

TENDER DOCUMENT

LINING, REHABILITATION & CONSTRUCTION OF CHOCHMAN MAIN CANAL AND ITS STRUCTURES

TENDER NO:

APPENDIX B

SCOPE OF WORK, TECHNICAL SPECIFICATIONS, BILL OF QUANTITY AND DRAWINGS

1. SCOPE OF WORK

Farmers at the villages in Samangan Province have poor harvest and low earning as their irrigation system leaks and wastes precious water. SWIM intends to rehabilitate Chochman Main Canal with its related structures in Samangan Province, Khulm District in order to reduce seepage and increase farmer's hope for better harvests in **4680** hectares. For this purpose, under this RFQ, major work consists of the following items:

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| 1. Proposed for RCC canal lining | L=10.25 km |
| 2. Proposed turnouts for rehab/cons | No=37 |
| 3. Proposed foot culverts for rehab/cons | No=7 |
| 4. Proposed slab culvert for rehab/cons | No=1 |
| 5. Proposed drain inlet for rehab/cons | No=3 |
| 6. Proposed drop structure for rehab/cons | No=35 |
| 7. Proposed box culvert for rehab/cons | No=9 |
| 8. Proposed public utility for rehab/cons | No=6 |

The completion of the above items includes the following scope of work:

1. Excavation for canal and structures
2. Plain cement concrete lining on canal bed
3. Reinforced concrete for canal lining and structures
4. Rubber watertight gate fabrication and Installation
5. Rubble/Stone Masonry on slab culvert.

1.1 EXCAVATION FOR CANAL AND STRUCTURES

- a) The work to be done under these specifications consists of the excavation of **44421 m³** soils in various strata, and the conveyance and disposal of the excavated stuff for canals (including distributaries, laterals etc.,) for cut-off trenches of embankment, for diversion channels, drains and ditches, for the trenches of culverts, for catch water drains, for retaining walls, for service road and inspection path and for structures. The contractor shall furnish all tools, plant, labour and materials and execute the work satisfactorily.
- b) When existing public facilities like road drainage, drinking water supply pipe lines, telephone lines and power lines etc. are to be disturbed for constructions activities, the contractor shall, after due approval of the Engineer, provide and maintain in satisfactory condition at his cost, temporary structure like diversion roads for ensuring uninterrupted and satisfactory functioning of the facilities. Precautionary measures like signal, night lamps, fencing and barricading etc. will also be provided by him at his cost. The cost of permanent measures for the rehabilitation of the facilities, however, will be borne by the Subcontractor.

1.2 CONCRETE LINING ON CANAL BOTTOM

- a) Concrete lining for canal and structures in total volume of **1612 m³** of unreinforced cement concrete of M20 grade (1:1.5:3) with maximum size of aggregate of 20 mm. The concrete used shall be of controlled M20 grade, the mix proportion being decided by the preliminary tests. The thickness of lining shall be as shown in the drawing. The canal sections shall be as shown on the drawings. If during construction it is found necessary to alter the canal sections and side slopes or the thickness of lining, the contractor shall be informed in writing of such changes, and he shall

execute the work accordingly at the rates quoted in the BOQ without any extra claim on account of changes in the section of the canal and thickness of lining. The scope of work for canal bed lining also includes the following:

- i) Preparing the base for lining and laying the concrete lining including dewatering and desilting. Providing grooves for joints to required depth and width at specified intervals as per drawings and as directed by the Engineer-in-charge.
- ii) Providing filter materials of approved quality, where specified as per drawings.
- iii) Trimming the canal section for preparing sub-grade for concrete lining, in all sorts of soil, murrum and rock and back filling the over excavated sections with suitable materials including watering and compacting the bed and slopes using suitable compacting equipment and dewatering and desilting where required.

1.3 REINFORCED CONCRETE ON CANAL LINING AND STRUCTURES

- a) The specification covers the requirements of reinforced concrete for use in various components of structures. The scope of work covered under this section consists of furnishing all materials including **formwork**, equipment, labour for the manufacture, transport, placing, vibrating, finishing and curing of the concrete for the structures and performing all the operations necessary and ancillary thereto including dewatering and desilting etc., as required to produce **6653 M³** of reinforced cement concrete of M25 grade in a mix of 1:1:2.

1.4 RUBBLE STONE MASONRY ON SLAB CULVERT

- a) The work covered under this section consists of furnishing all material, equipment and labour for providing and laying **30 m³** of uncoursed rubble masonry in substructure and superstructure

1.5 RADIAL OR VERTICAL LIFT SLIDE GATES FOR REGULATORS AND ESCAPES

- a) The item is for supplying and erection of **74 vertical lift slide gates** for the vents of the cross regulators in canal branches or escapes and head works of canal. The dimensions and the outline arrangements of gates shown in the tender drawings are tentative. The SWIM shall however supply, working drawings of the structures showing therein the precise dimensions of the gates, the hoisting arrangements etc. On receipt of these drawings, the contractor shall submit within 30 days design and drawings of the gates including those of embedded parts, anchorages, hoisting arrangements etc. for the approval of the SWIM. The designs and drawings shall be transmitted to the contractor with the approval or the suggestions for modification within a period of 15 days. If the drawings are returned with suggestions for modification the contractor shall affect necessary modifications and submit the final drawings within a period of 15 days and the final approval shall be communicated in not more than 30 days, provided all suggestions made are complied with in full.

2. TECHNICAL SPECIFICATION

All scope of works shall be carried out in accordance with relevant Code (S) of practice, technical specifications under this RFQ/Contract as directed by SWIM Quality Assurance Engineer-in-Charge where necessary.

2.1 GENERAL

These specifications are intended for general description of quality and workmanship of materials and finished work. They are not intended to cover minute details. The work shall be executed in accordance with sound Engineering practice where reference is made to any standard specification of Afghanistan Standards Institution or any other similar body, information and provisions of the latest revised edition of the specifications at the date of submission of the tender shall be applicable. If the provisions of such standard specifications conflict with the provisions stated in the specifications, latter provisions shall have precedence.

- (a) The intending tenderer is deemed to have visited the work site and acquainted himself of the nature of the sub-soil to be executed. No claim or extra will be allowed as a result of any misunderstanding or incorrect assessment or misinformation or ignorance of the contractor on the prevailing site conditions or soil strata.
- b) All the materials to be used on the works are required to be of the best quality as specified and described and all the materials to be used on work are required to be tested at no extra cost to the employer for their respective strength and quality. Tested samples of materials are not paid for and are non-returnable to the contractor. Testing labs to be established for testing concrete etc. Equipment for control concreting should be used for preparing concrete as per specifications at the cost of the contractor.
- c) Contractor shall submit to the employer samples of all materials for prior approval and no work shall commence before such samples are approved by the Engineer-in-charge.
- d) All material and methods shall conform to the latest specifications of Afghanistan Standards and ASTM/ACI relevant codes. All measurements will be taken in accordance with latest specifications of ASTM/ACI and relevant codes.
- e) All works shall be carried out strictly according to the drawings and instructions of Engineer if, in the opinion of the Employer / Architects / Engineer any portions of the work is found to be defective or unsound the same shall be pulled down and reconstructed at no extra cost to the employer. Defective materials shall not be brought to the work site by the contractor.
- f) A site order Book shall be maintained by the contractor's authorized agent at work site, and the instructions issued by the SWIM QA Engineer during periodical inspection visits shall be duly entered therein.
- g) No standing tree shall be cut by the contractor without the permission of SWIM QA Engineer-in-Charge.
- h) The site shall be cleared of all rubbish shrubs, vegetational roots, loose boundary materials and got levelled up by filling hollows before starting construction.
- i) Before starting the work, the subcontractor or his duly authorized agent shall be present while taking ground levels/ pre levels along and across the alignment of the various works,

etc., and shall have to sign the field book and also working plans showing working longitudinal and cross sections of their alignment in token of having accepted the ground levels without which they will not be allowed to start the work.

