included in the design.

The most important zones are briefly explained below:

It is the mandatory requirement of the specification, that the degree of compaction and material parameters which includes but not limited to, percent compaction, the angle of internal friction, cohesion intercept, shear strength, permeability and others of the above-mentioned zones shall be the same or on the safe side as that specified /assumed by the designer in stability and seepage analysis of the dams. Normally Improper compaction and using low quality material will cause the dams failure.

2.2.11. Sampling and testing of Material

Before using of the embankment material from the approved barrow area or any other source material shall be sampled and tested to verify the quality of the material considering the requirements below.

2.2.11.1. Sampling of Material for different zones: The first step in testing candidate materials is to collect the sample. It is important that a representative sample be collected in accordance with ASTM D75, "Standard Practice for Sampling Aggregates" and USBR 7000 [1]. The sample must be large enough to represent the material accurately; collection of undersized samples is a common problem within the practice. ASTM D75 includes minimum sizes of samples of aggregates as shown in table below:

Minimum sampling size based on maximum particle size Maximum size of aggregate (mm)

Maximum size of aggregate (mm)	Minimum sample size (kilograms)
Fine aggregate	
2.36 mm (No. 8 sieve)	10
4.75 mm (No. 4 sieve)	10
Coarse aggregate	
9.5 mm (3/8 inch)	10
12.5 mm (1/2 inch)	15
19.0 mm (3/4 inch	25
25.0 mm (1 inch)	50
37.5 mm (1.5 inches)	75
50mm(2inches)	100

2.2.11.2. Material Sources or barrow areas investigation:

The availability of suitable material for construction of the different zones shall be investigated close to the project area as far as possible. Representative and sufficient weights of samples as shown in the table above shall be taken and the below quality tests shall be conducted on them.

Beside the below tests, triaxial-test, direct shear test, permeability tests shall be conducted on the barrow area material.

Quality tests and quality Acceptance criteria shall be as follows:

Test Type	ASTM Standard	Acceptability Criteria
Abrasion resistance	C131	Zone 2B, 2C: 40% maximum loss of weight at 500 revolutions
Sodium sulphate soundness	C88	Zone 2A, 2B, 2C: 10% maximum weighted average loss by weight after five cycles
Specific Gravity	C127	Zone 2A, 2B, 2C: 2.60
Water Absorption	C127	Zone 2A, 2B, 2C: 2.0% Maximum
Atterberg Limits and Plasticity Index	D4318	Zone 2A, 2B, 2C: Liquid Limit not obtainable or Plasticity Index(P.I) = 0%
Flakiness Index	D4791	Zone 2B, 2C: Flakiness Index not to exceed 35%
Sand equivalent value	ASTM D2419,	shall be greater than 80 for filter material
Caly lumps and fribale particles	ASTM C142	Shall not be more than 3%for filters.
Petography test		

Note: Three tests for each of the above quality tests shall be conducted per source or barrow area and the avearge of the three values shall be considered, provided that three is not a big difference between the three values, in this case the avearge shall be based on the two values which are close to each other. If the source is changed, then the same tests and the same number of tests shall be repeated.

2.2.12. Saddle Dam Embankment construction

Applicable standards to construction of Embankment Dam /Rock fill Dam are USBR DS-13-(chapter 3), USBR DS-13(chapter 10) , USBR Earth Manual (Part 1) , EM 1110-2-1911 and EM1110-2-2300 whichever is applicable.

First of all, cut off trench shall be excavated to the levels, dimensions and slope specified by the designer on the design drawings, then construction of the different zones of the saddle dam shall be started as briefly described below:

2.2.12.1 Impervious Core and Upstream Impervious Blanket - Zone 1 (Clay core)

Clay core shall be constructed to the dimensions and levels specified on the design drawings by the designer. Material for Zone 1 (impervious core and upstream impervious blanket) shall be, clayey gravels or clayey sands (GC or SC), clays (CL), silt (ML)and silty clays (CL-ML) available in approved borrow areas and specified by the designer. The compacted thickness of the layer shall be 15 cm. Normally material that contains at least 25% of material passing sieve No.200 can be considered as impervious material. Normally sheep's-foot roller will be used and 8 to 12 passes will be adequate for compaction, provided that the compaction requirement meets. The minimum acceptable compaction for clay core of 15 m or lower dams

is 95% and the moisture content shall be within the limit's optimum moisture content±2%. For dams higher than 15m the minimum acceptable compaction for clay core is 98% and the moisture content shall be within the limit's optimum moisture content -0 to +2%. The compaction values are the minimum values and shall not be lower than that specified by the designer. The permeability of the clay core material shall be less than or equal to that considered by designer in the seepage analysis. The angle of internal friction. cohesion intercept and shear strength of the clay core material shall be equal to or greater than that considered by the designer in the stability analysis.

To be specific,below are the characteristics of the clay core barrow area material reported by the dam designer and considered in the design,which needs to be used after verification by the construction contractor.

Material type: Clay, Color: Reddish, Size: <0.002 mm with 25%-30% percentage, overall , percentage of Fines (that passes #200 mesh or 0.075 mm): > 50%, Plasticity Index>=10, Grain size distribution: = 0.002 mm to 50 mm, Hydraulic conductivity< 10-8 m/s, Source Borrow Area A or D (and it needs to be confirmed in the field as borrow area-A is within the reservoir. Borrow Area-A, Borehole-11 i.e. from 1m-10m depth have fines contents in a range of 70% with clay contents of 40% (<0.005mm). With presence of sand – gravel particles, when it is compacted by modern roller it will give us higher friction angle (Φ), which will increase FS against slope failure.

2.2.12.2 Chimny filters Filters and Drains - Zones 2A, 2B & 2C

Filters shall be designed and constructed per the requirement of USBR DS-13, chapter 5.Filters are necessary at different locations in the body of the dam. These are between the core and shell, between the foundation and shell, between the riprap and shell and also between the rock toe and shell. Every filter has to satisfy two main criteria. On one hand the migration of the soil particles (piping) should be prevented and on the other hand, the seepage water has to be freely drained to reduce the development of uplift pore water pressure. To satisfy these three main important criteria, the following relationships have to be fulfilled (USBR, 2011):

1. (D15 of filter)/ (D15 of protected (base) material) ≥5, provided that the filter doesn't contain more than 5% of material finer than 0.07mm (No. 200 sieve).
2. (D15 of filter)/ (D85 of protected(base)material) ≤5
3. (D85 of filter)/ (Max. opening of pipe drain) ≥2
4. Generally the filter will be uniformly graded material to provide adequate permeability and prevent segregation during processing,handling and placing.

Where D15 and D85 are the soil particles diameters from gradation curve at the 15% and 85% finer respectively.

The grain size of the curve of the filter should be roughly parallel to that of the base material. These filter criteria ranges are very narrow and usually lead to multiple layers to satisfy strictly the above standards which in general requires crushing of sands with stringent sieving and blending. However, multiple layers for small earth dams should be avoided; they are more efficient but add to the cost of filter construction.

Filters and drains shall be constructed to the dimensions and levels specified on the design drawings by the designer. The filters and drains can be graded natural, graded screened or graded crush material designed by the designer using the approved local barrow areas or manufactured in plants per the criteria specified in USBR DS-13, chapter 5. The construction contractor is responsible to verify the filter design conducted by the designer, filter material

specified in the specification or newly design the filter if needed. The filter design conducted by the contractor shal be submitted to the Client dam designer for reviewe. The Material for Fine and Coarse Filters (Fine and Coarse Sand) and for drains (uniform graded Gravel), in chimney drain adjacent to the Impervious Core and horizontal drainage blanket downstream of the Imperious Core, shall comprise hard, durable non-cohesive particles derived from alluvial deposits or crushed hard rock. They shall be free from organic impurities and materials which are soluble in water, to be impounded by the embankment, and shall conform to the gradation limits specified by the designer and the requirements of USBR DS-13, chapter 5 . Durability specifications and acceptance criteria for the materials to be used in these zones, are based on different tests to be performed on source material from selected borrow areas. Important properties of filters are gradation, compaction and permeability. Normally two or more filters with uniform of narrow gradation band are preferable to a single well graded filter. The maximum size of the coarse filter material is 3inch. The amount of fines (material passing through sieve No.200) in filter material shall not be greater than 5% after compaction. The filter shall be compacted to an average value of 75% of the relative density and any single value of the relative density shall not be lower than 70% and shall not be lower than that specified by the designer. Usually, smooth steel drum vibratory roller uses for compaction.

The loose thickness of layers shall not exceed 30cm to 38cm, average loose thickness become 34cm and average compacted thickness shall not exceed 30cm. and normally four or more passes of the smooth drum steel-wheeled roller will be adequate, provided that the required relative density requirement meets. The material shall be very wet during the compaction.

As a minimum, the raw material should meet the durability requirements of concrete aggregate as defined in ASTM C 33. In addition to the quality of ASTM C 33, the material shall be no plastic.

The permeability and shear strength of the filter and drain material shall be equal to or greater than that specified/considered by the designer in the design.

When a filter is being designed to address seismic issues, the size of the filter is generally controlled by the maximum deformation expected from the seismic event.

Deformations come from foundation fault displacement, foundation or embankment liquefaction, slope failure, and nonliquefaction settlement of the embankment or

foundation. As an initial rule of thumb, the filter size should be at least twice as large as the expected deformation (horizontal or vertical) in order to provide an adequate factor of safety.When seismic protection is not required, filter width is typically controlled by construction methods. Since a variety of equipment is used for hauling and placement, and the size of that equipment is related to the size of the job, a variety of filter widths are found to be acceptable. Proven methods indicate that inclined chimneys can be reliably constructed at 6-foot and wider widths.

2.2.12.2.1 Commercially Available filter and drains material

In lieu of complete filter design, experience has shown that a modification to fine concrete aggregate, as designated in ASTM C33, meets the design requirements for many base soils. This material is commonly referred to as "C33 concrete sand" or,more simply, "concrete sand." The additional requirement on the No. 200 sieve is needed to meet the permeability requirement of the

filter design procedure.Table 2-1 gives an acceptable gradation band for this material. Because conditions differ from site to site, this gradation specification (gradations in tables 2-1 and 2-2)must always be checked by both the designer and the construction contractor before using if fit to the base material and satisfy the required criteria.In a similar manner, when modified C33 concrete sand is used as a filter (first stage), standard materials can be used as the gravel drain or second stage. Several materials in ASTM D448 have been checked against modified C33 concrete sand and are included in table 2-2. When using modified C33 concrete sand, the D448 materials do not have to be checked because the gradation range of the first stage is fixed. Three materials have been included because not all materials will be available in all areas.

Table 2-1. Filter Material gradation (Modified gradation of ASTM C33 fine aggregate[1])

Sieve size	Percent passing, by weight
3/8-inch	100
No. 4	95-100
No. 8	80-100
No. 16	50-85
No. 30	25-60
No. 50	5-30
No. 100	0-10
No. 200	0-2[2]

[1] Requirement beyond the ASTM C33 designation.

[2] Two percent (or less in stock pile), five percent(or less) in-place after compaction

3.The gradation above is applicabe only if it fits to the base material ,satisfy the criteri and not specified otherwise by the designer

Table.2-2. Gradation of drain materials ASTM D448 (percent passing, by weight)

Sieve size	Blend 579[1]	No. 8	No. 89
2 inches	—	—	—
1½ inches	100	—	—
1 inch	90-100	—	—
¾ inch	75-85	—	—
½ inch	—	100	100
3/8 inch	45-60	85-100	90-100
No. 4	20-35	10-30	20-55
No. 8	5-15	0-10	5-30
No. 16	0-5	0-5	0-10
No. 50	—	—	0-5

[1] This gradation is a blend, in equal parts, of gradation Nos. 5, 7, and 9. It is not an ASTM standard aggregate.

2. The gradation above is applicabe only if it fits to the base material ,satisfy the criteri and not specified otherwise by the designer.

2.2.12.3. Shell Material – Zone 3/Random fill (Sandy Gravel)

Are Zones of higher strength soil to support the upstream face of the core and the chimney and downstream slope of the core respectively. The geometry of the upstream core is sometimes dependent on the rapid drawdown loading case.

Material for Zone 3 (sandy gravel or rockfill for the main dam body) used in the upstream and downstream shells shall be obtained from a designated quarry/borrow area, and shall conform to the requirements specified by the designer with maximum particle size not greater than 75%-layer thickness approved by the Engineer. Usually, shell material is free-draining cohesion less sand and gravel containing less than about 5 percent fines (material passing the 75-μm (No. 200) sieve) and conform to the requirements specified by the designer.

Generally GW, GP, SW and SP are suitable material for shell construction.

Four criteria must be satisfied in controlling construction of zones of sand and gravel:

-The material must be formed into a homogeneous mass free from large voids.

-The soil mass must be relatively free draining depending upon its intended use.

-The material must not consolidate excessively under the mass of superimposed fill

.-The soil must have a high angle of internal friction.

The average compacted thickness of layers shall not be greater than 30 cm, provided that the compaction criteria(relative density requirement) meets and normally four or more passes of the smooth drum steel-wheeled roller will be adequate. The material shall be very wet during the compaction.

The compaction of the shell material shall be measure using the relative density (ASTM D 4253 and D 4254) the relative density Dd of in-place material can be computed by this equation

Dd% = $\frac{\gamma dmax\,(\gamma d - \gamma dmin)}{\gamma d\,(\gamma dmax - \gamma dmin)}$ X 100 Where: γd = dry unit weight of the pervious fill in place (in-place density), pounds per cubic feet [lb/ft3]

γdmin = minimum density, lb/ft3, from laboratory tests (ASTM D4254)

γdmax = maximum density, lb/ft3, from laboratory tests (ASTM D4253)

A vibratory hammer test (ASTM D 7382) is now in use to provide compaction control of these soils.

For cohesion less soil (fine sand) containing 0 to 25% plus 4.75mm material the minimum acceptable relative density is 75%. For cohesion less material (coarse sand) containing 0% to 25% plus 4.75mm material the minimum acceptable relative density is 70% and for coarse sand and gravel with 0 to 100% plus 4.75mm material, the minimum acceptable relative density is 65% . These are the minimum values which shall not be lower than that specified by the designer.

In the current project, random fill is specified by the designer instead of shell material for economical purposes but still the stability and seepage criteria must meet.

Below are the characteristics of the random fill(considered by the designer as shell material in the current project) barrow area material reported by the dam designer and considered in the design,which needs to be used after verification by the construction contractor.

Material type: alluvial with high clayey contents, Color: Gray to Reddish, Size: with Percentage of Fines (0.075 mm) > 25%, Plasticity Index>=7, Grain size distribution: = 0.002 mm to 70 mm, Hydraulic conductivity< 10-6 m/s, source : Borrow area D.