- j) Accurate marking and recording of earthwork and structure of different portions of canal using total station instrument is the responsibility of the subcontractor.
- k) Temporary benchmark pillars of masonry shall be constructed by subcontractor. These benchmarks are required to be maintained by subcontractor for checking elevation at various stages of work.
- l) Lift, hoists, elevators, ramps and ladders of proper strength and rigidity shall be provided by the subcontractor not only for conveyance of construction materials to various heights, but also for the safe reaching of workmen and inspection parties to reach all spot of construction, the cost of which are deemed to be included in the rates.
- m) Deep trenches of excavation, newly placed concrete work is required to be properly protected from rain, bad-weather and accidents by adequate means at no extra cost to the employer.

2.1.1 BAILING OUT WATER OR DE-WATERING:

- a) The rates for various items quoted by the subcontractor, should include the cost of dewatering. Separate payment will not be made on this account.
- b) Should the contractor desire to substitute/ deviate any material or workmanship for any reason whatsoever during construction, prior written approval of the SWIM QA Engineer-in-charge must be obtained, or else such portion of works will be rejected.
- c) All preliminary and enabling construction at site, like site office (for himself & client) , store, cement shed, labour/ watchmen quarters and temporary water storage tank shall be constructed and removed after completion of works by the contractor at no extra cost to the employer.

2.2 EARTH WORK IN CANALS

2.2.1 SETTING OUT

- a) Before start of work center line of the canal shall be marked by suitable and firm pegs each at about 30 m interval in straight reaches. In the curved reaches of the canal the curve shall be laid out and top and bottom edges of excavation and toe of embankment shall be suitably peg marked. The center line in such reaches shall be marked by pegs at an interval of 5 m to ensure smooth curve profile during excavation/filling. Distance pegs shall be constructed at 200 m interval at canal boundary for proper alignment.
- b) All levels of canal profiles shall be referred to a specified and established firm benchmark not subject to subsidence/interference or disturbance. Temporary benchmark pillars shall be constructed at suitable locations for reference of levels during construction.

- c) Canal section in fill and cut reaches shall be marked at intervals of 25m at curves and 50 m in the straight reaches or as directed by Engineer-in-charge before start of earth work in the reach.

2.2.2 CLEARING OF LAND

- a) Before beginning the construction/repair of embankment, the land over which excavations or embankment is to be done/placed shall be cleared of all trees, bushes, vegetation, rubbish, roots, ant hills and any other objectionable material before excavation or placing earth for embankment. The cleared material shall be the property of the Government and its disposal shall be done in a manner as approved by the SWIM QA Engineer-in-Charge. The land so cleared shall be maintained free from any growth and vegetation during progress of construction.
- b) In filling reaches, all holes and hollows whether originally existing or produced by digging up roots shall be filled with suitable earth well rammed and leveled off. The depth to which topsoil is removed shall be adequate to remove all perishable material and any soil which may become unstable on saturation or may interfere with the development of proper bond between the existing surface and new embankment. The depth of stripping **as guide** for containing light grass cover shall be 5 to 7.5cm. It shall be 20cm for soil containing thick vegetation/agricultural land.

2.2.3 DRAWINGS

- a) All works shall be carried out in accordance with the Construction drawings to be supplied by the SWIM. As Built Construction drawings will be approved in stages, by the SWIM before the start of actual construction at site. After careful study of the drawings approved by the SWIM, contractor shall prepare, where necessary supplementary construction/ fabrication drawings with field/construction information and shall submit the same to the SWIM for approval prior to construction.

2.2.4 EXCAVATION

- a) Before commencement of the excavation in any reach the contractor shall inform and obtain in writing from the SWIM Quality Assurance Engineer-in-Charge, necessary instructions.
- b) The contractor shall excavate whatever material may be encountered up to the depth of excavation shown on the Cross-section of the channels. Extra payment shall however be admissible for rock excavation, if any. All material, thus excavated, shall be the property of the Government.
- c) Excavation to be carried out shall strictly conform to the plans and levels shown on the profile of excavation in the Cross-sections. The bed of the canal will have a longitudinal gradient as given in L-section and will be kept level transversely. The side slopes shall also conform to those given in the drawings and shall be neatly finished. Any excavation below the prescribed bed level shall not be paid.
- d) Excavation of internal section in main canal shall be carried out by suitable earthmoving equipment/tractors.

2.2.5 DRAINAGE DURING EXCAVATION

- a) Suitable arrangements of drainage shall be provided to take surface water clear of the excavation during the progress of work. Sumps may be constructed at suitable places and water collected may be pumped out. When cutting on cross sloping ground, it is advisable to cut a catch water drain on the higher side to prevent water from flowing down.
- b) Wherever ground water is met during excavation, adequate arrangements shall be made for dewatering. The choice of method to be adopted and type of equipment to be used would depend on the volume of water.
- c) If there is a continuous flow of water, a sub-drain with sumps at suitable intervals may be provided. Excavation from downstream to upstream side will be helpful to drain away all water from the working face.
- d) All operations for proper drainage and to make the work area suitable for excavation shall be carried out by the contractor at his own costs i.e. no payment for dewatering shall be made extra.

2.2.6 EMBANKMENT

- a) For the embankment construction /rehabilitation the toe of the slope on each sides of the bank shall be Dag-Belled and marked by pegs firmly driven in the ground at interval of 20m. Profiles made by bamboos, earth and strings shall be setup for the guidance of workmen at 50m. interval over straight reaches and about 25m. apart for curved reaches. A suitable allowance for settlement shall be made in setting up the profile for embankment.
- b) Surface Preparation: The base of the extension portion of embankment shall be stripped and roots & other vegetation's shall be removed. The stripping operation is to be done up to the bottom of root zone of vegetation so that all roots are removed out of the surface. The stripping depth may vary at places depending upon type of vegetation growing on the area/slopes. The cost of all such stripping up to bottom of roots shall be deemed to be included in the unit rates of the excavations.
- c) The slope of existing banks shall be benched. Benching of slopes shall be done with a little slope towards the inside of benches to give a good grip/bond to the embankment soil with the sub-grade. Unless otherwise specified, the benches shall be 0.3x0.6m on the front and rear slope of the embankment.
- d) Before benching, canal slopes shall be cleared of all roots, vegetation, rubbish etc. No separate payment shall be made for these and the rates quoted for raising the embankment is inclusive of these operations. The areas shall be pre-wet by sprinkling water before the construction of embankment commences. Unless otherwise specified, the water applied for pre-wetting the areas shall not be paid being considered included in the unit price per cubic meter bid in the bill of quantities for compacting the embankment.
- e) Before laying soil on existing embankment, the slopes shall be properly cut and benched in steps not steeper than 2: 1.
- f) The earth to be used in banks shall be thoroughly broken before laying. The embankment shall be built to the height and slope shown on the drawings. All the edges of the embankment shall be neatly aligned symmetrical to the center line of the channel.

2.2.7 BORROW PITS

- a) Suitable excavated material available from canals cutting, foundation excavation, structures, any other associated excavations within economic leads shall be used for embankment and backfill. Where canal excavation does not furnish sufficient suitable material for embankments, additional material required shall be identified from the borrow pits for which land shall be arranged by the contractor and approved by SWIM QA Engineer-in-charge.
- b) No borrow pits shall be dug within 5m of the toe of embankment, if their depth is less than 0.5m, and 10m, if their depth is more than 0.5 m; or within such a distance from the toe of the bank where a 4:1 hydraulic gradient line cuts the ground surface whichever is more. Borrow pits shall not be more than 1 m in depth and 25m in length. A clear distance of 1 m shall be left between the pits. The bed of borrow pits shall be left reasonably smooth and even.
- c) The borrow area shall be clearly demarcated by the contractor with the approval of the SWIM QA Engineer-In-Charge. Borrow pits in sodic areas or in areas having expansive and dispersive clay shall be prohibited.
- d) The Contractor shall be responsible for the rehabilitation of the borrow area and shall ensure the consent of the farmers.
- e) Suitability of borrowed earth shall be decided by the Engineer In-charge after proper examination of the soil based on laboratory tests to be submitted by the contractor.