2.2.12.4. Stone Riprap - Zone 4

Material for Riprap slope protection of embankment, flexible riprap apron, and stone pitching at other designated areas shall be obtained from a designated quarry/borrow area, and shall conform to the gradation limits shown in drawing and USBR DS-13, chapter 7. Riprap shall comprise hard, sound and durable pieces of rock, not liable to deteriorate during handling or placing, or on exposure to weather, still or flowing water and wave action. Each piece of rock shall be free from cracks, seams, fissures, planes of weakness or other flaws which would tend to unduly increase its deterioration from natural causes. Any pieces showing signs of significant edge or corner wear, or of severe rounding, shall not be accepted. Riprap also shall not contain impurities or foreign matters in such quantity as would be damaging to the environment or the integrity of the Works.

Abrasion after 500 revolutions in a Los Angeles machine in accordance with ASTM C535 shall not exceed a loss in weight of 40%. The soundness shall be measured in sodium sulphate solution in accordance with ASTM C88, and the weight loss after 5 cycles shall not exceed 10%. The absorption measured in accordance with ASTM C97 shall not exceed 2%. The specific gravity (SSD) shall not be lower than 2.6.

Freeze-thaw durability (ASTM D5312, USBR 4666): Freeze-thaw durability testing indicates structural weaknesses and is a measure of durability for various field exposure conditions as freezing, thawing, wetting, drying, and wave action. Because it can be used as a general indicator of durability, freeze-thaw test results are applicable even in areas not experiencing freeze-thaw.

The length to width ratio of less than 30% of the riprap by weight shall comprise pieces whose length is greater than 2.5 times their width

The 'Wx' of the riprap is defined as the weight, which exceeds the weight of x% by weight of the rock pieces. The Maximum median stone weight (W50) of the riprap shall not be less than the value defined for the particular type of riprap (approximately 907kg.) and the minimum W50 is 160Kg. The ratio of W85 to W15 shall not be less than three nor greater than ten, and no piece of riprap shall weigh more than five times the required value of W50. Not more than 2% of the riprap shall comprise pieces weighing less than one thirtieth of the required value of W50.

The 3ft thickness of riprap normal to the slope is usually economical and satisfactory for major dams. The minimum thickness shall be equal to or greater than $2D_{50}$,unless specified otherwise by the designer.

2.2.12.5. Transition Zone - Zone 5

Below characteristics are specified by the designer for the transition zone material

Material type: Sand-Gravel, Layer_thickness=2m, Color: white, Coarse particle Size: 4.75mm -50 mm, Percentage of Fines (<0.075): <=3%, Grain size distribution: = 0.005 mm to 50 mm, Hydraulic conductivity< 10-1 m/s. Source = sorted riverbed material.

The loose thickness of layers shall not exceed 30cm to 38cm, average loose thickness become 34cm and average compacted thickness shall not exceed 30cm. and normally four or more passes of the smooth drum steel-wheeled roller will be adequate, provided that the required relative density requirement meets. The material shall be very wet during the compaction.

The Transition zone material shall be compacted to an average value of 75% of the relative density and any single value of the relative density shall not be lower than 70%. Unless specified otherwise by the designer.

2.2.13 Frequency of control testing of the material during the construction of the different zones in embankment dams:

Test name	standard	Frequency of testing for the indicated zones of the dam			
		Clay core	**Shell/Randam fil**	**Filters and drains(zon 2A,2B and 2C)**	**Rip-Rap**
Gradation	ASTM D6913	One test per each 2000 to 5000CUM, but not less than one test per shift.	During initial placing one test per each 750 CUM placement. After placement procedures have proved satisfactory, no doubt in compaction and no change in the material type, one test for every 7500CUM is enough.	One test per each 200CUM to 1000CUM.	Every 2000 CUM
Atterberg limits	ASTM D4318	One test per each 4000 to 20000 CUM, but not less than one test per shift.	Non plastic	N/A	N/A
Classification	ASTM D2487	Three tests per source/barrow area and then one test per each 5000 CUM	Three test per source/barrow area and then one test per each 7500 CUM	N/A	N/A
Compaction	ASTM D 5030	The number of field density depends on the extent and number of the doubtful	At beginning one relative density for each 750CUM and then one test	one relative density test per each 3800CUM, but not less	One test per each layer placed. In-place density of the

		areas. when no doubtful area or embankment operations concentrated areas occur than one test for each 1500 CUM or one test per each layer Which ever gives the greater tests shall be conducted. If doubt ful area/areas occurred, then at least one test shall be conductedPer each doubtful area. Below areas can be the doubtful areas: 1.rolled earthfill embankment along abutments, cutoff walls , outlet works and other structures.. 2. Areas where rollers turn during rolling operations. 3. Areas where too thick a layer is being compacted. 4. Areas where improper water content exists in amaterial. 5. Areas where less than specified number of rollerpasses were made. 6. Areas where oversize rock has not been removed fromthe fill. 7. Area of instrumentation(piezometers and others)	per each 7500CUM, but not less than one test per layer.	than one test per layer.	compacted material, after rolling, must be determined directly by large-scale conventional methods (ring density tests USBR 7220 or 7221; ASTM D 4914 or D 5030) or indirectly by observing and measuring settlement of the fill. The later method(indirectly by observing and measuring settlement of the fill)is generally used because conventional density tests in rock fills are difficult,

Moisture content	ASTM D 2216	One test per layer	One test per each 7500 CUM.not less tnan one test per layer.	One test per layer.	N/A
Permeability test in situ(dam body after compaction)	ASTM D5856	A minimum of 10 tests if the soil is uniform and 20 tests if the soil is variable per barrow area and then one test each 40000CUM to 100,000CUM.	A minimum of 3 tests per barrow area and then one test for each 4000 to 20000 CUM.	One test per each 1000 to 4000CUM for fine filter. One test per each 5000 to 10000CUM of coarse filter and one test per each 2000 to 10,000CUM of the drains.	N/A
Direct shear test	ASTM D6528	Three tests per source/barrow area and then one per each doubt in change of the material type or as specified by the designer and not less than one test per each 22936 CUM.	Three tests per source/barrow area and then one per each doubt in change of the material type or as specified by the designer and not less tan one test per each 30000 CUM.	Three tests per source/barrow area and then one per each doubt in change of the material type or as specified by the designer	Three tests per source.
Un confined compression test	ASTM D2166	Three tests per source/barrow area and then one per each doubt in change of the material type or as specified by the designer.	Three tests per source/barrow area and then one per each doubt in change of the material type or as specified by the designer.	Three tests per source/barrow area and then one per each doubt in change of the material type or as specified by the designer	Three tests per source.
Tri-axial test	ASTM D7181	Three tests per source/barrow area and then one per each doubt in change of the material type or as specified by the designer and not less than one test per each 22,936 CUM.	Three tests per source/barrow area and then one per each doubt in change of the material type or as specified by the designer and not less than one test per each 30000 CUM.	Three tests per source/barrow area and then one per each doubt in change of the material type or as specified by the designer	Three tests per source.

2.2.14 Payments:

The payment items are indicated in the table below and the payment shall be made

According to the contract BOQ unit price.

Pay Item No.	Description	Unit of Measurement
2.1.3.1	Soil excavation including (excavation, loading, transportation and unloading) per the design drawings and specification.	CUM
2.1.3.2.	Rock excavation if any, including (excavation, loading, transportation and unloading) per the design drawings and specification.	CUM
2.2.12.1	Impervious Core and Upstream Impervious Blanket - Zone 1 (Clay core) construction including(excavation, loading, transportation ,unloading, spreading ,watering , compaction and testing) per the design drawings and specification.	CUM
2.2.12.2	Filters and drains construction including(supply, loading, transportation , unloading, spreading ,watering , compaction and testing) per the design drawings and specification.	CUM
2.2.12.3	Shell/Randam fill construction, including(excavation, loading, transportation , unloading, spreading ,watering , compaction and testing) per the design drawings and specification.	CUM
2.2.12.4	Rip-Rap construction including(supply, loading, transportation , unloading, spreading ,watering , compaction and testing) per the design drawings and specification.	CUM
2.2.12.5	Transition zone construction including(supply, loading, transportation, unloading, spreading ,watering , compaction and testing) per the design drawings and specification.	CUM

3. SECTION-III - CONCRETE WORK

3.1 scopes

Concrete work includes provision of all the required material, labore and Equipment needed for the manufacturing, transportation, placement, vibrating, finishing, testing,repairing and curing of concrete along with supply and installation of reinforcement, formwork,joints, joint materials, joint treatment and all other works associated with cast-in-place and precast concrete(if any) per the design drawings and the requirement of the this specification.

3.2 REFERENCE STANDARDS

Reference Standards are referred to in the text of the Specifications in abbreviated form. The numbers and subjects are given below for convenience:-

STANDARD	SUBJECT
American Concrete Institute (ACI)	
ACI 201.2R	Guide to Durable Concrete
ACI 207.1R	Guide to Mass Concrete
ACI 211.1	Standard practice for selecting proportions for normal, heavyweight, and mass concrete
ACI 224.3R	Joints in Concrete Construction
ACI 305R	Hot weather concreting
ACI 306-66	Recommend Practices for cold weather concreting
ACI 315	ACI detailing manual
ACI 318	Building code requirements for reinforced concrete
ACI 350	Code Requirements For Environmental Engineering Concrete Structures
American Society for Testing and Materials (ASTM)	

STANDARD	SUBJECT
ASTM A36	Specification for structural steel
ASTM A615	Specification for deformed and plain billet-steel bars for concrete reinforcement
ASTM C27	Precast Standards
ASTM C31	Practices for making and curing concrete test specimens in the field.
ASTM C33	Specification for concrete aggregates
ASTM C39	Test method for compressive strength of cylindrical concrete specimens
ASTM C40	Test method for organic impurities in fine aggregates for concrete
ASTM C42	Methods of obtaining and testing drilled cores and sawed beams of concrete
ASTM C88	Test method for soundness of aggregates by use of sodium sulphate or magnesium sulphate
ASTM C94	Specification for ready-mixed concrete
ASTM C117	Test method for materials finer than 75 μm (No. 200) sieve in mineral admixtures by washing
ASTM C 127	Test method for specific gravity and absorption of coarse aggregate

STANDARD	SUBJECT
ASTM C 131	Test method for resistance to degradation of small-size coarse aggregate by abrasion and impact in the Los Angeles machine
ASTM C 136	Method for sieve analysis of fine and coarse aggregates
ASTM C 142	Test method for clay lumps & friable particles in aggregates
ASTM C 143	Test method for slump of Portland cement concrete
ASTM C144	Standard Specification for Aggregate for Mortar
ASTM C150	Standard Specification for Portland Cement
ASTM C151	Test method for autoclave expansion of Portland cement
ASTM C186	Test method for heat of hydration of hydraulic cement
ASTM C205	Specification for Portland Blast-Furnace Cement
ASTM C231	Test method for air content of freshly mixed concrete by the pressure method
ASTM C260	Specification, for air-entraining admixtures for concrete
ASTM C309	Specification for liquid membrane-forming compounds for curing concrete
ASTM C311	Method for sampling and testing fly ash or natural pozzolans for use as a mineral admixture in Portland cement concrete
ASTM C404	Specifications for aggregate for masonry grout
ASTM C441	Test method for effectiveness of mineral admixtures in preventing excessive expansion of concrete due to the alkali-aggregate reaction

STANDARD	SUBJECT
ASTM C451	Test method for early stiffening of Portland cement (Paste method)
ASTM C494	Specification for chemical admixtures for concrete
ASTM C618	Specification for fly ash and raw or calcined natural pozzolan for use as a mineral admixture in Portland cement concrete
ASTM C989	Specification for ground iron blast-furnace slag for use in concrete and mortars
ASTM D1190	Specification for concrete joint sealer, hot-poured elastic type
ASTM D1751	Preformed expansion joint fillers for concrete paving and structural construction (Non-extruding and resilient bituminous types)
ASTM D 1752	Specification for preformed sponge rubber and cork expansion joint fillers for concrete paying and structural construction.
ASTM D1850	Specification for concrete joint sealer, cold-application type
ASTM D2419	Test method for sand equivalent value of soils and fine aggregate
ASTM C1602	Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
ASTM C1782	Standard Specification for Segmental Concrete Paving Slabs
ASTM C144	Standard Specification for Aggregate for Masonry Mortar
ASTM A421	Standard Specification for Stress-Relieved Steel Wire for Prestressed Concrete
ASTM C90	Standard Specification for Loadbearing Concrete Masonry Units
ASTM C129	Standard Specification for Non Loadbearing Concrete Masonry Units

STANDARD	SUBJECT
U.S. Army Corps of Engineers (US COE)	
CRD C568	Rubber - preparation of pieces for test from other than standard vulcanised sheets
CRD C570	Test for brittleness temperature of plastics and elastomers by impact
CRD C571	Test for stiffness of plastics by means of a cantilever beam
CRD C572	Specifications for polyvinyl chloride water-stop
CRD C573	Test for rubber properties in tension
US Federal Specifications (US)	
SS S1614	Scaling compound, jet-fuel resistant, hot-applied, one-component, for Portland cement and tar concrete pavements
TT C598C	Caulking compound oil and resin base type (for building construction).
TT S00227E	Sealing compound elastomeric type, multi-component (for caulking, sealing, and glazing in buildings and other structures)
AWS D1.4	Structural Welding Code— Steel Reinforcing Bars

3.3 Certificates and Mill Test Data

The Contractor shall furnish manufacturers' or suppliers' certificates of compliance with relevant standards for each shipment of all materials and accessories used in the Permanent Works including

- Cement
- Pozzolanic materials
- Admixtures
- Curing compound
- Jointing materials, including water-stopper
- Reinforcing steel

The Contractor shall also submit appropriate mill analysis and laboratory test data of samples tested by the supplier. Mill analysis and test data shall be representative of materials furnished for the Permanent Works. The frequency of sampling and testing by the supplier shall conform to applicable standards.

3.4 Results of Tests Performed by the Contractor

The Contractor shall furnish:-

- Mix design of concrete, mortar and grout attached with the tests result of all the quality tests conducted on cement, fine aggregate, coarse aggregate and water per the requirements of ASTM C-150, ASTM C33 and ASTM C-1602, sulfate content in ground water and water impounded and soil which comes in contact with the concrete shall be submitted to MEW for approval. .
- Each delivery of each size of the re-inforcement shall be tested and the test results shall be submitted to MEW for approval.
- The test result of any other test not mentioned here, but required per the specification codes and standards (ASTM, ACI code, USBR and USACE) shall be submitted to MEW.
- A summary of the tests result of strength, slump , percent air-entrained and temperature tests conducted per the specified frequency of sampling and testing shall be submitted. Along with each invoice.