2.2.8 CONSTRUCTION/REHABILITATION OF CANAL EMBANKMENT AND DISPOSAL OF EXCAVATED EARTH

- a) Embankment shall be built in layers not exceeding 20cm to 25cm loose. Each layer will be laid horizontally in 30cm more than full width of the section and the banks and berms shall then be dressed after compaction in full width and to the required slope. The top of embankment shall be leveled and finished to be suitable for roadway. Where provided, a cross slope of 1 in 80, outward to drain away rain waters may be given.
- b) All material of excavation in excess of requirement for rehabilitation of banks shall be disposed outside the embankment at designated disposal sites on either side of canal.
- c) The surplus earth will be disposed off to approved disposal sites. The contractor will have to take and communicate to the engineer in charge, the formal consent of landowners, tenant and /or cultivators of plots selected for silt disposal. Where canal excavation does not furnish sufficient suitable material, additional quantity of earth required may be taken from approved borrow pits. The bidder/contractor must arrange suitable borrow areas for borrowing of the earth. Before start of excavation, the contractor will finalize and get borrow areas approved from the SWIM QA Engineer in charge.
- d) Contractor shall be responsible that no unwanted disposal is being made in the work area. Any such disposal shall be removed at his own cost to the satisfaction of SWIM QA Engineer-in-Charge. Similarly, the contractor shall ensure that there is no blockage of drains or damage to the canal and to the existing outlets of canal due to disposal of material. If anything found contrary, the contractor shall arrange to rectify at his own cost within the prevalent environmental regulations.
- e) Where the embankment is constructed by taking material from borrow pits, care shall be exercised that large clods are broken and no clod bigger than human fist, say 8 to 10 cm, grass and other rubbish are buried in the earth used for rehabilitation of banks. Before taking materials from borrow pits, all perishable material shall be stripped off

from the top surface as specified or as directed by the SWIM QA Engineer-in-Charge. In areas where gravel and stone are mixed with earth, these should be removed as far as possible. But the areas where all gravel material cannot be economically removed, cobbles, stones of size greater than 40 mm should be removed to ensure proper compaction. The existence of nest of cobbles may result in more seepage and piping. In view of this, measure to remove cobbles of larger size should be taken at the excavation area itself.

- f) All surplus earth lying on embankments above designed bank level shall be removed by the contractor.

2.2.9 COMPACTION REQUIREMENT

Embankments shall be compacted, as shown on the drawings, to achieve the requirements laid down as under:-

2.2.9.1 LAYING OF EARTH ON EMBANKMENT:

- a) The fill material shall be deposited in horizontal layers. The thickness of each horizontal layer before compaction shall normally be not more than 25 centimeters (loose layer), or as determined by the SWIM QA Engineer-in-charge and the layer shall be laid to full width of embankment. The thickness of layer shall be governed by the type of compaction equipment to be deployed based on the space available for compaction. The excavating and placing operation shall be such that the material when compacted will be blended sufficiently to secure minimum DBD of 80 %. If the surface or any compacted layer of earth fill is too dry or too smooth to bond properly with the layer of material to be placed thereon, it shall be moistened and/or sacrificed in an approved manner to provide a satisfactory bonding surface before the next succeeding layer is placed.

2.2.9.2 COMPACTION OF EARTH (COHESIVE MATERIAL):

- a) Prior to and during compaction, the embankment materials shall possess optimum moisture content. The embankment materials shall have optimum moisture content required for the purpose of compaction and this moisture content shall be uniform throughout the layer. Optimum moisture content is the moisture content that corresponds to the laboratory maximum dry density. In so far as practicable the moistening of the material shall be performed at the site of excavation, but such moistening shall be supplemented as required by sprinkling water at the site of compaction, if necessary. If the moisture content is greater than optimum for compaction, the compaction operations shall be delayed until such time as the material has dried to the optimum moisture content or to the level directed by Engineer-in-charge.
- b) Compaction shall be done by 8-10 T power rollers/sheep foot rollers/vibratory power rollers/mechanical compactors (fuel or pneumatic operated)/mechanical tampers depending upon the extent of space available. Manual compaction through wooden rammers shall not be allowed except in confined areas.

- c) Density tests shall be made after rolling every layer. The dry bulk density of the soil in compacted embankment materials shall not be less than 80% of the maximum dry bulk density at optimum moisture content (proctor density).
- d) The above compaction tests will be conducted by contractor in the presence of the SWIM QA Engineer-in-charge or his representative at his cost and the contractor shall ensure specified compaction, till the SWIM QA Engineer-in-charge or his authorized representative is satisfied that the specified dry density at optimum moisture content is obtained, and permits the laying of next layer.

2.2.9.2 COMPACTION OF COHESION LESS MATERIALS:

- a) Where compaction of cohesion less, free draining materials, such as sands and gravels are required, the materials shall be deposited in horizontal layers and compacted to the specified relative density. The excavating and placing operation shall be such that the materials when compacted will be blended sufficiently to secure specified relative density. Water shall be added to the materials as may be required to obtain the specified density by method of compaction being used.
- b) The thickness of the embankment layer shall not exceed 25 centimeters (loose layer) before compaction, or as determined by the SWIM QA Engineer-in-charge, and it shall be spread over the full width of the embankment and compaction shall be done by tracks of crawler tractors or vibratory rollers or vibratory compactors. Thickness of layer shall be suitably adjusted in accordance with the type of compaction equipment used, to achieve the specified density. The relative density of the compacted material shall not be less than 70% .

2.2.9.3 TESTING:

- a) Density tests shall be carried out after rolling to ascertain the state of compaction, which should be measured in term of dry density. Standard proctor density tests shall be carried out at regular intervals to account for variations in the borrow area material.
- b) Density test shall be conducted from time to time at site to ascertain whether compaction is attained as specified. For every 300 cubic meter of compacted earth fill, at least one field density test using core cutter or sand replacement method shall be conducted. The Engineer-in-charge may also deploy 'Portable Electronic Testing Device' for quick on-site determination of moisture content, in place density, and compaction efficiency. However, minimum four density tests shall be made per day irrespective of quantity of earth work. In case the tests show that the specified densities are not attained, suitable action shall be taken either by moisture correction or by additional rolling, to obtain the specified density, which shall be checked again by taking fresh tests at the same locations. The test locations should be so chosen as to represent the whole layer under test. Each layer should be tested for proper compaction before a fresh layer is allowed over it.

2.2.10 IMPORTANT POINTS FOR REHABILITATION OF EXISTING CANAL EMBANKMENTS

For rehabilitation of old canal embankment, the following care shall be taken for proper bonding of the freshly laid soil with the old embankment.

- a) All trees, bushes, roots and other vegetation growth from the existing embankment shall be removed.

- b) The base of the extension portion of embankment shall be stripped and roots & other vegetation shall be removed. The stripping operation is to be done up to the bottom of root zone of vegetation so that all roots are removed out of the surface. The stripping depth may vary at places depending upon type of vegetation growing on the area/slopes, the cost of all such stripping up to bottom of roots shall be deemed to be included in the unit rates of the excavations.
- c) The slope of existing banks shall be benched to depth of 15 cm. to 30 cm. as per requirement at site for proper bonding of the freshly laid soil with the old embankment. The cost on this account shall be deemed to be included in the unit rates of the excavations.
- d) Earthwork shall be done in layers of specified thickness. Clods must be broken.
- e) Under no circumstances, the embankment shall be widened by material dumped from the top of the existing embankment.
- f) Adequate quantity of moistening/watering shall be done at the junction of the freshly laid soil with the old embankment for proper bonding.
- g) If initial moisture content in the soil is less than the optimum moisture content (OMC) water shall be sprinkled over the freshly laid layer before compaction. A tolerance of + 1% of OMC moisture content shall be permitted.
- h) Where the width is sufficient/adequate, compaction shall be done mechanically by 8-10 tones power roller/vibratory power roller to achieve at least 80% of Procter density for cohesive soils and relative density of 70% for non-cohesive soil. Where space is not sufficient for the deployment of 8-10 Tones Power Rollers, the earth work shall be compacted by deploying appropriate smaller dimensioned vibratory power rollers (of the same compacting effort as of the 8-10 Tones plain power rollers) or using mechanical compacters/pneumatic compacters (by reducing the thickness of layers to \pm 10-15cm) to achieve at least 80% proctor density.
- i) In case of minors manual compaction may be done with permission of SWIM QA Engineer-in-charge.