Minimum compressive strength of 4000Psi (28 MPA) as specified by the designer.

The concrete is air-entrained concrete with 5±1% air content.

Maximum water cement ratio is 0.45.

Unless otherwise specified or permit-ted, concrete shall have, at the point of delivery, a slump of 7.5 to10cm. Determine the slump by ASTM C 143/C 143M.

3.5 strength and other Characteristics of concrete for different types of structures

The different characteristics of the different classes of concrete are summarized in the table below: All of the below classes may not be involved in the current project.

S/No	*Type of Structure*	*Mini. Cylindrical Concrete strength (MPA)*	*Cement Type*	*Max. water cement ratio*	*Nominal max. size of aggregate (mm)*	*Slump (mm)*
1	Lean concrete	15 MPA at 28 days	Portland cement type-I	Per mix design	25mm	Reasonable consistency
2	All CVC concrete, except of mass concrete or concrete exposed to freezing and thawing.	28 MPA (4000 psi) at 28 days, unless specified otherwise by the designer	ASTM C-150 type-I	0.45	25mm	75-100 mm
3	CVC concrete for normal hydraulic structures and other locations where specified by the designer	31 MPA at 28 days	ASTM C-150 type-I	0.42	25mm	75-100 mm

Notes:

1. The strengths values indicated in the table above are the minimum values which shall not be lower than that specified by the designer.
2. All concrete must be Air-entrained concrete with at 5±1% air content, except the concretes which are not subject to freezing like structures in hot climates and interior concrete of buildings.
3. All concrete must be plant mixed for large jobs, and machine mixed for very small jobs, provided that the slump, strength and air content requirements meets.

3.6. Material

The ingredients material of concrete is fine aggregate, coarse aggregate, Cement, water and admixture if any which are briefly described below.

3.6.1. Fine aggregate

Fine aggregate for concrete shall conform to the quality requirements of ASTM C33 and shall consist of natural and/or crushed sand. Fine aggregate shall be washed.

In addition to the above, fine aggregate for concrete shall meet the following physical requirements:

- Fineness modulus (ASTM C33) 2.30 to 3.1
- Sodium sulphate soundness (ASTM C88) 5 cycles maximum 10% loss
- Sand equivalent (ASTM D2419) minimum 75%.
- Clay lumps and friable particles (ASTM C33) in coarse aggregate max 2% by weight
- Clay lumps and friable particles (ASTM C33) fine aggregate max 3% by weight
- Material passing 0.075 mm sieve 3% by weight
- Coal and lignite 1 % by weight
- Total of other deleterious substances (such as mica, chlorite, coated grains and soft flaky particles) 3% by weight
- The sum of the percentages of all deleterious substances shall not exceed 5% by weight
- When tested in accordance with ASTM C 136, fine aggregate shall be well graded within the following graduation requirements:-

GRADING OF FINE AGGREGATES(ASTM C33)

Sieve Designation	Percentage Passing by Weight.
3/8 inch	100
No. 4	95–100
No. 8	80-100
No. 16	50–85
No. 30	25-60
No. 50	5-30
No 100	0–10

3.6.2. Coarse aggregate

Coarse aggregate for concrete shall conform to the quality requirements of ASTM C33, and shall consist of crushed gravel or crushed stone. Coarse aggregate shall be washed and shall be separated into at least three different nominal size ranges. The specific gravity and absorption of coarse aggregates shall be determined in accordance with ASTM C127.

In addition, coarse aggregate for concrete shall meet the following physical requirements

- Sodium sulphate soundness 5 cycles (ASTM C88) maximum 12% loss
- Los Angeles abrasion value (ASTM C131) maximum 40% loss
- Coarse aggregate shall contain, not more than one (1) percent by weight material passing the No. 200 sieve by

When tested in accordance with ASTM C136, the coarse aggregate nominal size ranges shall meet the graduation requirements of size No.6 table-2 of ASTM C-33 shown below

GRADING OF COARSE AGGREGATE (ASTM C33 table-2)

Size number	Nominal size(sieves with square openings)	Percentage by weight Passing Laboratory Sieves Having Square Openings, in Inches							
		2½	2	1½	1	¾	½	3/8	No. 4
1	3 1/2in to 1/1/2 in	25-60	.....	8-15	.....	0-5	.....	.....	.....
2	2 ½ to 1 1/2in	90-100	35-70	0-15	.....	0-5	.....	.....	.....
3	2 in. to 1 in	100	90-100	35-70	0 -15	....	0-50	.....	.....
357	2 in. to No. 4	100	95-100	.....	35-70	.....	10-30	.....	0 5
4	1½ in. to 3/4		100	80-100	20-55	0-15	.....	0-5	.....
467	1½ in. to No. 4		100	95-100	.....	35-70	.....	10-30	0 5
5	1 to 1/2in			100	90-100	20-55	0-10	0-5	.....
56	1 to 3/8 in			100	90-100	40-85	10-40	0-15	0 5
57	1 in. to No. 4			100	100	.....	25-60	.....	0-10
6	¾ to 3/8 in				100	90-100	20-55	0-15	0 5
67	¾ in. to No. 4					90-100	.....	20-55	0-10
7	½ in. to No. 4					100	90-100	40-70	0-15
8	3/8 in to No.8						100	85-100	10-30
89	3/8 in to No 16						100	90-100	20-55
9	No 4 to No16							100	85-100

3.6.3 Cement

Selection of the type of cement depends on the exposure condition to which the structure subjects after construction, heat of hydration produced during concrete casting and shall be selected per

the table indicated in section 3.5. For more details please refer to ACI 350.

For mass where the heat of hydration is a matter of concrete cement Type-II or cement type-I plus fly- ash comply to ASTMC150 shall be used. For ordinary box culvert where the heat of hydration is not a matter of concern, ordinary Portland cement Type-I can be used.

If the soil or water to which the concrete comes in contact has high sulphate content, sulphate resistant cement type-V shall be used. Cement shall comply with the requirement of ASTM C150.

3.6.4 Water

Water for washing aggregates, mixing concrete and curing shall be clean and free from harmful matter and shall comply with the recommendations contained in the Appendix to ASTM C1602. The concentration of sulphates and chlorides shall be such that the concrete mix as a whole complies with the limits of salts content also recommended in ASTM C1602.

3.6.5 Admixture

The Contractor shall furnish and use a water-reducing set- retarding admixture in all concrete unless otherwise approved by the Engineer. The water-reducing set-retarding admixture shall conform to ASTM C494, Type D.

The Contractor shall furnish and use an approved air-entraining admixture in all concrete except in high strength concrete. The air-entraining admixture shall be a neutralized vinyl resin and shall conform to the requirements of ASTM C260

3.7. Proportioning of concrete/ Concrete Mix design

At least 60 days ahead of the concrete commencement , concrete mix shall be designed and submitted to MEW for approval.

First of all, all the required quality tests shall be conducted on cement, water, fine aggregate, coarse Aggregate and if the quality tests results of materials meets the requirement , then concrete mix design will be conducted according to ACI 211.1. At least three trial baches with three different water cement ratios shall be conducted and a graph of strength verses W/C shall be drawn.
Below is the summary of the required quality tests needed for a concrete mix design along with the Specification limits:

Type of test	AASHTO Designation	Specification Limit
Max. size of aggregate		In no event will the nominal maximum size aggregate exceed one-fifth of the narrowest dimension between sides of forms; one-third the depth of slabs; nor three-fourths of the minimum clear spacing

		between, individual reinforcing bars. For non-reinforced mass concrete suggested maximum size of aggregated can be 1.5in(38mm).
Maximum Water cement ratio		0.45 for structures not exposed to freezing and thawing 0.42 for conrecete exposed to freezing and thawing in saturated condition
Slump		50--75mm for mass concrete. 75mm to 100mm for reinforced concrete.
Moisture content of fine aggregate and absorption of fine aggregate		As determined.
Moisture content of coarse aggregate and absorption of coarse aggregate		As determined.
Unit weight of coarse aggregate	T-19	1120 min
Gradation of fine aggregate		AASHTO M6/ASTM C33
Gradation of coarse aggregate		ASTM C33
Air Content		5±1%
Finess modulus		2.3 - 3.1
Sand equivalent value	T-176	75% min
Soundness loss	T-104	10 % max.
LAV	T-96	40% max
Clay lumps and friable particles	T-112	2% max. for coarse aggregate; 3%max for fine aggregate
Cement		ASTM C150

Water		ASTM C 1602
Admixture(if any)		ASTM C 260(for air-entraining admixture). ASTM C494 (for water reducing admixture)
Compressive strength	T-22 and T-23	As specified in section 3.5.2 but not less than value specified by the designer

Once the mix design is approved, then the concrete can be started.

3.8. Preparation for Concreting

Before placing concrete, the Contractor shall ensure that:

- For proper bonding of the facing concrete with stone masonry, the older mortar(if any) shall be broken and cleaned up with hand hammer without losing the stones.
- The surface of the previously placed concrete or the foundation is clear of all oil, loose fragments of rock, earth, mud, timber, pieces of tie-wire or any other foreign material, running or standing water, dust, etc.
- Excavated surfaces on which concrete is to be placed shall consist of undisturbed in situ material. They shall be compacted if so directed by the Engineer.
- Where concrete is to be placed on compacted fill, the compacted fill shall be extended beyond the foundation line by a distance sufficient to ensure that all fill below the foundation surface is compacted to the specified degree. The fill shall then be trimmed to the foundation level shown on the Drawings. The surfaces shall be re-compacted if so, directed by the Engineer.
- All reinforcement is in its correct place, well tied and fitted with spacer blocks to maintain correct cover, and is clean.
- All formwork is well supported, made to dimensions shown on the Drawings, erected to the specified tolerances, cleaned, oiled, inspected and accepted by the Engineer.
- All necessary tools and plant, e.g. vibrators, and all necessary materials for protection and curing of concrete are available and in working order.
- All surfaces against which concrete is to be placed are wet.

- Concrete materials are within specified temperatures.

3.9. Transporting Concrete

Concrete shall be conveyed from mixer to its place on the Permanent Works as rapidly as possible by ways and means, which will prevent segregation or drying out and ensure that the concrete is of the required consistency at the time of placing.

Buckets, belt conveyors, chutes or other similar equipment will be permitted for conveying concrete subject to approval of the proposed system by the Engineer.

All conveying equipment and methods shall be designed for and capable of handling concrete of all specified aggregate sizes and slumps, including low-slump concrete.

Clear indication shall be provided for the identification of different mixes of concrete and their destination, and each consignment shall be accompanied by a copy of the batching plant printed record as specified as per specification.

3.10. Placing Concrete

All concrete shall be placed so as to produce a set concrete that is hard, durable, dense, free from honeycombing, formwork irregularities and other surface blemishes per the requirements of ACI 304R ,ACI301 and ACI 207.1R .

At least sixty calendar days before placing concrete in any major structure, the Contractor shall submit to the Engineer for his approval details of his proposed construction procedures including a description of the methods of concrete placement. Approval of construction procedures and methods of placement will not relieve the Contractor of his responsibility for their adequacy and he shall remain solely responsible for satisfactory construction of the Permanent Works.

For each concrete placement, the Contractor shall provide the Engineer with written notice, a drawing and a pre-placement checkout sheet signed by the Contractor's appropriate supervisory personnel that demonstrate that foundation preparation, construction joint cleanup, formwork, installation of reinforcing steel, blackouts and all embedded items for the placement have been completed according to the Drawings or as specified. Before Concrete placement is permitted, each item on the checkout sheet shall be initialed by the Engineer showing that the item has been inspected and is ready to receive concrete. Concrete placement will not be permitted when, in the opinion of the Engineer, conditions prevent proper placement consolidation, finishing and curing.

Concrete mixed in stationary mixers and transported by non-agitating equipment shall be placed within thirty minutes of mixing. When an agitator is used for transporting concrete, the concrete shall be delivered to the site of the work and discharge shall be completed within 1 hour after introduction of cement to the aggregates except that, when the temperature of the concrete exceeds 21°C (70°F), the time shall be reduced to 45 minutes. The concrete shall be placed within 20 minutes after it has been discharged.

Per ACI 207.1R and ACI 301,For placement of thick lift/lifts of concrete, the lift shall be divided and placed into equal horizontal layers not exceeding 30cm to 45cm in thickness. The layer thickness should be an even fraction of the lift height or of the depth of the block. The layers are carried forward in a stair-step fashion in the block by means of successive discharges so there will be a setback of about 5 ft(1.5 m) between the forward edges of successive layers. Placement of the steps is organized so as to expose a minimum of surface and to lessen warming of the concrete in warm weather and reduce the area affected by rain in wet weather.

To prevent cold joints between the layers and where a lift of concrete is built up in a series of layers, each layer shall be placed where the underlying layer is still in the plastic state and properly vibrated and merged into the preceding layer before initial set takes place in the preceding layer by the vibrator penetrated in to the preceding layer. The layers shall be horizontal, inclined layers are not acceptable.

Construction joints occur wherever concreting is stopped or delayed so that fresh concrete subsequently placed against hardened concrete cannot be integrated into the previous placement by vibrating. Horizontal construction joints will occur at the levels between lifts, whereas vertical joints occur where the structure is of such length that it is not feasible to place the entire length in one continuous operation. In general, the preparation of a vertical construction joint for acceptable performance and appearance is the same as for horizontal joints.

For proper bonding of the new concrete lift with the old concrete lift, the surface of the old concrete shall be clean and washed by a water jet and surface dry and then the new lift shall be placed on the top of it.

Concrete shall not be allowed to slide or flow down sloping surfaces, except in underground galleries, but shall be placed in its final position from skips, trucks, barrows, down pipes or other placing machine or device or, if this is impossible, it shall be shoveled into position with care being taken to avoid separation of the constituent materials. Concrete placed in horizontal slabs from barrows or other tipping vehicles shall be tipped into the face of the previously placed concrete

Concrete dropped into place shall be dropped vertically. It shall not strike the formwork between the point of its discharge and its final place. Concrete shall not be dropped freely through a height greater than 5 ft. Chutes and conveyor belts shall be so designed that there is no segregation or loss of mortar and shall be provided with a vertical tapered down pipe, or other device, to ensure that concrete is discharged vertically into place.

When pumps are used, the end of the supply pipe shall be arranged so as to avoid segregation. Mortar or water used at the beginning or end of a run shall be discharged outside the formwork

Where concrete abuts against earth or other materials liable to become loose or to slip, the Contractor shall take steps to prevent any such loose material falling onto the surface of the concrete.

3.11. Lift Height and Time Between Placement

The permissible depth of concrete, placed in one lift and the minimum time elapsing between the placing of successive lifts shall be as follows unless otherwise shown on the Drawings or directed by the Engineer

Sr. #	Location	Maximum Depth of Concrete Placed in One Lift	Minimum Time Elapsing between Placing of Successive Lifts
1	Concrete in base slabs and in walls, columns and piers whose thickness does not exceed 3 m (10 ft)	3.0 m (10 ft)	120 hr
2	Gate guide blackouts	4.5 m (15 ft)	8 hr
3	All other concrete	1.5 m (5 ft)	120 hr

3.12. Concreting in Hot Weather

All hot weather concrete shall comply with the requirements of ACI 305R. Hot weather concreting plan shall be submitted by contractor at least 30 days ahead of the Hot weather to approval of Engineer 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 Engineer 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°C (77°F) 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 surfaces and to 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.

If, in the opinion of the Engineer, the maximum temperature reached by the concrete during Hydration could nevertheless damage the finished work, he may order: -

- avoiding the placement of concrete during the hottest part of the day, or
- Placement only at night, or
- an increase in the minimum period between lifts, or
- a combination of these.

3.13. Concreting in Cold Weather

Cold weather is defined as a period when, for more than 3 consecutive days, the

following conditions exist:

1) The average daily air temperature is less than 40 F (5 C) and

2) The air temperature is not greater than 50 F (10 C) for more than one-half of any 24-hr period.

Cold weather concreting plan shall be submitted by contractor at least 30 days ahead of the cold weather to approval of Engineer. Contractor should plan to protect fresh concrete from freezing and to maintain temperatures above the designated minimum for the required time after placing, well in advance of expected freezing temperatures All equipment and materials necessary should be at the work site before the first frosts are likely to occur. No concreting will be done with prior arrangement of protective measures against freezing point.

3.14. Vibrating/Compaction of concrete

Vibrators shall be inserted into the un-compacted concrete vertically and at regular intervals such that the radius of action overlaps that of the previously vibrated concrete. A layer shall not be covered with a succeeding layer until it has been thoroughly vibrated as specified. Where the un-compacted concrete is in a layer above freshly compacted concrete, the vibrator shall be allowed to penetrate vertically for about 4 inches into the previous layer. In no circumstances shall vibrators be allowed to come into contact with the formwork, nor shall they be withdrawn quickly from the mass of concrete, but shall be drawn back slowly so as to leave no voids. Internal-type vibrators shall not he placed in the concrete in a random or haphazard manner, nor shall concrete be moved from one part of the work to another by means of the vibrators. Care shall be taken properly to vibrate concrete placed in contact with previously placed concrete or embedded parts.

The duration of vibration shall be limited to that required to produce satisfactory compaction, without causing segregation. Compaction of the concrete by vibration shall be such as to produce a concrete that has the maximum practicable density, is free from pockets of coarse aggregate and entrapped air and makes complete contact with the foundation, previously placed hardened concrete, embedded items and the formwork.

3.15. Curing of concrete

Concrete shall be cured by approved methods. Means shall be provided for protecting the newly cast surface from the effects of sunshine, drying winds, frost, rain, running

water or mechanical damage. The Contractor shall submit proposals for the means of curing that he proposes to use to the Engineer for approval.

The curing shall be maintained for a continuous period of at least 14 days or until covered by the next lift or as otherwise approved by the Engineer

3.16. Routine Sampling and Testing of Concrete during construction

During concrete production, the Contractor will routinely test the concrete under the direct supervision of the Engineer for compliance with specified requirements. In general, one set of six cylinders will be made for each76 CUM, or a fraction thereof, of each class of concrete placed in each structure in a shift or from each day's placement as appropriate. The Contractor shall provide a suitable device to sample the discharge from each mixer and shall provide all help that may be required by the Engineer to carry the samples to the laboratory.

Test specimens will be made by the Engineer in accordance with the requirements of ASTM C31.

Test specimens will be tested by the Engineer in accordance with the requirements of ASTM C39 for compressive strength, to develop a comprehensive and historical record of mixtures, strength development and the degree of quality control achieved. In addition, the Engineer shall also determine the air content and density of the fresh concrete samples from which a set of specimens are cast.

Where there is evidence that concrete production and placement has resulted in work that does not meet the quality requirements of these Specifications, core boring will be ordered by the Engineer in accordance with ASTM C42. In the event that examination and tests on samples removed from the structure show that the concrete does not conform to these Specifications, measures as prescribed by the Engineer shall be taken by the Contractor to correct the deficiency. The entire cost of testing and corrective action shall be borne by the Contractor. Concrete samples containing aggregate particles larger than 1.5" will be wet-screened to remove such particles before making the slump test or casting 6 inches by 12-inch cylindrical compression test specimens.

Below is the summary of the frequency of sampling and testing during the construction

Type of test	AASHTO Designation	Frequency of sampling	Location of sampling	Specification Limit
Air Content	T-152 or T-196	1 per load	Point of discharge	4-6%
Slump	T-119	1 per load	Point of discharge	75mm to 100mm or as specified by the designer
Temperature	Field measurement	1 per load	Point of discharge	10 - 32°C
Compressive Strength	T-22 and T-23	One per every 76m³ (not less than one per days work per structure per mix design). *For each test at least 6 cylinders shall be casted, 3 for 7-days strength and 3 for 28-days strength*	Point of discharge	Average of five consecutive tests≥ Specified strength and Any single test (average of two cylinders) should not be lower than the specified strength by more than 3.5 MPA.

3.17. Form work

3.17.1 General

All formwork shall be soundly constructed, true to grade and line, firmly supported, adequately strutted, braced and tied to withstand the placing and vibrating of concrete and the effects of weather.

The contractor shall be responsible for the adequacy of the design and safety of formwork. The type, size, shape, quality and strength of all materials shall be subject to approval by the Engineer. The form work shall comply with the requirement of ACI 347.

Faces of formwork in contact with concrete shall be free from adhering foreign matter, projecting nails and the like, splits or other defects, and all formwork shall be clean and free from standing water, dirt, shavings, chippings, tying wire or other foreign matter. Joints shall be sufficiently watertight to prevent the escape of mortar or the formation of fans or other blemishes on the face of the concrete.

Except where the surface is subsequently to be rendered, formwork in contact with the concrete shall be treated with an approved non-staining form mould oil to prevent adherence of the concrete. Care shall be taken to prevent the oil 'from coming in contact with reinforcement or with concrete at construction joints. Surface retarding agents shall

not be used unless specified.

Openings for inspection of the inside of the formwork, for the removal of water used for washing down and for placing concrete shall be provided and so formed as to be easily closed before or during placing concrete. Before placing concrete, all bolts, pipes or conduits or any other fixtures which are to be built-in shall be fixed in their correct positions, and cores and other devices for forming holes shall be held fast by fixing to the formwork or otherwise.

3.17.2 Removal of the form work

Formwork shall be so designed as to permit easy removal without resorting to hammering or levering against the surface of the concrete.

The periods of time elapsing between the placing of the concrete and the striking of the formwork shall be as approved by the Engineer after consideration of the loads likely to be imposed on the concrete and shall in any case be not less than the periods shown in the following table:

Minimum Time for Removal (Concrete using Ordinary Portland Cement):

Sr. #	Position	Normal Weather (Days)	Cold Weather (Days)
1	Beam Sides, Walls and Columns	3	6
2	Slab and Beam Soffits	14	20

Minimum removal time shall be longer than that indicated above when pozzolanic materials or cement type-II are used.

Cold weather is defined as a period when, for more than 3 consecutive days, both of the following conditions exist:

1) the average daily air temperature is less than 40 F (5 C) and
2) the air temperature is not greater than 50 F

(10 C) for more than one-half of any 24-hr period.

- Normal weather is at all other times.

Where soffit formwork is constructed in a manner that allows the removal of the majority of the

formwork and the retention, during and after such removal, of a sufficient number of adequate supporting props in an undisturbed condition, the Contractor may, with the agreement of the Engineer, remove the formwork at the earlier times listed above provided that the props are left in position and are not disturbed during removal of the majority of the formwork.

Notwithstanding the foregoing, the Contractor shall be held responsible for any damage arising from removal of formwork before the structure is capable of carrying its own weight and any incidental loading.

3.18. Joints in the concrete

Joints in concrete shall be constructed per the requirements of ACI224.3R , EM 1110-2-2902 and ACI 350 whichever is applicable

Unless otherwise specified by the designer the spacing, between the transverse contraction joints shall be 6m for soil foundation and 9m for rock foundation.

All joints shall be provided with PVC water stops unless specified otherwise by the designer.

3.18.1. Jointing Materials

Jointing materials include fillers, paints, caulking compounds, sealants, adhesives, water-stoppers and other such materials required for the making of joints in concrete.

Jointing materials shall be specified by the designer or proposed by the Contractor and approved by the Engineer. They shall be handled, used and stored in accordance with the manufacturer's recommendations.

Where there is no appropriate standard to which reference may be made in respect of any proprietary jointing material, the Contractor shall prove by demonstration, tests or otherwise the suitability, adequacy and performance of the material under Site conditions. In other instances the Contractor shall supply manufacturer's test sheets to certify compliance with relevant quality standards. Only such materials as have been approved by the Engineer shall be used in the Permanent Works.

Bond-breaking coating for application to concrete surfaces to prevent bonding of fresh concrete to concrete previously placed shall be of a type that will adhere to damp surfaces of concrete and perform its function of breaking bond without any damage to the new concrete. The Contractor shall furnish detailed specifications and samples of the material he proposes to use for the approval by the Engineer.

Jointing materials used in the work shall conform to the following standards:-

Sr. #	Material	Standard
1	Hot-poured joint sealing compound	ASTM D 1190 or US SS S 1614 Sealer; Hot-poured type for joints in concrete
2	Cold application type	ASTM D 1850

Sr. #	Material	Standard
3	polysulfide-base or polysurethane-base joint sealant	US TT S00227E
4	Performed expansion	ASTM D1751
5	Joint filler	ASTM D 1752 Type II
6	Caulking compound	US TT C598C, Grade 1 or 2, colour as shown on the Drawings or as approved
7	Extruded plasticized polyvinyl chloride resin (PVC) water stop	US COE Specification CRD C572 for polyvinyl chloride water stop

3.19. Water Stops

PVC water-stoppers shall comply with the requirements of USACE CRD-C572 and be nominally 300 or 250mm mm wide as specified by the designer. Water stop shall be designed, installed and tested per the requirements of EM 1110-2-2102 and CRD-C752.

Specification of the water stop is summarized in the table below:

Summary of the specification for PVC water stop.

Sr. #	*Physical Characteristics*	*Requirement*	*Test Method*
1	Tensile strength, using diec, not less than	1750 psi(12.17 MPa)	CRD-C573
2	Ultimate elongation, using die C, not less than	300%	CRD-C573
3	Low temperature brittle-ness,	no sign of failure, such as cracking or chip-ping at -35 F (-37.2 C)	CRD-C570
4	Stiffness in flexure, not less than:	600 psi (4.13MPa)	CRD-C571
5	Accelerated Extraction Ultimate elongation, using die C, not less than: Tensile strength, using die C, not less than:	 280% 1500 psi(10.3 MPa)	Paragraph 7.1 of CRD-C572
6	Effect of Alkalis Change in weight after 7days, Change in	 between: -0.10 and+0:25%	Paragraph 7.2 of CRD-C572
	Shore durometer readings after 7 days, not more than:	±5	

3. 20. Reinforcement

3.20.1 General

Reinforcing bars shall be deformed bars complying with ASTM A6.5 and ASTM A 615. The specified characteristic grade will be Grade-60 with the yield strength of 60000 psi(415 MPA). Grade 40 steel is not allowed. Each size of steel bars in each delivery shall be tested.

3.20.2. Drawings and Bar Lists

The Construction Drawings furnished to the Contractor will show the amounts of steel reinforcement to be included in the various parts of the Permanent Works. From the information given on these drawings, the Contractor shall prepare detailed reinforcement drawings and schedules for approval. The detailed reinforcement drawings and schedules shall clearly show the numbers, shapes, lengths, sizes and weights of the bars and the laps and couplings to be used. The reinforcement detailing shall be in accordance with the recommendations of ACI 318, with lap lengths chosen to transmit 90% of the yield stress of the steel except where otherwise directed.

The reinforcement drawings issues with the specification indicate only the engineering requirements for reinforcing bars and fabric in the various structures.

3.20.3. Placing Reinforcement

The contractor shall be responsible for accuracy of the cutting, bending and placing of the reinforcement. Reinforcement will be inspected for compliance with the requirements as to grade, size, shape, length, splicing locations, position and amount after it has been placed.

Before the reinforcement is placed, the surfaces of the bars and the surfaces of any metal bar supports shall be leaned of heavy rust, loose mill scale, dirt, grease and other objectionable foreign substances. Heavy flaky rust which can be removed by firm rubbing with Hessian or equivalent treatment is considered objectionable. After being placed, the reinforcing bars shall be maintained in a clean condition until they are completely embedded in the concrete.

Reinforcing bars, dowel bars or fabric shall be accurately placed and secured in position so that there will be a clear distance of at least 1 inch between the bas or fabric and any adjacent embedded metalwork and so that the bars will not be displaced during the placing of the concrete, and the contractor shall ensure that there is no disturbance of the reinforcing bars or fabric in concrete that has already been placed.

Chairs, hangers, spacers and other acceptable metal, plastic or concrete supports may be furnished and used by the contractor for supporting reinforcing bars or fabric. Concrete supports where used shall conform to the concrete requirements of this Specification. Steel spacers which are liable to cause rust staining of finished surfaces shall not be used.

Reinforcing bars partially embedded in concrete during construction shall not be bent or straightened without prior approval. Such bending or straightening shall only be carried out by using an approval tool. In the case of bending, a former shall be used to ensure that the internal diameter of the bend is maintained at not less than 5 bar diameters. Before nay bar is straightened or bent after straightening, the length affected by bending and 2" beyond shall first be annealed by heating it to a dull red heat with oxyacetylene torch and then allowing it to air-cool. Quenching will not be approved.

3.20.4. Installation

Where it is necessary to splice reinforcement, the splices shall be made by lapping by mechanical means. No welding will be done.

Joints or splices in reinforcing bars shall generally be made at the positions shown on the drawings, but the contractor will be permitted to make joints or splices at positions other than those shown on the drawings; provided that such positions are approved and that the joints and splices in adjacent bar are staggered if directed.

. 3.20.5. Bending of Reinforcement

Bars shall be cut and bent in accordance with the provisions of ACI 315. Bending shall be carried out slowly, at a steady even pressure, and without jerking, impact or heating. The temperature of the steel at the time of bending shall not be less than 5°C (40°F). Bent bars shall not he re-bent unless permitted by the Engineer.