2.2.11 TESTS AND THEIR FREQUENCIES FOR EMBANKMENT CONSTRUCTION

SN	Test	Frequency	Purpose
1	Grain size analysis for classification	One test per day or periodically as directed by Engineer	To know the classification of soil actually put in embankment
2	Specific gravity	One test per day	-do-
3	Field density and moisture content	One test in 300m ³ of earth work or in each layer laid on embankment	To determine the placement density and moisture content
4	Standard Proctor test	One test per day for individual borrow area	To determine MDD (maximum dry density) and OMC (optimum moisture content) of the soil and compare the results with laboratory value
5	Moisture content	One test in each sample	To know the moisture content in the sample
6	Relative density test	One test in 300 m ³ of earth work Placement	To know the relative density of cohesion less soil

2.2.12 MEASUREMENTS

- a) The measurements shall be taken correct to a cm. Before commencement of earthwork in each canal, initial cross sections at every 50m interval in straight reach and at every 25 m interval in curved reaches shall be taken jointly by the SWIM Engineer and authorized representative of the subcontractor, which shall be recorded in M.B./ level book. Subcontractor/his authorized representative shall have to record his acceptance of levels and measurements on the M.B./level book before start of work. The contractor shall submit the detail programme for carrying out the joint measurements. A notice for recording the measurements shall be issued to the contractor and even then, if the contractor or his authorized representative does not turn up on the desired date, time & place, the work of taking measurements will continue and it will be deemed as acceptable to the contractor.
- b) If the earth from cutting internal section is not enough to achieve designed section after compaction, then cross section shall be taken before placing the borrowed earth to achieve designed section wherever required. Similarly, after completion of work as per design/drawing, final cross sections shall be taken at the same locations. During the execution of work, cross-section at intermediate state shall also be taken if required. These cross sections shall be prepared in Auto-Cad by the contractor. All such cross sections shall be utilized to derive quantities of earthwork mentioned under different items in Bill of Quantities. Only joint measurement shall be the basis of the payment. It will be the duty and sole responsibility of the contractor to get the joint measurements done as and when required before commencing any new activity. Quantity of borrowed earth shall be derived based on cross sections as described above. Quantity of earthwork in cutting shall be derived based on initial & final cross section. This earth (only suitable quantity) shall be used for the rehabilitation of banks and surplus earth shall be disposed off as per Disposal plan.

2.2.13 RATES

Rate for earthwork shall include and take in to account the following –

- a) Making Profiles.
- b) Setting out works, cost of land for haul roads, disposal area/borrows area etc.
- c) Disposal of the surplus excavated material including arranging disposal area as per disposal plan or as per direction of Engineer-in-charge taking into consideration environmental & social aspects.
- d) Borrowing earth from approved borrow area and rehabilitation of banks.
- e) Preparation of cross sections in Auto-Cad.
- f) All leads, lifts and dressing of earth.
- g) Labour charges, providing all surveying and leveling instruments and material needed for measurements, checking of works and taking initial/final cross sections of canal.
- h) Cost of maintenances of works during contract period.
- i) Spreading in layers, watering & compaction as per specification.

2.3 EARTHWORK IN EXCAVATION OF STRUCTURE FOUNDATION

- a) Foundation trenches for laying of culverts and retaining walls shall be dug to exact length and width as per drawing. The sides shall be left plumb where the nature of the soil permits it, but the sides must be sloped back or shored up carefully when the soil appears likely to fall in or the depth of trench exceeds 1.5m. The disposal of excavated material shall be as per direction of Engineer-in-charge. The earth obtained from excavation of foundation shall be used for back filling and surplus earth shall be utilized for rehabilitation of banks.
- b) The foundation bed for culverts shall be excavated true to lines and grades shown on drawings or as directed by Engineer-in-charge. The minimum width of trench on either side of the pipe shall be 150 mm or one-fourth of the diameter of culvert whichever is more and shall not be more than one-third of diameter of the culvert . The sides of the trenches shall be as nearly vertical as possible. The culverts shall be placed where ground for the foundation is reasonably firm. When during excavation the material encountered is soft, spongy or other unsuitable soil, such material shall be removed to such depth, width & length as directed by SWIM QA Engineer-in-charge and shall be filled with lean concrete at contractor's own cost.
- c) The bottom of the foundation trenches must be perfectly leveled both longitudinally and transversely. The bottom of the trenches shall be slightly watered and well rammed. If excavation is done deeper than shown in the drawing, the contractor shall fill the extra depth with appropriate material at his own expense. Roots of all trees and plants encountered in digging trenches shall be removed carefully if possible, otherwise they shall be cut up to 30cm on sides and bottom of trench and shall then be burnt and smeared with boiling coal tar at the expense of contractor. If boulders are found in bed they shall be removed at contractor's own cost. The extra depth caused by removal of roots of trees or removal of boulders from the trench, shall be filled with appropriate material at contractor's own cost.

2.3.1 MEASUREMENTS

The measurements of excavation shall be taken as the area in plan by the depth of the foundations below designed bed level, notwithstanding that the contractor may find it more convenient to take out the excavations with sloping sides.

2.3.2 RATE

The measurement of the excavation shall cover back filling, watering and ramming of the excavated earth in the space of the trenches and the sloping off and dressing of the excavated earth. All such filling shall be done in courses and along with the masonry/concrete. Any dewatering if required and any shoring that is necessary shall be included in the rate of excavations. The superfluous material not required for refilling shall be removed and disposed off suitably.

2.4 CANAL BED CONCRETE LINING

2.4.1 PREPARATION OF SUB-GRADE FOR CONCRETE CANAL BED LINING

2.4.1.1 GENERAL

A sound and firm bed for lining shall be obtained by suitably preparing the sub-grade as follows:

- (a) The last 200 mm of excavation in all soils shall be carried out immediately before placing the concrete lining. Prior to this excavation, the sub - grade soil will be scarified and wetted if necessary and compacted at optimum moisture content. The compacted sub-grade, thereafter, shall be trimmed and dressed to required profile.
- (b) If there are over excavations, the back filling will be carried out to give suitable procedure of back filling the over excavation of soils. If at any point the sub-grade consisting of earth is disturbed or loosened, it shall be moistened, as required, and thoroughly compacted by tamping, rolling or other approved methods to form firm foundations for placing the concrete lining. In case of excavation in soft or hard rock, all loosened and disturbed sub-grade will be knocked out and removed.
- (c) All loose materials shall be removed at the end panels of existing lining against which lining is to be placed under the specifications, and all voids beneath the exiting lining shall be refilled and thoroughly compacted.
- (d) Suitable material trimmed from the canal shall be used for canal embankments, for road embankment, for back fill around structures or for bedding material. Where material suitable for bedding as determined by the SWIM QA Engineer-in-charge is encountered during trimming operations and cannot be placed in one continuous

operation, such material shall be stockpiled along the right of way where designated by the Engineer - in - charge.

2.4.1.2 TOLERANCE IN PREPARATION OF SUB-GRADE

Excavated profile provides the final base for lining and departure from the lines show on the drawings shall not exceed :

Alignment	± 20 mm on straight section
	± 50 mm on tangents
	± 100 mm on curves

Departure from levels shown on the drawings ± 20 mm

The above tolerance shall be negotiated gradually through smooth transition in a length of 30 meters

2.4.2 MATERIAL

2.4.2.1 CEMENT

- Cement for use in works shall be ordinary Port land Cement (OPC) conforming to ASTM C150.
- Pozzolana port land cement (PPC) may be used in specific locations, components of the work subject to permission of SWIM Engineer-in-charge. However, difference between the market rates of OPC and PPC at the time of execution of such work shall be deducted for the quantity of PPC used.

2.4.2.1.1 PROPERTIES

- The compressive strength of cement shall be as under.

S.No.	Time	Compression strength	
		OPC	PPC
1	72 ± 1 hours (3 days)	230 kg/cm ²	160 kg/cm ²
2	168 ± 2 hours (7 days)	330 kg/cm ²	220 kg/cm ²
3	672 ± 4 hours (28 days)	430 kg/cm ²	330/cm ²

- Unit weight of cement shall be 1.44 T/m³. Average net mass of cement per bag shall be 50 kg.
- The Pozzolana cement requires curing for a longer period.
- The cement shall have normal setting time. The initial setting time shall not be less than 30 minutes and final setting time shall not be more than 600 minutes.

e) TESTS

- a) Manufacturer of cement shall furnish, on demand, a certificate to indicate that cement conforms to the requirements regarding chemical constituents, fineness, soundness, setting time and compressive strength.
- b) Average weight of cement Bag shall be 50 kg.
- c) The number of bags in a sample for calculating the average net mass of a cement bag shall be –

S.No.	Batch Nos.	Size	Sample nos.
1	A	100 – 150	20
2	B	151 – 280	30
3	C	281 – 500	50
4	D	501 – 1200	80
5	E	1201-1200	125
6	F	3201 and above	200

- d) The bags in a sample shall be selected at random.
- e) Number of bags showing minus error greater than 2% of standard mass of 50 kg shall not be more than 5% of sample. Also, the minus error in no such bag shall exceed 4% of standard mass of 50 kg.

2.4.2.1.2 COMPRESSIVE STRENGTH

- a) The average compressive strength at 7 days and 28 days per source of cement shall be tested on 2 sets of at least 3 mortar cubes of size $7.06 \times 7.06 \times 7.06$ cm (face area 50 cm^2). Material for each cube shall be mixed separately with following quantities.
- b) Cement 200 gm, standard sand 600 gms and potable water. Standard sand shall be of quartz with grains of spherical shape and shall be free from silt. The sand shall pass 100% through 2 mm IS sieve and shall be retained 100% on 90 micron IS sieve.
- c) Cement and sand are mixed dry, and the water is added to prepare a uniform mix of mortar. Mixing time shall not be less than 3 minutes and more than 4 minutes. Mortar is then filled in cube mould and prodded 20 times in 8 seconds to ensure elimination of entrapped air/honey combing. The mortar in the mould is compacted by placing the mould on the table of vibration machine and given vibration for 2 minutes. Top surface of cube is finished with trowel. Filled mould is kept in moist closet for 24 ± 1 hours.
- d) Moulds are then removed and cubes are cured for 14 days.
- e) Cubes are tested on their sides without any packing between cubes and steel plates of testing machine. One of the platters shall be carried on the base and load is uniformly increased @ 350 N/mm^2 per minute starting from zero. Compressive strength is calculated by dividing maximum load with cube surface area. Specimen giving variation of more than 10% is rejected. At least two strength values are considered for determining compressive strength.

2.4.2.1.3 CONSISTENCY TEST

- a) This test is conducted at source of cement. A paste of weighed quantity (about 500 gms) of dry cement with weighed quantity of potable water is prepared. Mixing time shall not be less than 3 minutes and more than 5 minutes which shall be counted from time of adding water to the time of starting to fill the paste in the vacant mould. The mould is placed over non-porous plate and slightly shaken to expel the entrapped air while mixing. Top of paste surface is finished with a trowel.
- b) The test block in mould together with non-porous plate is placed under the rod bearing the vacant plunger. The plunger is gently lowered to touch the surface of the test block and is quickly released allowing it to sink into the paste just after filling the mould. Trial pastes with varying %age of water is prepared and tested until the amount of water for allowing the plunger to penetrate to a point 5 mm from bottom of vacant mould is found. This amount of water in percentage gives the standard consistency of cement.

2.4.2.1.4 SETTING TIME TEST

- a) **Initial setting Time** – Procedure for preparing cement paste and testing it are similar to those described for consistency test. A neat cement paste is prepared with 85% of amount of water required to procedure a paste of standard consistency. The needle of vacant plunger is gently lowered to just touch the surface of test block and is quickly released to penetrate test cube. Initially needle will completely pierce the block. Process is repeated until needle fails to penetrate the cube beyond 5 ± 0.5 mm measured from bottom of cube. The time elapsed from this moment to the moment of adding water to cement to prepare paste shall be the initial setting time of cement.
- b) **Final Setting Time:**

The needle of vacant apparatus is replaced by a needle with annular attachments. The cement is considered as finally set when upon applying the needle gently to surface of test cube, the needle makes an impression there on while the attachment fails to do so. The time elapsed from these moments to the moment of adding water to cement shall be the final setting time of cement.

2.4.2.1.5 STORAGE

- a) The cement shall be stored in such a manner so as to prevent deterioration due to dampness or water.
- b) It shall be stored in waterproof building and on wooden floor which will prevent the absorption of moisture from ground.
- c) The cement shall be staked in rows having two bags in width and 8 bags in height. Bags shall be arranged length wise and cross wise in alternate layers.
- d) The rows shall be separated by sufficient space to provide easy access for inspections.
- e) Cement shall be used on 'first in first out' basis i.e. cement received first shall be used first.
- f) Cement loses strength with storage period. Cement older than 90 days shall be used only after testing its properties.

2.4.2.1.6 DELIVERY

- a) The cement shall be packed in bags bearing manufacturing name or his registered trademarks. The words grade as the case may be (or the trademark of other type of cement), nominal average net mass of cement, date of manufacture and Batch No. shall be legibly marked on each bag. The bags shall be in good condition at the time of inspection.

2.4.2.2 FINE AGGREGATE (SAND)

- a) The fine aggregate to be used in preparation of plain concrete, reinforced concrete, cement sand mortar shall be clean, hard, durable and strong form of crushed stone, gravel or some suitable combination of natural sand, crushed rock/grand. The fine aggregate shall not contain dust, lumps, soft or flaky materials, mica, silt, organic impurities or any other type of deleterious materials. Presence of mica (Muscovite & Biotite) in sand will reduce, considerably, the durability and compressive strength. The sand/fine aggregate shall be washed off all the mixed earth before use. Fine aggregate having positive alkali-silica reactions, shall not be used.
- b) Quick color test shall be conducted in the field to determine the presence of any harmful organic impurities in sand with 3% solution of sodium hydroxide, as under :-
- A colour less liquid indicates clean sand free from organic matter
 - A Straw color liquid indicates some organic matter but not enough to be seriously objectionable.
 - A dark color will mean unsafe limits of organic matter.

2.4.2.2.2 GRADING

- a) The grading of fine aggregate has been divided in following four zones.

Sieve size	Zone I	Zone II	Zone III	Zone IV
	% age passing by weight			
10 mm	100	100	100	100
4.75 mm	90-100	90-100	90-100	95-100
2.38 mm	60-95	75-100	85-100	95-100
1.18 mm	30-70	55-90	75-100	90-100
600 micron	15-34	34-59	60-79	80-100
300 micron	5-20	8-30	12-40	15-50
150 micron	0-10	0-10	0-10	0-15

- b) Sand conforming to zone I & II shall be used for concrete works. Sand conforming to zone III & IV can also be used for concrete work, but concrete mix shall be properly designed. The sand conforming to zone IV shall not be used in reinforced concrete works.