. 3.20.6. Storage of Reinforcing Bars and Fabricated Mats

The Contractor shall stack separately and label different types of reinforcement for positive identification of the manufacturer, size and production run or other number, which relates to the test certificates furnished by the manufacturer.

Steel reinforcing bars shall be kept clean and shall be free from pitting, loose rust, mill scale, oil, grease, dirt, paint or any other material, which may impair the bond between the concrete and the reinforcement. All reinforcement shall be stored under cover on

wooden or concrete supports at least 6 inch clear of the ground.

3.20. 7. ACCESSORIES

Spacer blocks for maintaining concrete cover to reinforcement shall be of concrete of the same texture, color and composition as the in-situ concrete. They shall be cast in the form of a truncated cone or pyramid with the smaller face having a minimum dimension of 2 in.

PVC spacer blocks of color matching with the concrete shall be used where formed surfaces are designated. The Contractor shall submit samples and manufacturer's technical data to the Engineer for his approval. They shall not be used for any surface that may be in contact with water.

Chairs and other accessories for maintaining reinforcement in position shall be of steel and shall not be placed within the specified minimum cover to steel. Binding wire shall be 1/8" soft iron wire.

3.20.8. Concrete cover on reinforcement

Clear cover of concrete on the reinforcement is indicated in the table below:

Sr. #	*Type*	*Cover*
1	Bottom of foundations and footings in contact with soil	7.5cm
2	Backfilled surfaces, water-retaining surfaces , surfaces subjected to submergence or rapid flow and all hydraulic structures except stilling basin where the clear cover shall be 15cm.	10cm
3	Elements greater than 3 ft thick	7.5cm
	Elements 2 to 3 ft thick	5cm
	Elements less than 2 ft thick	3cm
	Exterior beams or columns	5cm
4	Interior beams, girders and columns	4cm
5	Interior walls and slabs	2cm

3.21. Payment:

The payment items are indicated in the table below and the payment shall be made According to the contract BOQ unit price.

Pay Item No.	Description	Unit of Measurement
3.5(1)	Lean concrete including provision of all material, mixing, transporting, placement, vibrating , finishing, curing, form work and testing in locations indicated on the design drawings or as actually needed as per site but not shown on design drawings.	CUM
3.5(2)	4000 psi (28 MPA) concrete including provision of all material, mixing, transporting, placement, vibrating , finishing, curing, testing and form work per the design drawings.	CUM
3.5(3)	4500 psi (31 MPA) concrete including provision of all material, mixing, transporting, placement, vibrating , finishing, curing, testing and form work per the design drawings.	CUM
3.18.1	Jointing material as per the design drawings	M
3.19	Water stop including supply, placement and testing if advised by the MEW QA.	M
3.20.1	Steel reinforcement including supply to the project site, fixing and testing.	Ton

4. SECTION IV- STONE MASONRY WORK

4.1. GENERAL

Stone masonry is composed of field, quarried or casted stone units bonded by mortar.

The basic parts of a stone masonry structure are the stones and cement mortar. The cement mortar is a mixture of fine aggregate, cement and water.

In general there are two basic types of stone masonry:

Ashlar stone Masonry.

Rubble Stone Masonry

Each of the above two types are briefly explained below:

Both types can be either stone masonry without pointing or with pointing which shall be specified by the designer.

Normally in locations subjected to high dynamic forces and vibrations, stone masonry shall not be recommended, as the bonds between the stones established by masonry the mortar are weak points and easily breaks.

Hydraulic structures are rarely built of stone masonry because of the weak bond between the stones and the recent advances in concrete technology and good performance of the concrete

4.2. ASHLAR STONE MASONRY

Ashlar stone masonry is composed of stones with regular rectangular

Shapes having sawed, dressed, or square bed surfaces and bonded by mortar and shall be used in special locations where specified by the designer and will not be used in the current project.

The supply and furnishing of all labour, materials and equipment and performance of all operations necessary to complete the work of random ashlar stone masonry in accordance with the drawings and specifications given herein.

4.2.1 MATERIALS

4.2.1.1. Stones

All stones to be used in the works shall be obtained from quarries approved by the Engineer after quality tests. The stone shall be of hard, tough, sound, durable, free from voids, flaws, cracks, earth cover, zeolite etc.

Generally lime stones and quartz-base stones are not suitable for using in general construction

work, but Marble, granite and slate are suitable for using in general construction work.

In specific the stone shall be such as will not absorb more than 4.2 % of water by weight after being kept under water for twenty four hours and shall not be less than 20 cm in thickness and the width shall be not less than 1.5 times the thickness or 30 cm whichever is greater or as specified by the designer or Engineer. The minimum apparent specific gravity of stones (AASHTO T-85) shall not be less than 2.5. The stone with round surface shall not be used. The ashlar stone masonry shall be of various sizes of stones with regular shapes.

The stone shall conform to the following tests:

Water absorption test of stone shall be as per ASTM C-127 /AASHTO T-85

The stone shall withstand 30 cycles of durability test with sodium sulphate solution as per ASTM C-88 i.e. will not show any cracking or excessive rounding at edges of test specimen after completion of 30.

Table 1: summary of the part of the quality tests to be conducted for stone selection:

Type of test	AASHTO Designation	Frequency of sampling	Location of sampling	Specification Limit
Apparent specific gravity of stone	T-85	One test (average of 3 stones per source)	Source	2.5 min
Absorption of stone	T-85	One test (average of 3 stones per source)	Source	4.2%
Minimum compressive strength of stone		One test (average of 3 stones per source)	Source	40MPA unless otherwise specified by the designer.

4.2.1.1.1. DRESSING

Every stone shall be fine tool dressed on all beds, joints and faces, full true and square giving perfectly vertical and horizontal shall joints with the adjoining stone. The faces of stone shall be chisel dressed for this work true square and full. The surface of stone shall be plain or to uniform cures or twist as shown in Architectural drawings or as directed by the Engineer-in-Charge. All stones on the work shall be same as per approved samples.

4.2.1.1.2. SIZES OF STONES

The dimensions of the stones to be used shall not be less than 20 cm in thickness and the width shall be not less than 1.5 times the thickness or 30 cm whichever is greater. The stone course shall be of 40 to 60 cu. in height but no course shall be thicker than any course below it. The surface of stone shall be plain or to uniform cures or twist as shown in Architectural drawings or as directed by the Engineer-in-Charge. All stones on the work shall be same as per approved samples.

4.2.1.2. CEMENT MORTAR

The cement mortar required for stone masonry shall be according to ASTM C270-type S. Cement mortar shall be in proportion of one part cement and three parts sand by volume.
Cement mortar is a mixture of cement, fine aggregate and water.
Cement can be Portland cement type-I, mortar cement and masonry cement.
Water shall comply with the requirement of ASTM C1602.
Fine aggregate (sand) Sand for use in masonry mortar shall be confirm to ASTM C-144 and consist of natural sand or manufactured sand. Manufactured sand is the product obtained by crushing stone, gravel, or air-cooled iron blast-furnace slag specially processed to ensure suitable gradation.

Table 2. Graduation Requirements for Stone Masonry Mortar Fine Aggregate (ASTM C144)

Sieve Size (mm)	% Passing (by Weight)	
	Natural Sand	Manufactured Sand
4.75	100	100
2.36	95 - 100	95 - 100
1.18	70 - 100	70 - 100
0.6	40 - 75	40 - 75
0.3	10 - 35	20 - 40
0.15	2 - 15	10 - 25
0.075	0 - 5	0 - 10

In addition to the above requirements the aggregate shall not have more than 50% retained between neither any two consecutive sieves nor more than 25% between No.50 and No.100
Dry mortar shall be prepared by using and corresponding to one bag of cement measured by batching boxes and then spreading the bag of cement over it. The mixture shall then be obtained for the final mortar for use. Mortar once mixed shall be consumed preferably within 20 minutes and not later than 30 minutes in any case. Old mortar remaining back in taslas shall be thrown away and taslas thoroughly cleared before filling the same with fresh mortar. In no case fresh mortar shall be mixed with old mortar.

Cement Mortar Mix Design

The following tests shall be conducted and results furnished for cement mortared stone masonry mix design:

Table3: tests required for cement mortar mix design

Type of test	AASHTO Designation	Specification Limit
Gradation of fine aggregate	T-27 and T-11	ASTM C144
7 day and 28 day compressive strength (average of at least three 5cm x 5cm x 5cm mortar cubes)	T-106	14 MPa for 28 days
Cement : Sand (by volume)		1:3
Ratio of Cement to Sand for pointing (by volume) if specified by the designer		1:1 to 1:2 as specified by the designer.
Amount of water used	ASTM C109 or ASTM C780	To produce a mortar with good consistency

4.2.2. PREPARATION OF BED

The bed of stone masonry over concrete/rock shall be thoroughly cleaned of all loose materials including chips, sand, dirt and slightest film of oil or grease. This shall be done with the help of stiff wire brooms, hammers, picks, air and water jet at pressure. The bed of masonry shall be kept completely dry during construction and still such time as would be required for the masonry to set.

4.2.3. WETTING OF STONES

All stones, shall be cleaned and free dust or mud to ensure good bond with mortar and shall be thoroughly wetted before being laid. For this purpose, the stones, that are immediately to be used, shall be kept sprinkled with good clean water before laying of stone masonry.

4.2.4. LAYING OF RANDOM ASHLAR STONE MASONRY

The stone shall be laid on large base with flatbed over a layer of cement mortar already spread on full width for suitable length. The face stone shall be laid headers and stretchers alternatively. The stones in adjacent layers shall break joint on the face for at least half of the height of course and proper bond shall be maintained throughout the wall. Each course shall be truly horizontal and each stone shall be laid in its natural bed and side joints vertical throughout. The wall shall be truly in plumb.

The bed or joints being in no case more than 0.31 cm (1/8 inch) in thickness and all visible edges shall be quite free from Insightly chippings. Each stone shall be struck with a maul, when laid to bring it to a solid bearing, both as to bed and joints. All courses shall be of same height unless otherwise specified or directed by the Engineer-in-Charge, but no course shall be thicker than the course below it. In walls through stones 75 cm thick and under as the headers shall run right throughout the wall.

No fresh course shall be laid over masonry previously laid before 24 hours of its laying. The maximum height of masonry course that it allowed to be constructed at a time shall be 60 cm.

The frames of doors, windows, glazing cupboards, etc. shall be housed into the masonry work at the correct location and level as directed. All fixtures, pipes, outlets, of water etc. which are required mortar without any extra cost.

4.2.5. CURING

Green work shall be protected from rain and sun. The masonry shall be kept moist on all the faces for a period of ten days. The top of masonry work shall be kept well wetted at the close of the day.

4.2.6. POINTING MASONRY

The cement mortar required for cement pointing on stone masonry shall be in proportion of one cement and two fine sand by weight or richer as specified by the designer.

4.2.6.1 WORKMANSHIP OF POINTING

The mortar in stone masonry shall be ranked out of the joints for a minimum depth of 5 mm when the mortar is still green in stone masonry.
Before commencing pointing, the joints shall be thoroughly cleaned of any dirt or loosely adhering cement or mortar by brushing and shall be washed with water properly and thoroughly wetted. The joints shall then be filled with cement mortar of specified proportion, in slightly excess and thoroughly pressed by proper tool of required shape. The mix shall be neither too dry nor too wet when used. The extra mortar if any, shall be removed and surface finished. Mortar shall not spread over the face of stones. Ruled pointing shall be carried out. The finished work shall give a neat and clean appearance with straight edges. The pointing shall be cured for 10 days.

4.2.7. Ashlar Stone masonry Construction quality control:

The following tests shall be conducted and results furnished for pitching and stonework production and construction:

Table4. List of Routine tests and their specification limit to be conducted during construction of the stone masonry.

Type of test	AASHTO Designation	Frequency of sampling	Location of sampling	Specification Limit
28 day compressive strength (average of at least three 5cm x 5cm x 5cm mortar cubes)	T-106	One sample per installation	Work site	14 MPA
Cement : Sand (by volume)			Work site	1:3
Minimum thickness of stone		As required by Engineer	Work site	200mm min
Minimum width of stone		As required by Engineer	Work site	300mm or 1.5 times the thickness of stone, whichever is greater

The mortar shall be prepared either by a mixer or manually inside a 1300 x 1300 x 300mm metal container to prevent the loss of water.

The material shall be mixed at least three times at dry state when the hand mixing method is used for mortar preparation.

A measuring box of 300 x 300 x 370mm shall be used to measure the quantity of sand required for one bag of cement.

The mortar shall be prepared in small quantities in order that it can be incorporated into the works within 30 minutes.

4.3. RANDOM RUBBLE STONE MASONRY

4.3.1. GENERAL

Rubble stone masonry is composed of irregular-shaped stone units bonded by cement mortar. Random rubble stone will be used in locations as shown in the drawings or as directed by the Engineer-in-Charge. In the current project this type of stone masonry (random rubble stone masonry) shall be used. First of all the damaged stone masonry and lose stone masonry shall be re-instated and replaced with new cement mortared stone masonry and then the additional new stone masonry shall be constructed as specified in the design drawings.

4.3.2. MATERIALS

4.3.2.1. Stone and Sand

Stones and sand shall be in accordance with the specification detailed under the section of ashlar stone masonry stated above.

Quality tests required for selection of stones shall be as per table 1.

4.3.2.2. Mortar

The mortar shall be according to ASTM C270-Type S as specified above.

The same specification for cement, sand and water are applicable as that stated in the previous sections.

The tests required for mortar mix design shall be per the requirements of table 3 above.

Dry mortar shall be prepared by using sand corresponding to one bag of cement measured by batching boxes and then spreading one bag of cement over it. The mixture shall then be thoroughly mixed and then specified quantity of water added to obtain the final mortar for use. Mortar once mixed shall be consumed preferably within 30 minutes in any case. Old mortar remaining back in taslas shall be thrown away and taslas thoroughly cleaned before filling the same with fresh mortar. In no case fresh mortar shall be mixed with old mortar.

4.3.3. DRESSING

Stones as received from the quarry shall have their weal corners and edges knocked off and hammer dressed on the face, the sides and the beds to enable it to come into proximity with neighboring stones.

4.3.4. LAYING

The stones shall be wetted before laying. Every stone shall be carefully fitted to the adjacent stones so as to form close joints as far as possible. The chips and spalls of stone be used wherever necessary to avoid thick mortar beds and joints. The ships shall not be used below the hearting stones and its use shall be restricted to the filling of inter stick between the adjacent stones in the hearting and these shall not exceed 20% of the quantity of stone masonry.