- c) If grading falls outside the limits of particular zone of sieves, except 600-micron sieve, by a total amount not more than 5%, it shall be taken as conforming to that zone.
- d) Percentage (by weight) passing through 600-micron sieve as specified in the table gives the grading zone of the sand.
- e) **The amount of deleterious substances shall not exceed the percentage given below :**

Deleterious substances	Percentage more than
Shale	1.00
Coal and ignite	1.00
Cinders and clinkers	1.00
Material passing 75-micron sieve	0.50
Alkali, mica and coated grain	3.00

- f) The sum of the percentages of all deleterious substances shall not exceed 5% by weight. The sand shall also be sound and free from any amounts of organic impurities.

2.4.2.2.3 TESTS

- a) One test per each consignment of sand shall be conducted.
- b) The weight of the samples for gradation shall not be less than that shown below.

Maximum size (mm) present in Substantial proportion	Minimum weight of sample for sieving (kg.)
4.75	0.2
2.36	0.1

- c) The sample for sieving shall be prepared from larger sample either by quartering or by means of a sample divider. The sample shall be brought to an air-dry condition by drying it at room temperature before sieving. Air dry sample is weighed and sieved successively on the appropriately sized sieves, starting with the largest sieve. Each sieve shall be shaken separately over a clean tray until not more than a trace passes but for a period of not less than two minutes. If sieving is done with a nest of sieves on a machine, not less than 10 minutes sieving shall be continued.
- d) To prevent blinding of sieve apertures by overloading, quantum of sand placed on each sieve shall be such that the weight of sand retained on the sieve at the completion of the operation is not greater than as under

<u>Sieve</u>	<u>Maximum weight (for 20 cm dia sieve) gm</u>
2.36 mm	200
1.18 mm	100
600 microns	75
300 microns	50
150 microns	40
75 microns	25

- c) After completion of sieving, material retained on each sieve together with any material cleaned from mesh shall be weighed. The result shall be reported as –
 - The cumulative percentage, by weight, of the total sample passing each sieve to the nearest whole number.

- Percentage, by weight, of the total sample passing one sieve and retained on the next smaller sieve to the nearest 0.1%.
- Specific gravity of sand shall be minimum 2.6

2.4.2.2.4 BULKING OF SAND

- Sand may contain an amount of moisture which will cause it, when loosely filled in a container, to occupy a larger volume than it would occupy if dry. If the sand is measured by loose volume, it becomes necessary to increase the measured volume of sand put into concrete or mortar to compensate for this bulking. In ordinary sand, the bulking varies from 10 – 30%. The bulking is more in fine sand. If sand is measured by weight, no allowance/ increase for bulking are needed.
- For estimation of bulking, a graduated cylinder is filled with sand to approximately 2/3 height. The cylinder is shaken, and sand is leveled. The height of sand (H_1) is noted. The cylinder is then filled with water and is shaken well. The cylinder is kept undisturbed so that the sand settles down. The height of settled sand (H_2) is noted. The percentage bulking of sand = $(H_1 - H_2/H_2) \times 100$. Therefore, when sand is measured by volume.

2.4.2.3 COARSE AGGREGATE

- Coarse aggregate shall consist of clean, hard, strong, dense, non-porous and durable pieces of crushed stone, crushed gravel, natural gravel or a combination there of or other approved inert material. The coarse aggregate shall not contain disintegrated stones, soft, flaky elongated particles, vegetative matter or others deleterious materials. The aggregate should either be rounded or cubical in shape. The unloading and stacking of coarse aggregate shall be done in a manner to avoid any segregation. The coarse aggregate shall be washed of all the mixed earth before use. The minimum specific gravity shall be 2.2 to 2.5.

2.4.2.3.1 PROPERTIES

- Gradations** – The coarse aggregate for use in concrete shall be well graded and should conform to the specified gradation.

Sieve size	Percentage passing by weight for graded aggregate of nominal size	
	40 mm	20 mm
80 mm	100	-
40 mm	95 – 100	100
20 mm	30–70	95 – 100
10 mm	10–35	25–55
4.75 mm	0.5	0.10

- Aggregate Impact Value** – This is a relative measure of the resistance of an aggregate to sudden shock or impact. This shall not exceed 45% by weight for general concrete and 30% of weight for concrete in wearing surfaces.

c) **Aggregate crushing value** – This is a relative measure of resistance of an aggregate to crushing under a gradually applied compressive load. This value shall not exceed 45% by weight for general concrete and 30% by weight for concrete in wearing surfaces.

d) **Water absorption** – The water absorption of aggregate value submerged for 24 hours in water shall not exceed 2% Water absorption is an indication of porosity of the aggregate.

e) **Flakiness Index** – This is the percentage (by weight) of particles in the aggregates passing through various thickness gauges or sieves whose least dimension (thickness) is less than 3/5 of their mean dimension. The index shall not exceed 25% by weight.

2.4.2.3.2 TESTS

a) One test for each consignment of course aggregate shall be conducted.

2.4.2.3.3 GRADATION

a) The weight of the samples for gradation shall not be less than that shown below –

Maximum size present in substantial proportions (mm)	Minimum weight of sample for sieving (kg)
40	15.0
20	2.0
10	0.5
6.3	0.2
4.75	0.2

b) The sample for sieving shall be prepared from larger sample by quartering. The sample shall be brought to an air-dry condition by drying it at room temperature before sieving. The air-dry sample is weighed and sieved successively on appropriately sized sieves starting with largest sieve. Each sieve shall be shaken separately over a clean tray until not more than a trace passes but for a minimum period of two minutes. The material shall not be forced through the sieve openings by hand pressure. If sieving is carried out with a set of sieves on machine, minimum period of sieving shall be ten minutes.

c) To prevent blinding of sieve operations by overloading, the quantum of aggregates placed on each sieve shall be such that the weight of aggregate retained on the sieve at the end of operation is not more than the value as under –

Sieve	Maximum weight for 30 cm dia sieve (kg)
50 mm	4.5
40 mm	3.5
31.5 mm or 25 mm	2.5
20 mm	2.0
16 mm or 12.5 mm	1.5

10 mm	1.0
6.3 mm	0.75
4.76 mm	0.5
3.35 mm	0.3

d) The material retained on each sieve shall be weighed. The result shall be reported as-

- The cumulative percentage, by weight, of total sample passing each sieve to the nearest whole numbers.
- Percentage, by weight, of the total sample passing one sieve and retained on next smaller sieve to the nearest 0.1%.
- The material retained on each sieve shall be weighed and percentage passing through each sieve is calculated to determine the gradation of the aggregate.

2.4.2.3.4 FLAKINESS INDEX

a) Sample shall consist of sufficient quantity of aggregate to provide minimum number of 200 pieces of any fraction to be tested. Sample shall be sieved in the manner described for gradation of aggregate with sieve sizes specified below. Each fraction shall be gauged in turn for thickness on sieves having elongated slots. Width of slots used in sieve shall be of the dimensions shown here under.

Size of aggregate		Thickness gauge (mm)	Length gauge (mm)
Passing through sieve (mm)	Retained on sieve (mm)		
63	50	33.90	-
50	40	27.00	81.00
40	25	19.50	58.50
31.5	25	16.95	-
25	20	13.50	40.50
20	16	10.80	32.40
16	12.5	8.55	25.50
2.50	10	6.75	20.20
10	6.3	4.89	14.70

b) Total amount passing the gauge shall be weighed to an accuracy of 0.1% of the weight of test sample. The flakiness index is the total weight of the aggregate passing the various sieves expressed as a percentage of total weight of the sample gauged.

2.4.2.3.5 AGGREGATE IMPACT VALUE

- a) The test sample shall consist of aggregate, the whole of which passes a 12.5 mm IS sieve and is retained on 10 mm IS sieve. The sample shall be dried in an oven for a period of four hours at temperature of 100 – 110°C and cooled.
- b) A cylindrical metal mould of 75 mm diameter and depth of 50 mm shall be filled about 1/3 full with the aggregate and tamped with 25 strokes of round tamping rod. The mould shall be filled up to top in stages in same manner. Net weight of aggregate in the mould shall be determined
- c) The impact machine shall rest without any packing on a level platform. Cylindrical steel cup in the machine shall be fixed firmly in position on the base of machine and the whole of the test sample is placed in it and compacted by a single tamping of 25 strokes. Hammer of the machine shall be raised until its lower face is 38 mm above the upper surface of aggregate in the cup. The hammer is allowed to fall freely on the aggregates. The test sample shall be subjected to a total of 15 such blows, each at an interval of one second or more. The crushed aggregate shall then be removed from the cup and whole of it sieved on 2.36 mm IS sieve until no further amount passes through it in one minute. The weight of fractions passing the sieve (B) and retained on it (C) shall be determined to an accuracy of 0.1 gm. In case weight (B+C) is less than (A) by more than one gram, result shall be discarded, and a fresh test is made. Two tests shall be made.

$$\text{Aggregate impact value (AIV)} = B/A \times 100$$

- d) The mean of two results shall be reported to the nearest whole number.

2.4.2.3.6 WATER ABSORPTION

- a) A sample of not less than 2000 gm of aggregate shall be tested. Two tests shall be made. Two samples should not be tested concurrently.
- b) The sample shall be washed to remove all fine particles and dust, drained and then placed in a wire basket and immersed in distilled water at a temperature 22 – 32°C with a cover of at least 5 cms of water over top of basket. The entrapped air shall be removed from the sample by lifting the basket containing it 25 mm above the base of the tank and allowing it drop 25 times at a rate one drop per second. The basket and aggregate shall remain completely immersed during the operation and for a period of 24 ± 0.5 hours after words. The basket and the sample shall then be lifted and weighed in water (A1). Basket and the aggregate shall then be removed from water, drained and the aggregate shall be gently emptied from the basket on a dry cloth. Empty basket shall be returned to water and weight (A2). The aggregate placed on dry cloth shall be gently surface drained and spread out not more than 1 stone deep on a dry cloth. The aggregate is completely surface dried by keeping it in sunlight for 10 minutes and is weighed (B). The aggregate shall then be placed in oven in a shallow tray at a temperature of 100 – 110°C for 24 ± 05 hours. It will then be removed from oven, cooled in an airtight container and weighed (C).

$$\text{Water absorption (\% of dry weight)} = \frac{100(B-C)}{C}$$

- c) The individual and mean results, along with size of aggregate shall be reported.

2.4.2.3.7 STORAGE:

- a) The aggregate shall be stacked in such a way as to prevent intrusion of any foreign materials such as soil, rubbish, vegetation etc. Heaps of fine and coarse aggregates shall be kept separate. When different sizes of fine and coarse aggregates are procured separately, they shall be stored in stockpiles so that they do not get intermixed. The aggregates shall be stock piled near to mixer site/B & M plant to minimize re-handling. The aggregate shall be placed on a dry hard patch of ground if available otherwise a plat- form or plane galvanized iron sheet or a floor of dry bricks shall be prepared. If the coarse aggregate is stored on normal ground, it is advisable not to use the bottom 20cm layer of the aggregate.

2.4.2.4 WATER

2.4.2.4.1 WATER FOR MIXING

- a) The water used for mixing of concrete and cement/sand mortar shall be free from any injurious amounts of deleterious materials. The waters containing any sugar, excess of acid, alkali or salt shall not be used. The pH value of water should be between 6 and 8. The tests for determination of solid contents shall be conducted and potable water is generally considered fit for mixing concrete and preparation of mortar

Limits of permissible impurities

Type of Impurity	Permissible Limits (By weight)
Organic	0.02%
Inorganic	0.30%
Sulphates	0.05%
Alkali Chlorides	0.10%

2.4.2.4.2 CURING WATER

- a) The use of water in curing is intended to penetrate the concrete/ mortar. The water should not produce any unsightly deposit or objectionable stain on the surface. Even very low concentration of iron and organic matter can cause staining on the surface. The presence of tannic acid or iron compounds are objectionable in curing water. In case of doubt about the suitability of water particularly in remote areas or where water is taken from sources, not normally utilized for domestic purposes, water should be tested before use.

2.4.3 CAST-IN-SITU CONCRETE LINING

2.4.3.1 GENERAL

Concrete for lining works shall be of grade M20 (1:1.5:3) mix, using well graded aggregate with maximum size of aggregate of 20 mm.

2.4.3.2 BATCHING AND MIXING

A good concrete requires the use of specified qualities and proportions of ingredients, methods of mixing, manner of laying green concrete in position compaction and curing.

2.4.3.2.1 PROPORTIONING OF CONCRETE

- a) The cement concrete shall be composed of cement, fine aggregate, coarse aggregate, water and admixture if considered necessary by the Engineer in Charge.
- b) The determination of proportion of cement, aggregates and water to attain the required compressive strength shall be made as under:
 - By designing the concrete mix (Design mix concrete)
 - By adopting nominal concrete mix (Nominal mix concrete). It involves higher cement contents.
- c) The design mix shall be done only for specified materials to be procured for works at site as per specifications and shall be approved by Engineer-in-Charge.
- d) The mix design done earlier, but not prior to one year, may be considered adequate for works provided there is no change in source and quality of materials.
- e) The Design mix concrete shall be preferred to nominal mix. If design mix concrete cannot be used or the quantity of concrete is small, nominal mix concrete of grade not higher than M20 may be used with permission of Engineer-in-Charge.
- f) Temperature control of concrete has to be kept in view in extreme weather conditions, Concreting shall not be done when atmospheric temperature falls below 4.5°C or rises above 40°C.

- g) The various ingredients of different nominal concrete mixes for one cement bag of 50 kg shall be as under (For guidance only).

Ingredients of Concrete	Quantity of ingredients required for concrete					
	Nominal Aggregate Size 20 mm			Nominal aggregate size 40 mm		
	M-10 (1:3:6)	M-15 (1:2:4)	M-20 (1:1.5:3)	M-10 (1:3:6)	M15 (1:2:4)	M-20 (1:1.5:3)
Weight of Coarse Aggregate	320 Kg	220 Kg	165 Kg	345 Kg	235 Kg	180 Kg
Weight of Fine Aggregate	160 Kg	110 Kg	85 Kg	135 Kg	95 Kg	70 Kg
Quantity of Water	34 Lt	32 Lt	30 Lt	34 Lt	32 Lt	30 Lt

- h) The cement Contents of above nominal mixes shall be proportionally increased if quantity of water in the mix is to be increased to facilitate placement and compaction of concrete so that specified water cement ratio is maintained.
- i) The cement level to be used in various design concrete mixes will be as under:

Grade of Concrete	Cement Level (Kg/M ³ of concrete) with Coarse Aggregate of nominal size	
	40 mm (A40)	20 mm(A20)
M10	207	221
M15	259	288
M20	329	366

In case of mix design:

- The quantity of cement in M15, M20, M25 & M30 concrete as calculated by Mix Design should not be less as indicated in the bill of quantities.
- If actual cement quantity, as warranted by mix design in any case, is lesser than that given in table, cost of less cement used will be deducted from the bills.

2.4.3.2.2 BATCHING

- a) Smallest practical number of concrete mixers shall be used on a work to avoid error in batching.
- b) The contractor shall provide all necessary equipment and plant to determine and control the actual amount of materials entering into each batch. The coarse and fine aggregates, water and cement shall be batched and measured by weight. Specified air entraining agent/water proofing compound, if any, shall be measured by weight and added separately to the mix, as directed by Engineer-in-charge.
- c) The weigh batchers should be capable of weighting, controlling and determining accurately the prescribed quantity of various materials for each batch of mix.