The masonry shall be carried up regularly and no step shall be allowed to be more than 60 cm but when the masonry of one part has to be delayed the work must be raked back at an angle not exceeding 45°.

Through or bond stones running through the thickness of wall shall be provided in walls upto 60cms. thick and if these walls are more than 60 cm thick, two or more bond stones overlapping each other by at least 15cm shall be provided in a line from face to back. At least one bond stone or a set of bond stones shall be provided for every 0.5 sq. meter of wall surface. The walls shall be carried out truly in plumb.

The thickness of the joint shall not exceed 2.5cm.

4.3.5. QUALITY CONTROL OF RANDOM RUBBLE STONE MASONRY CONSTRUCTION

The routine tests indicated in the table 4 shall be conducted during the Random rubble stone masonry construction.

4.3.6. PROTECTION AND CURING

The masonry during construction shall be protected from sun and rain by suitable covering and the masonry shall be kept moist for at least ten days after completion. When the work is to be done under frost condition special precautions shall be taken as directed by Engineer-in-Charge such as mixing of calcium chloride at the rate of 1% in cement, use of warm water in mixing and curing, covering of masonry with gunny bags etc. Watering shall be carefully done so as not to wash any mortar out of the joints.

4.3.7. Payment

The payment items are indicated in the table below and the payment shall be made According to the contract BOQ unit price.

Pay Item No.	Description	Unit of Measurement
4.3	RANDOM RUBBLE STONE MASONRY including provision of all stones and mortar including provision of all the required material, mixing, transporting, placement, spreading , testing and curing in locations indicated on the design drawings or as actually needed as per site and approved by the engineer but not shown on design drawings.	CUM
4.2.6.	POINTING (IFANY) including provision of all the required material, mixing, transporting, placement, spreading , shaping and curing in locations indicated on the design drawings.	LM

5. SECTION-5.ROCK-FILLED CONCRETE

5.1. Applicable codes and standards

1. Rock-filled concrete by Feng Jin.Department of Hydraulic Engineering .Tsinghua University,Beijing,China and Duruo Huang, Department of Hydraulic Engineering ,Tsinghua University ,Bejing,China.

2.ICOLD.

3.ASTM

4.ACI code

5.2. Defination

5.2.1. Rock-filled concrete(RFC)

Rocks usually large than 300mm are laid by machinery or other means as a riprap layer in lifts not more than 0.70 m thick formed by the form work with 45% voids and filled with high performance self compacted Concrete(HSCC) using concrete pump at intervals of 3 m spacing. Some large rocks may be exposed and projected above the surface of the HSCC for proper bonding of the next layer to be place.

In one cubic meter of Rock filled concrete the the volume of HSCC is 0.45 Cubic meter and the rest 0.55 Cum is volume of Rocks.

5.2.2. Self compacted concret(SCC)

Self compacted concrete is composed of aggregate bonded with hydraulic cement and have high flowability due to using of the admixture of superplasticizer and no need vibration and compaction. The flowablity of the SCC concrete will be tested using ASTM C1611 slump flow of the self consolidated concte(ASTMC 2021b)

5.2.3. High performance self compacted concrete(HSCC).

The SCC concrete used in RFC that meets the requirment of filling and with low cement consumption is called HSCC

5.3. Materials (components of the Roack filled concrete)

5.3.1. Rocks.

Normally using of small pieces of Rocks are not desirable as it will reduce the voids among rocks and prevents the penetration of the HSCC concrete into the voids.Moreover using of very big rocks are also not desireable.Slate or shale and sand stone types of rocks shall not be used.

Speciifcation of the Rocks used in Rock-filled concrete dams has been summarized in the table1 below:

Table1. Specifications of the Rocks to be used in Roack filled dams

Sr.No.	Rock characteristics	Specification limits	Remarks
1	size	1. Minimum size:Lager than 300mm and at least 10-15 times the size of the coarse aggregate used in HSCC. . 2.Recommended Maximum size can be one-fourth of the short dimention of the structure or 50 cm whichever is smaller.	
2	Staurated compressive strength	Greater than 30 MPA , but not less than two times the design compressive strength of the HSCC concrete used in filling the voids among Rocks in Rock filled concrete. unless higher strengths are specified by the designer. The design strength of the HSCC shall be as specified by the Designer .	For more information please refer to table 5.1 of the Rock-filled concrete dam by Feng Jin and Duruo Huang.
3	The rocks surfaces shal be clean of mud and dust.	Mud content≤0.2%(NEA,2018).	
4	Dry density (Ton/CUM)	≥2.4	

5.3.2. Aggregates

5.3.2.1 Coarse aggregate

Aggregate are processed from natural deposits of gravel ,free of orgnainc and harmful material and clay content with uniform gradation(one or two size fractions) with a maximimum size of 20mm and the sum of elongation index and flakinesss index should not exceed 8%. Shape and gradation of the aggregate shall be so selected to produce HSCC of high flowabiltiy.

The requirments of the rest of the properties of the coarse aggregate in HSCC ,such as content of the of the organic matter, sulfides and sulfates and Alkali aggregate reaction are similar to those of CVC concrete(ASTM C33).

5.3.2.2 Fine aggregate

Shape and gradation of fine aggregate shall be so slected to produce HSCC with reasonable flowability. Normally Natural or crushed sand free of organic material can be mixed with stone dust /Roack Rock floor to improve the flowabilty of HSCC. A maximum of 18% limestone powder can be mixed with fine aggregate.

The requirments of the rest of the properties of the fine aggregate in HSCC ,such as content of the of the organic matter, finess modulus,sulfides and sulfates and Alkali aggregate reaction are similar to those of CVC concrete(ASTM C33).

5.3.2.3 Cement and Fly Ash

All type of the Ordinary Portland cement which complies with the requirments of ASTM C 150 can be used, except of the cement type-III(high early strength cement).

The use of fly-ash in HSCC can improve the workability, reduce heat of hydration and Shrinkage. Fly-ash is the supplement cementenious material most commonly used in HSCC(ICOLD 2022).

5.3.2.4 Water

Water shall be drinkable and free of organic material and harmful chemicals and shall comply with the requirement of ASTM C1602.

The amount of water to be added shall be fixed using trail-batchs of the mix and should be between 170 and 200 kg/CUM of HSCC.

5.3.2.5 Superplasticizer and other chemical admixtures

For a Rock-filled concrete dam the most commonly used admixture is a superplasticizer which has the water reducing properties and improve workability of the HSCC and must be be used in the mix.No HSCC mix is acceptable without using the admixture of superplasticizer and air-entraining admixture. The amount of superplasticizer to be used shall be determined using trail batches . In table 5.3 of the book *Rock-filled concrete by Feng Jin and Duruo Huang, Department of Hydraulic Engineering ,Tsinghua University ,Bejing,China,*

Some values are indicated ranging from 6 to 7.3 kg/CUM.

Air-entraiing admixture may be used to increase air content when freez-thaw resistance is required.

It is worth to mention that the flowabilty of the HSCC mix shall not be improved by adding additional water, instead the shape, gradation of the coarse and fine aggregate shall be controlled and stone dust/lime stone powder along with proper amount of the superplasticizer shall be used and several trail batches of the HSCC mix are needed to be conducted to find a HSCC mix with the specified strength , workability and economy..

Accelerators admixture shall never be used.

The slump of the HSCC concrete rangges fro 260 to 280mm.

5.3.2.6 Rock flour/lime stone powder,

Shall pass through No200(sieve 75 micron).

5.4. Mix design of HSCC

After the raw material(fine aggregate, coarse aggregate, stone powder , cement ,water and superplasticizer) are selected, the mix desing of HSCC plays an important role and has significant effects on behavior of HSCC and Rock-filled concrete. The HSCC mix shall be freezing and thawing resistant as the dam is located in a region of cold climate.

Test results of the Core cutting from the hardened Rock-filled concrete shows that the strength and durability of the Rock-filled concrete is significantly higher than that of the HSCC.However it is suggested that the design compressive strength of the of the RFC should be assumed to be the strength of the HSCC.

Mix design of the HSS shall be conducted per the requirements of sections 5.2, 5.3,5.6.4 and other related sections of the book of *Rock-filled concrete by Feng Jin and Duruo Huang, Department of Hydraulic Engineering ,Tsinghua University ,Bejing,China,* conducting of several laboratory trail batches.

The construction contractor is fully responsible for porper mix design of HSCC,and MEW review,no objection and even approval will not relieve the contractor from the responsibility of any error or omission in the HSCC mix design along with future consequencies associated with the improper mix design.

Mix desing of the HSCC differs from that of CVC and RCC,as in HSCC mix a fair amount of coarse aggregate is substitiuted by fine aggregate and using the admixture of superplasticizer for providing sufficient flowabiltiy .The coarse and fine aggregate particles should be suspended in cement material paste during the entire pouring process.The absolute volume method should be adopted in mix desing of HSCC since a high self -compacting ability is closely related to the volume ration of each component of the Mix. The water/cementenious materials (W/CM) and water powder (W/P) ratios are important parameters in the mix design of HSCC.

W/CM ratio is based on weights, while the W/P ratio is based on volumes.

The W/P ratio is determined according to the flowability and segregation resistance using trail batches.

In the book of Rock-filled concrete by Feng Jin and Duruo Huang, Department of Hydraulic Engineering ,Tsinghua University ,Bejing,China, the following parameters are recommended:

1. The volumetric ratio of coarse aggregate in HSCC should be in the range of 0.27-0.33.

2. The water amount in HSCC should be between 175-200kg/CUM.

3. The W/P ratio varies from 0.8 to 1.15, according the powder type.

4, The volumetric ration of the powder amount of HSCC should be between 0.16 and 0.2.

5. The air content of HSCC should be in the range of 1.5% -4%.

Pratical design mixes in several rock-filled concrete dams are provided in table 5.3 of

book of Rock-filled concrete by Feng Jin and Duruo Huang, Department of Hydraulic Engineering ,Tsinghua University ,Bejing,Chin

5.5. Requirments for HSCC and Rock-filled Concrete.

The main requirments for HSCC are flowability, segregation resistance, and strength.

The flowability some times called self compacting ability of filling ability of the HSCC can be tested using slump flow-test and V-funnel test.

According to code specification, an acceptable range of the slump values is 260-280mm, while for a slump flow test it ragnes from 650 to 750mm and the passing time of the V-funnel ranges from 7 to 25 seconds.

As dams construction takes longer times compared to the ordinary structures. So normally 90 days strength is specified by the designer instead of 28-days strength.

5.5.1 Slump flow test

A cone with 100mm inner diameter in top, 200mm diameter at bottom and 300mm high is used to for doning the slump flow test and the procedure is summarized below;

1. Place the HSCC concrete in the conical mold, scrap the top of the concrete, so that the top level of the concrete is flush with the top mouth of the mold.

2. Pull up the mold vertically in 2 to 3 seconds and measure the maximum diameter of the concrete after the spreading of the concrete stops.

3. Repeat step two above and the average of the two diameters will be the slump flow value of the concrete

5.5.2 V-Funnel test

The dimensions of the V-Funenel are indiated on page no.41 of *book of Rock-filled concrete by Feng Jin and Duruo Huang, Department of Hydraulic Engineering ,Tsinghua University ,Bejing,Chin*

The procedure of the V-funnel test is summarized below:

1.Place the HSCC concrete in the V-Funnel mold, scrap the top of the concrete, so that the top level of the concrete is flush with the top mouth of the V-funnel mold.

2.close the bottom out let of the funnel for 60 seconds and open it after 60 seconds and start recording of the timmig using stop-watch .

3. Stop timming record when a light appears in the bottom out let of the funnel.If the timing exceeds 60 seconds, stop the test and record it 60 seconds.

5.6. Quality Control during RFC Dam construction

Qaulity of the dam consruction mainly dependes on the Quality of the HSCC raw material and production, rock quality and placement and HSCC placement. The raw material frequency of testing,types of tests to be conducted and the specification limits are briefly described below.

5.6.1.Quality control and Frequency of testing of the raw material, HSCC and RFC

The quality of the HSCC concrete depends on the quality of its raw material. Good quality raw material produce good quality HSCC concrete.

The raw material frequency of testing,types of tests to be conducted and the specification limits are sumrized in the table below.

Type of material to be tested	Type of test	Applicable standard	Frequency of sampling	Location of sampling	Specification Limit
Cement	Complete testing of the cement brand	ASTM C-150	Once per project.	Project site	ASTM C150
	Mill certificate	ASTM C-150	Once per project.	Shall be provided as a proof for quality of the cement before conducting of the mix design.	ASTM C150
	Time of setting (Gilmore test) (minutes)	AASHTO T-154	One per each delivery of the cement, not less than one per each 200 tons weight of the cement	Project site	Initial set≥60min Final set≤600 minutes

	Compressive strength of 5cmX5cmX5cm mortar cubes at 28 days	ASTM C 109	One test average of three cubes per each delivery but not less than one test per each 200 Tons of the cement weight	Project site	Minimum 19 MPA for 7 days and minimum 28 MPA for 28 days.
Superplasticizer	Solid content		One per each delivery to the site, but not less than one test per each 50 tons of the product.	Project site	ASTM C494 and the manufacturer data sheet
	density		One per each delivery to the site, but not less than one test per each 50 tons of the product.	Project site	ASTM C494 and the manufacturer data sheet
	PH value		One per each delivery to the site, but not less than one test per each 50 tons of the product.	Project site	ASTM C494 and the manufacturer data sheet, ASTM C494
Crushed fine aggregate	Apparent density		One per source	Stockpile at three locations of deeper than 0.5m inside the stockpile	≥2500kg/CUM
	Clay content		One per stockpile	Stockpile at three locations of deeper than 0.5m inside the stockpile	0
	Stone powder content in fine aggregate (stone dust passing through sieve 75 micron)		One per stockpile	Stockpile at three locations of deeper than 0.5m inside the stockpile	6-18%
	Sufides(So3) content		One per source	Stockpile at three locations of deeper than 0.5m inside the stockpile	≤1%
	Alkali silica reaction		One per source	Stockpile at three locations of deeper than 0.5m inside the stockpile	No alkali-silica reaction

	Moisture content		Daily bases	Stockpile at three locations of deeper than 0.5m inside the stockpile	The amount of mixing water shall be adjusted accordingly.
	Other properties		One per source	Stockpile at three locations of deeper than 0.5m inside the stockpile	Per ASTM C33.
Coares aggregate	Apparent density		One per source	Stockpile at three locations of deeper than 0.5m inside the stockpile	≥2500kg/CUM
	elongation index and flakinesss index		One per daily production of HSCC but not less than one per every 8 hrs,	Sampled from aggregated to be mixed in HSCC before mixing	sum of elongation index and flakinesss index ≤8%
	Size		One per daily production of HSCC	Sampled from aggregated to be mixed in HSCC before mixing	Min size=4.75mm Max size=20mm
	Mud lumps		One per daily production of HSCC	Sampled from aggregated to be mixed in HSCC before mixing	0
	Alkali silica reaction		One per source	Stockpile at three locations of deeper than 0.5m inside the stockpile	No alkali-silica reaction
	Other properties		One per source	Stockpile at three locations of deeper than 0.5m inside the stockpile	Per ASTM C33.
Rocks	Size		One per each layer	Per placed layer of the Rocks in RFC.	1. Minimum size:Lager than 300mm and at least 10-15 times the size of the coarse aggregate used in HSCC.. 2.Recommended Maximum size can be one-fourth of the

					short dimention of the structure , but not larger than 50cm 3. Number of stones smaller than 300mm shall be counted by the site personal after placement of each layer and shall be less than 10 pieces per each square meter and no concentration of small roacks.
	Saturated compressive strength		One(average of two sample) per source. But not less than one per each 5000 Tons of the rock	Layer of the rocks placed on random bases	Greater than 30 MPA , but not less than two times the design compressive strength of the HSCC concrete used in filling the voids among Rocks in Rock filled concrete. unless higher strengths are specified by the designer. The design strength of the HSCC shall be as specified by the Designer .
	The rocks surfaces shal be clean of mud and dust.		One(average of two sample) per source. But not less than one per each 5000 Tons of the rock	Each layer placed	Mud content≤0 2%(NEA,2 018).

HSCC Concrete (not exposed to freezing -thawing)	Air Content		1 per lift	Point of discharge	1.5-4%
	Slump flow		1 per load(one per each mixer)	Point of discharge	600- 750mm
	slump		At least one per each 4 hours of the pouring, not less than one per lift	Point of discharge	260mm -280mm
	V-funnel test time		At least one per each 4 hours of the pouring, not less than one per lift	Point of discharge	7-25s
	Temperature		1 per load	Point of discharge	2 - 32ºC
	Freezing and thawing resistance test		At least two tests or more on random bases	Point of discharge	As per the design requirement
	Permeability test		At least two tests or more on random bases	Point of discharge	As per the design requirement
	Compressive Strength (six specimen)		One test (average of three specimen) at 28 days per each lift and one test(average of three specimen) per each lift at 90 days	Point of discharge	≥design strength of RFC as specified by the designer of the dam.
Core drilling from the RFC The volumetric ratio of the rock should between 1/3 to ¾ of the core volume	Compressive strength test(average of three cores		One test per layer		Higher than or equal to the strength of HSCC concrete as specified by the designer. (in cores to be tested for strength the volumetric ratio of rock should be between 1/3 to ¾ of the core volume.)
	Water pressure test to evaluate the impermeability and compactness of the dam		Two tests on random bases during the progress of construction of the dam		The lugen value ≤design value.

Note: If the RFC is exposed to freezing-thawing, then the air-entraining admixture shall be used and the air content shall be 4%-6%.

5.7. Construction process of a roack filled-concrete :

After foundation and abutments preparation , the CVC cushion/layer as specified by the designer will be placed on the prepared surface and then the Rock fill construction will start following the step-by- step prcudeure outlined below;

Step No.1. Quarrying and Cleaning Rocks

First of all the Rocks shall be excavated in the approved Rock Quarry and Rocks larger than 30cm and not greater than 50 cm or as specified by the designer shall be washed by water jet to clean it as shown in the the figures below.

(a)Rinsing in the quarry (b) Automatic flushing platform

Rock cleaning (ICOLD, 2022)

Step No2. Erection of Formwork and Removal time

Design, erection, removal of a safe form work is the responsibility of the contractor.The rigidity and tightness of the formwork prevent runout and leakage of HSCC during casting.

The pressure of HSCC on the formwork, which can be estimated as 2.3 times the water pressure, is higher than that of CVC and RCC due to its high flowability, so the form work for the rock fill concrete shall be stronger than the CVC concrete.

The form work can be removed after 2 days from the vertical surface.

Step no.3. Transporting and Placement of Rocks

The most common practice for transporting rocks to a dam lift is adopting dump trucks when road access is available. Before a dump truck enters the workspace, the wheels of the truck must be washed to prevent potential mud contamination on the lifts. Excavators or loaders can help level the rocks on the lift surface. When dump trucks sometimes cannot reach the lift surface due to shortage of access roads, transporting machinery, such as lifting devices or tower cranes, is used to transport rocks onto the lift surface,then, rocks should be placed away from the formwork. Placement of large rocks near impervious zone should be careful. After rocks are placed, Facing CVC is placed to fill into the empty space between the rockfill and formwork and then the HSCC will be poured using the procedure below. First of all a small trail section of RFC shall be constructed in the central portions of the dam away from the upstream and down stream faces of the dam and cores shall be taken at three different locations , specified by the site QA to see if the HSCC is fully penetrated in the rock lift,otherwise the trail section will be removed and either the lift thickness or the slump flow will be adjusted ,but the slump flow shall be still with in the limits of the project specification and the trail section shall be repeated.

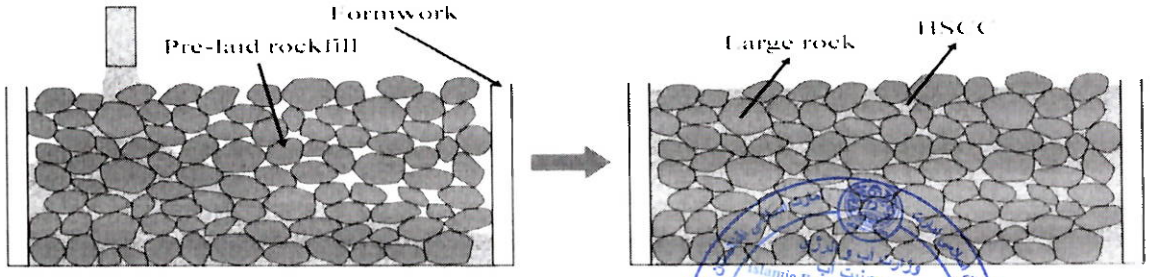
Step No.4 Mixing and Pouring HSCC

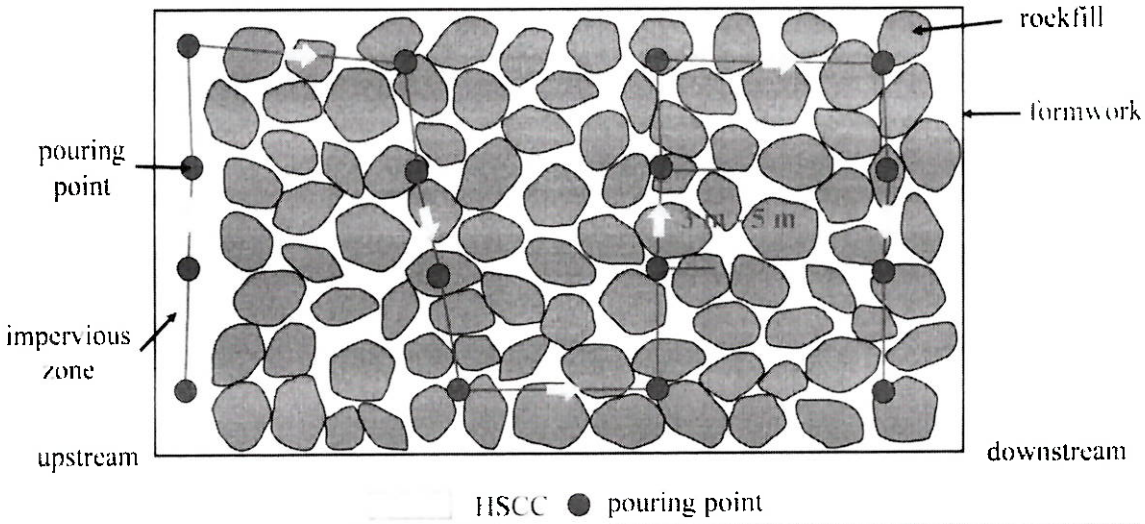
The quality of HSCC is another important issue for rock-filled concrete. The quality control during mixing, transporting and casting of HSCC should be paid enough

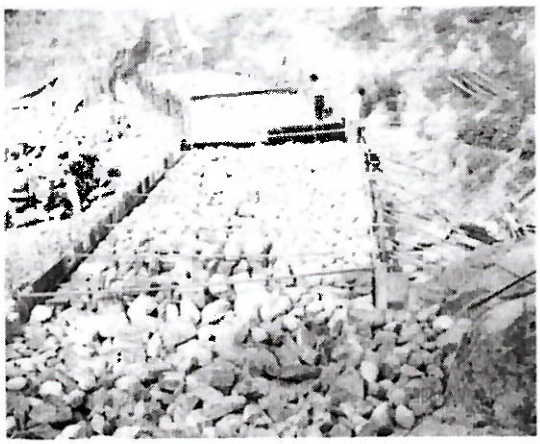
attention. Since HSCC is more viscous and stickier than CVC or RCC, only batch compulsory mixers are recommended. The mixing time may need to be prolonged to ensure the homogeneity of fresh HSCC. The quality of raw materials greatly affects the performance of HSCC. The quality of the cement, mineral and chemical admixtures should be rigourously checked when these products are unloaded on site. The quality of fine and coarse aggregates, such as their coating dust, particle shape, moisture and powder content, should be monitored during the construction process more strictly than that of CVC or RCC. The workability of HSCC should be monitored throughout pouring. Water consumption must be adjusted to maintain the stable workability of HSCC by experienced technicians based on the estimation or monitoring of moisture in aggregates. Therefore, the operator of the mixing plant should be trained before rock-filled concrete construction (ICOLD, 2022).
When mixing can be placed near the dam site, a concrete pump or a chute can deliver the HSCC to the rockfill surface directly without concrete trucks. In the case of mixing plants on the crest or at a high elevation, a chute can be used to transport the HSCC down into the concrete pump at the lower elevation considering that pumping downward often causes pump pipe blockages.
Concrete truck can be used to convey HSCC for long-distance transportation.
It should be noted that no water is allowed to be added to HSCC in the course of transportation, pumping, or placing. The total time of transportation, and pouring should be less than 1 h. Otherwise, some technical measures, such as set-retarding

admixtures, should be used when the transportation and placing times need to be extended. Themeasures should be verified by field trials. Notably, adequate construction quality inspection procedures have been established to ensure safe construction of RFC dams (NEA, 2020). Readers can refer to Chap. 8 for details of onsite quality control and instrumentation.
HSCC placement tools are selected based on the placement area, range, topography of theworking site, and quality of theHSCCmixture. Somecommonplacement methods are listed as follow (ICOLD, 2022):

(1) Pump: Pumping is an efficient way to place HSCC by ground pumps or pump trucks.The longest distance for ground pumping for RFC dam projects is approximately 300 m.
(2) Concrete truck: Placing HSCC directly with a concrete truck is a convenient way for the small working faces with widths less than 10 m, if road access to the placement area is available.
(3) Chute: Placing HSCC by chute is also a convenient, efficient and economic method.
(4) Loader/excavator: Pouring HSCC by loaders or excavators is suitable for lifts with small section sizes (i.e., retaining wall).
The placing points should be evenly arranged along the lift during the placement process, and the distance between placement points is usually within the limits of 3–5 m. HSCC placement and placing points are shown in the figures below.







(c) Placement of rockfill before casting HSCC

(d) HSCC casted by a pump truck

(e) Lift surface with rocks exposed

Step No.5 lifts surface treatment

Regarding treatment on the lift surface, upon which the rock-filled concrete is to be placed and to which the new concrete is expected to adhere, the bonding has to become so rigid that the new concrete can be incorporated integrally with the previously placed lift. The lift surface should be clean, rough, and dry when covered with fresh concrete. Green cutting typically includes the removal of laitance and loose aggregates on concrete surface. Green cutting and roughening should be accomplished by washing with air–water jets for the purpose of slight exposure of coarse sand prior to adjoining concrete placement.

The efficiency of green cutting depends on the time. If starting too late, the strength of rock-filled concrete will be too high, and the efficiency drops. If starting too early, the RFC is weak, which results in loose rocks on the lift surface. Other roughening measures, such as by excavator or labor, can also be used. To ensure the quality of the lift bonding, all rock debris should be collected and removed from the lift after surface roughening.

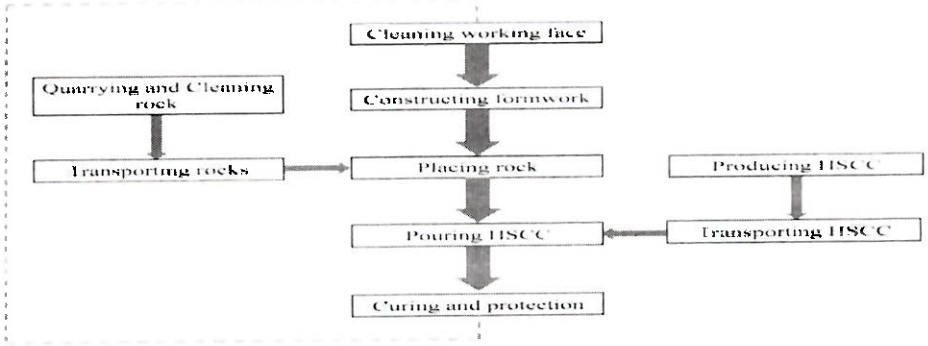
To ensure sufficient bonding between the lift and its shear resistance, exposed rocks should be greater than 30% of the area of the lift surface, and the exposed

height is 50–150 mm higher than the lift surface. The exposed rocks increase the abrasion of truck tyres, the rock transportation route on the lift surface should be arranged at advance if the rocks were transported into the lifts directly.

Step no.6 Curing Rock-Filled Concrete

One of the major causes of concrete cracking is a lack of proper curing. Laboratory tests show that the strength of poorly cured concrete can reach less than one-third of well-cured concrete. The curing of concrete is therefore important in the construction of RFC dams. In general, the curing of rock-filled concrete is in line with that of conventional concrete not less than 14 days. The full effectiveness of curing requires a continuous operation. Especially for the long intermittent construction of dam lifts, surface water storage maintenance are recommended. Pipe sprinkling can be used for curing on a vertical or inclined work plane. Wet covering curing is also recommended for hot and dry conditions.

The construction procedure of a rock-filled concrete is summarized in the flow chart below:



Procedure of rock-filled concrete casting.

5.8. Height of lifts and time intervals between lifts

In thick lifts of Rocks,High performance self compacted concrete can not penetrate deeply and properly, from the other side in shallow lifts Rocks lager than the specified size(30cm) can not be incorporated .

To fulfill both requirments the lift thickness shall not exceed 0.70m.

There is no any rule of thumb to fix the time interval between placement of the two lifts.

Generally the underlaying lift shall have enough strength, so that not destroyed by the new layer and can support the load of the new layer.

5.9. Payment:

The payment items are indicated in the table below and the payment shall be made According to the contract BOQ unit price.

Pay Item No.	Description	Unit of Measurement
5.2.1..	Rock filled concrete work including supply of all the raw material needed , production of HSCC, form work,stone supply and placement , pouring of HSCC on the top of the stones layers placed, testing and curing per the design drawings and specification.	CUM

6. SECTION VI BRICK WORK

All brickwork masonry required to be constructed under these Specifications and for all related purposes, shall consist of the materials herein specified. Cement sand mortar shall be proportioned, mixed, and bricks placed in accordance with the requirements stated herein. The requirements set forth herein shall apply to all brickwork, except when such requirements are specifically modified by the Engineer for any particular item of work.

6.1 Portland Cement

Portland cement shall conform to the requirements of ASTM C-150 type-I.

6.2 Sand

Sand for mortar used in brickwork shall conform to the requirement for the fine aggregate shall be according to AASHTO M 45 or ASTM C144.

Sieve Size	Percent Passing Natural Sand	Manufactured Sand
4.75-mm (No. 4)	100	100
2.36-mm (No. 8)	95 to 100	95 to 100
1.18-mm (No. 16)	70 to 100	70 to 100
600-µm (No. 30)	40 to 75	40 to 75
300-µm (No. 50)	10 to 35	20 to 40
150-µm (No. 100)	2 to 15	10 to 25
75-µm (No. 200)	0 to 5	0 to 10

6.3 Water

The water used in the preparation of mortar shall be free from objectionable quantities of silt, organic matter, salts or other impurities and shall comply with the requirements of ASTM C1602. No water shall be used without the approval in writing of the Engineer.

6.4 Mortar

Mortar shall comply with the requirement of ASTM C270.The mortar for all brickwork shall consist of one (1) part of Portland cement type-I to three (3) parts of sand by volume and of sufficient water to produce the proper consistency for the intended use. Cement mortar for brickwork masonry, rendering, screening, pitching and jointing concrete pipes shall consist of Ordinary Portland cement and natural washed sand free of any objectionable material mixed by hand or approved mechanical mixer in the proportions by volume of 1 part cement to 3 parts sand , except joints between precast slabs shall be with 1: 2. Cement sand mortar. The cement and sand shall first be mixed dry until the cement color can no longer be distinguished from the sand in any part of the mass and the whole shall then be uniformly wetted by approved means while undergoing further mixing. The water content shall be just sufficient to ensure a dense mortar of stiff consistency and adequate workability to permit troweling or floating into place. The workability of cement mortar to be used for rendering may be improved by adding an approved plasticizer in the proportions recommended by the supplier of the plasticizer. Mortar shall be prepared and used in such quantities that no more than 30 minutes shall

elapse between first wetting and its completed use. Under no circumstances shall any mortar that has stiffened before commencing to set, be made. Fresh mortar shall not be mixed with mortar prepared earlier and all batches shall be used entirely separately. ."

In any continuous face of the wall the finishing coat shall be applied continuously so that breaks due to cessation of work are not visible. Work shall be planned in such a way that the finishing coat can be stopped when architectural features are reached.

Cement Mortar Mix Design :

The following tests shall be conducted and results furnished for cement mortared Brick masonry mix design:

Table 6-1. Mortar Mix Design

Type of test	AASHTO Designation	Specification Limit
Gradation of fine aggregate	T-27 and T-11	ASTM C144
7 day and 28 day compressive strength (average of at least three 5cm x 5cm x 5cm mortar cubes)	T-106	14 MPa for 28 days
Cement : Sand (by volume)		1:3
Cement : Sand for pointing (by volume)		1:1 to 1:2 as specified by the designer.
Amount of water used	ASTM C109 or ASTM C780	To produce a mortar with good consistency

6.5 MORTAR BATCHING

Methods and equipment used for mixing mortar shall be such as will accurately determine and control the amount of each separate ingredient entering into the mortar and shall be subject to the approval of the Engineer. If a mixer is used, it shall be of approved design and the mixing time, after all the ingredients are in the mixer, except for the full amount of water, shall be not less than two minutes.

Mortar shall be mixed only in sufficient quantities for immediate use and all mortar not used within thirty (30) minutes after addition of the water to the mix shall be wasted. Re tempering of mortar will not be allowed. Mixing troughs and pans shall be thoroughly cleaned and washed at the end of each day's work.

6.6 Bricks

The burnt clay bricks shall conform to the requirements provided in ASTM C62. The size of the bricks shall be standard size 9"x4½"x3"(22.86 cm x 11.43 cm x 7.62 cm). They shall be well burnt without being vitrified. They shall be of uniform color, regular in shape and size with sharp and square corners and parallel faces. They must be homogeneous in texture and emit a clear ringing sound when struck. They shall be free from flaws and cracks. They shall not absorb more than 1/6th of their weight of water after being soaked for one hour, and shall show no signs of efflorescence on drying. Grade SW shall be used for brick in contact with earth or grade and for all exterior work and for all non-vertical surfaces For SW grade bricks, the average Compressive strength of five (5) bricks shall not be less than 3000 psi (20.7MPA) and the compressive strength of any individual brick shall not be lower than 2500psi (17.2MPA). Grade MW bricks shall be used in other brickwork. For MW grade bricks, the average Compressive strength of five (5) bricks shall not be less than 2500 psi (17.2MPA) and the compressive strength of any individual brick shall not be lower than 2200psi (15.2MPA).Bricks shall be tested per the requirements of ASTM C67.

Under normal condition shall not absorb water more than 1/5th of its weight when immersed for one hour in water. Before commencing brickwork, the contractor shall submit samples of the bricks he proposes to use for the approval of the Engineer. Deliveries shall be kept strictly to the approved samples.

On delivery to the site bricks shall be stacked to the approval of the Engineer. Facing bricks shall not be offloaded by tipping but by hand and no bricks with damaged exposed faces shall be used in the works.

Brickwork shall conform to the requirements of bending codes being used in Afghanistan and to the various Standards referred to therein.

Bricks shall be well soaked in water before being laid so that undue absorption of moisture from the mortar is avoided, but bricks shall not be left standing in water or be brought otherwise to a saturated condition. Each brick shall be "floated" and "rubbed in" or "hammered down" upon such sufficiency of mortar that the mortar shall be squeezed up into the joints, but if such joints are not filled up with mortar by this process they shall be flushed up with the mortar from the next succeeding bed. Joints shall not exceed 3/8" in thickness. Joints in brickwork to be plastered or rendered shall be raked out to a depth of ½" and any loose portions of mortar removed to provide a good key. The courses shall be laid truly level and at the time of bedding all joints shall be neatly struck with a trowel.

All propend shall be kept strictly plumb and square and no damaged bricks shall be used in their formation. Brickwork shall be built English bond for walls one brick thick and over and stretcher bond for walls half a brick thick and shall be reinforced with expand metal or other approved brick reinforcement every sixth course.

The open ends of walls shall be raked up and not toothed during construction and no part of the brickwork shall be raised more than 3 ft above adjacent work at any time.

The top of walls where work has been discontinued, shall be well wetted before the work recommences.

Brickwork shall be cleaned down after each day's work and newly laid brickwork shall be protected by sacks or other suitable material.

If brickwork becomes damaged by sun or rain, the brickwork so damaged shall be removed by the Contractor and rebuilt at no extra cost to the Employer.

Brickwork in building shall be set in mortar in the proportions by volume of 1-part cement to 3 parts sand.

6.7 BRICKWORK PLACING

The methods and equipment used for transporting the bricks and mortar shall be such as will not damage the bricks nor delay the use of mixed mortar.

All brickwork shall be placed only after the foundation surfaces have been prepared satisfactory in accordance with these Specifications and the Engineer's instruction.

Bricks shall not be placed during heavy or prolonged rain, which may wash the mortar from the bricks. Mortar already spread, which becomes diluted by rain, shall be removed and replaced before continuing with the work. Workmen shall not be allowed to walk on the brickwork before it is fully set.

All bricks to be used in brickwork with mortar joints shall be soaked into water for three to four hours before they are used, by a method, which will ensure that each brick is thoroughly, and uniformly wetted. All bricks shall be free from water adhering to their surface when they are placed in the brickwork.

All bricks shall be skillfully laid with level courses, uniform joints, square corners, plumb vertical and true surfaces, except otherwise shown on Drawings or directed by the Engineer. Brickwork constructed for a waterway will be of the best standard of workmanship obtainable, and objectionable offsets in the brick work shall be removed by

and at the expense of the Contractor. The smoothest practicable finished surface of the brickwork will be required whenever it is a part of waterway.

6.8 CURING

All brickwork requiring mortar shall be cured by water curing or other acceptable methods. All methods and operations of the Contractor in curing the different portions of the work shall be subject to the Engineer's approval.

When curing by water, the brickwork shall be kept wet for at least 7 days, unless specified elsewhere in these Specifications, by covering with water saturated material, or by a system of perforated pipes, mechanical sprinklers, porous hose, ponding, or by any other approved method which will keep all surfaces to be cured continuously wet. Water used for curing shall meet the Specifications for water used in the manufacture of bricks.

6.9 REPAIRING BRICK WORK

If after the completion of any brickwork, any bricks are found to be out of alignment or level, or do not conform to the lines and grades shown on the Drawings, or show a defective surface, they shall be removed and replaced by the Contractor at his expense unless the Engineer grants permission, in writing, to patch or replace the defective area

6.10 Testing of Mortar: At least three specimens of mortar shall be taken each day. A layer of mortar 13 to 16 mm thick shall be spread on the masonry units and allowed to Stand for one minute. The specimens shall then be prepared and tested for Compressive Strength in accordance with ASTM C780 or at least three cubes of 5cmX5cmX5cm of mortar

Type of test	AASHTO/ASTM Designation	Frequency of sampling	Location of sampling	Specification Limit
28-day compressive strength (average of at least three 5cm x 5cm x 5cm mortar cubes)	T-106	One sample (three cubes) per installation per day.	Work site	14 MPA
Cement: Sand (by volume)			Work site	1:3
Bricks	ASTM C67	10 bricks for lots equal to or less than 1000,000 bricks. For lager lots five additional specimens shall be taken for each additional 500,000 Bricks or fraction thereof.		ASTM C62 grade SW for horizontal use, exterior or grade use and grade MW for all other uses.

6.11 Concrete masonry units(CMU):

Concrete masonry units shall comply with the requirements of ASTM C 90.

Mortar used in CMU work shall be 1 part of cement and three parts of sand ASTM C 144 If reinforcement is used in the CMU walls, then the cavities inside the hollow CMU blocks shall be filled with grout comply the requirement of ASTM C476. The strength of the grout shall be tested according to ASTM C1019 and shall not be less than 14 MPA. The slump of the grout shall be 20cm to 22cm.

Ready mixed grout shall comply with the requirements of ASTM C94.

6.12 Payment

The payment items are indicated in the table below and the payment shall be made According to the contract BOQ unit price.

Pay Item No.	Description	Unit of Measurement
6.7.	Brick Masonry construction including supply of all the raw material needed(cement,sand,water,Brick), mortar preparation ,spreading ,laying of bricks ,curing and testing per the design drawings and specification.	CUM
6.11.	CMU construction including supply of CMU Blocks,Grout mix prepration and laying of CMU Blocks ,curing and testing per the design drawings and specification.	CUM

7. SECTION VII PLASTER WORK

7.1 Preparation of Surface

The surface on which plaster is to be applied should be in case of brick walls properly raked and wetted before application of plaster. In case of concrete face to receive plaster, all surfaces shall be properly roughened by dragging wire brushes while the concrete surface is still raw or by raking, if the surface had hardened so that 40 % of the surface is roughened to approval.

7.2 PLASTERING

Plaster works should be done in conformity with ASTM C926. Materials such as cement, sand and water shall conform to ASTM C150, ASTM C 897 and ASTM C1602 respectively. All tools should be cleaned by scraping and washing at the end of each day's work, or before use. Metal tools should be cleaned after each operation. All tools should be examined and thoroughly cleaned before plastering is begun.

7.3 STRAIGHTNESS

All corners and arises shall be rounded if required while plastering and the rate of plastering is inclusive of this provision. The plaster shall be laid to a true and plumb surface and -tested frequently with plumb bob and straight edge not less than 10 ft. in length. All horizontal lines and surfaces shall be tested with a level and all jambs and corners with a plumb bob as the work proceeds. All mouldings shall be worked true to template and shall be neat clean, level and parallel, or truly plumb. Allowable tolerance in 10 feet run will be 1/8 inch.

7.4 THICKNESS

Wherever a thickness is 20mm or more is specified, it shall be applied in 2 coats, rendering coat and final coat. The rendering coat shall be carried to full length of walls or natural breaking points. No vertical or horizontal joints shall be permissible. The rendering coat shall be roughened with waving lines drawn by wire brushes when wet to provide bond for final coat applied and the rendering coat shall be properly wetted. The final coat shall then be applied and finished with wooden cleats to present smooth and uniform surface.

All putlog holes shall be filled up in advance of the plastering as the scaffolding is being taken down. The plaster shall be kept wet for 7 days after completion.

7.5 PATCHING

Plaster containing cracks, blisters, pits, etc. or discoloration will not be acceptable. Such plaster shall be removed and replaced, with plaster conforming to this specification and approved by the Engineer. Patching of defective work will be permitted only as per

approval of the Engineer and such patching shall match the existing work in texture and color.

7.6 FLOATING COAT

Plaster coat of moist cement as specified shall be carried out as follows:

Immediately after the surface has been plastered and while the plaster is still green a floating coat of moist cement shall be applied on it and the surface rubbed smooth with steel trowel. No trowel marks to be visible after the surface has been finished, or it may be required to be dismantled and redone.

7.7 MORTAR

The mortar mix for plaster works for walls shall be in general in two coats, under layer 12 mm thick in cement mortar 1part cement to five parts of sand and a top layer 8mm thick in cement mortar 1-part cement to 3 parts sand. Otherwise, the procedure as specified on the drawings shall be followed and prepared in manner laid down for preparation of mortar described under Clause 6 'Brick Work'

7.8 Payment

The payment items are indicated in the table below and the payment shall be made According to the contract BOQ unit price.

Pay Item No.	Description	Unit of Measurement
7.2	Complete plaster work per the design drawings and specification	SQM