2.4.3.2.3 BATCHING PLANTS AND EQUIPMENT

- a) Hoppers for weighing cement, mineral admixtures, aggregates and water and chemical admixture (if measured by mass) shall consist of suitable containers freely suspended from a scale or other suitable load measuring device and equipped with a suitable discharging mechanism. The method of control of the loading mechanism shall be such that, as the quantity required in the weighing hopper is approached, the material may be added at a controllable rate and shut off precisely within the weighing tolerances. The weighing hoppers for cement, mineral admixtures aggregate shall be capable of receiving their rated load, without the weighed material coming into contact with the loading mechanism. Where the rated capacity of a batching plant mixing cycle is less than 2.0 m³, additional precautions shall be taken to ensure that the correct numbers of batches are loaded into the transit mixer. The weighing hoppers shall be constructed so as to discharge efficiently and prevent the build up of materials. A tare adjustment, up to 10 percent of the nominal capacity of the weigh scale, shall be provided on the weighing mechanism so that the scale can be adjusted to zero at least once each day. Dust seals shall be provided on cement hoppers between the loading mechanism and the weigh hopper and shall be fitted so as to prevent the emission of cement dust and not to affect weighing accuracy. The hopper shall be vented to permit escape of air without emission of cement dust.
- b) Vibrators or other attachments, where fitted, shall not affect the accuracy of weighing. There shall be sufficient protection to cement and aggregate weigh hoppers and weighing mechanisms to prevent interference with weighing accuracy by weather conditions or external build-up of materials.
- c) Where chemical admixture dispensers are used, they shall be capable of measurement within the tolerances and a calibrated container or weigh scales shall be provided to check the accuracy of measurement at least once a month.
- d) Where a continuous mixer with ribbon loading is used, the batching procedure specified by the manufacturer of the plant shall be followed.
- e) Each control on the batching console and weigh-dial or display shall be clearly labelled with its function and where concerned with the batching of materials, the material type.
- f) When more than one type or grade of cement is being used, the weighing device and discharge screw or other parts of the transfer system shall be empty before changing from one type of cement to another.
- g) When pulverized fuel ash and other mineral admixture are batched through the cement weigh system, the weighing device and discharge screw or other parts of the transfer system shall be empty when the weighing system has returned to zero reading or completed the batch.

- h) Where a back weigh system is utilized to weigh materials a system shall be in place so as to prevent materials being loaded during the process of weighing.

2.4.3.2.4 WATER CEMENT RATIO

- a) The strength of concrete is inversely proportional to water cement ratio. More water cement ratio will reduce the strength and durability of concrete.
- b) Water cement ratio determines the porosity of concrete. More water cement ratio will mean more porous concrete.
- c) For proper chemical Actions, the quantity of water required is only 25% of the weight of cement used. Additional water is added only to increase the workability of concrete.
- d) The water cement ration in concrete is kept between 0.4 to 0.6 depending upon adequate workability for placement of concrete and for adequate compaction.
- e) The quantum of moisture present in fine and coarse aggregate is adjusted while adding extra water for concrete mix.

2.4.3.3 MIXING

2.4.3.3.1 STATIONARY MIXER

- a) Mixing shall be done in Mechanical mixer. Mixing by hand shall not be allowed.
- b) Fine and coarse aggregate, before use, shall be washed with water to remove dirt, dust or any other material.
- c) Suitable mixers, 'preferably tilting type with hopper' and of adequate capacity to handle desired quantity of ingredients should be used to mix uniformly and discharging the prepared mix without segregation.
- d) The mixer drum shall be flushed clean with water. Measured quantity of dry coarse and fine aggregates shall be placed first in the rotating drum of mixer and mixed through. This shall be followed by mixing of measured quantity of cement (This process is to be followed only in case hopper type mixer is not available & that too with specific approval of Engineer-in-charge).
- e) The dry material shall be mixed for at least 4 turns of the drum after which measured quantity of water shall be added gradually while the drum is in motion to ensure even distribution with dry materials. The total quantity of water to be mixed for achieving the specified water cement ratio shall be added before $\frac{1}{4}$ mixing time has elapsed.
- f) The material shall be mixed for a period not less than 2 minutes (about 25 turns of drum) and until a uniform color and consistency of concrete are obtained. The time shall be counted from the moments all the materials have been put into the drum.
- g) The complete contents of the mixed concrete shall be emptied before recharging. When the mixer is closed down for the day or for any interval longer than 20 minutes, the drum shall be flushed clean.

2.4.3.4 TRANSIT MIXER

- a) When a transit mixer is used for the partial or complete mixing of concrete, mixing shall be considered to commence from the moment when all the materials required for the batch, including water, are in the rotating drum of the mixer.
- b) Transit mixers or agitators shall not be loaded in excess of the manufacturer's rated capacity. In order to produce a satisfactory mix, and where there is no data available to establish different period and speed of revolutions, mixing shall continue for not less than 60 revolutions of the transit mixer drum at a rate of not less than 7 revolutions/rein. All completely truck mixed concrete shall be visually inspected for uniformity prior to leaving the plant.
- c) When a transit mixer or agitator is used for transporting concrete which has been mixed before leaving the plant, the concrete shall be agitated during transit and re-mixed at the site for at least 2 min so that the concrete is of the required uniformity.
- d) Where water is added to the concrete in the transit mixer through the transit mixer water meter and when such water is being accounted for in the total water within the mix, it shall be ensured that the transit mixer water meter is in operational condition and properly calibrated. Where a water meter is not available, water must be measured in a suitable container before being added to the transit mixer.

2.4.3.5 WORKABILITY

- a) For workability, minimum slump required for concrete to be compacted by vibrator shall be 25-75 mm depending upon size of aggregate, thickness of member, quantum and spacing of reinforcement etc.
- b) For profile bed bars, slump of concrete shall be 25 mm.

2.4.3.6 PREPARATION OF SURFACE

- a) In concreting over previously laid concrete, old surface shall be roughened by thoroughly cleaning it of all the loose material, unsound concrete and cement slurry etc. using a wire brush or air/water jet and then slightly wetting the surface. To top surface of aggregate must be exposed.
- b) In case of foundation concrete, the prepared earth surface at the bottom, a 2 cm layer of 1:4 cement/sand mortar or a polythene sheet of appropriate thickness or tar paper may be placed to avoid loss of moisture of concrete by underneath earth bed.

2.4.3.7 CONCRETE PLACEMENT

- a) The concrete shall be deposited as near as practicable to its location of placement to avoid any re-handling.
- b) Before depositing the concrete, mortar of same ratio of concrete shall be laid on the forms, old foundation or old concrete surface.
- c) The entire concrete to be used in work shall be laid gently (not thrown) to avoid segregation. The maximum permissible freefall of concrete shall be restricted to 1.5 m. The chutes may be used for more heights.
- d) The concrete shall be placed and compacted before initial setting of concrete commences and not be disturbed subsequently.
- e) The whole quantity of prepared concrete shall be used preferably within 30 minutes of its mixing but not later than initial setting time.
- f) Placement shall be done in layers not exceeding 50 cm in thickness. This thickness may vary (lower) as per direction of SWIM QA Engineer-in-Charge and type of vibrator used.

- g) In slabs, the concrete shall be placed in direction of Span.
- h) The concreting shall be discontinued when the temperatures fall below 4.5°C or rise above 40°C.

2.4.3.8 COMPACTION

- a) The concrete shall be thoroughly compacted by using mechanical vibrators till a dense concrete is obtained. Concrete shall be fully worked by vibrators around reinforcement, any embedded fixtures and into the corners of the form work.
- b) Fresh Concrete shall be vibrated near all construction joints so that mortar of fresh concrete flows between large aggregates and develop proper bond with old concrete.
- c) Care should be taken, while placing and vibrating concrete to avoid any displacement of reinforcement or movement of form work or fixtures.
- d) Over or under vibration of concrete are harmful and should be avoided over vibration causes segregation of cement slurry resulting in its deposition on concrete surface. Under vibration causes honey combing.
- e) Suitable type of mechanical or electrical vibrators shall be used for compaction. Plate type vibrators will be used for small thickness of concrete such as in wearing coat over deck slab. Needle vibrators will be used where depth of concretes is more than 20 cm.
- f) At the end of compaction the needle vibrators shall be withdrawn out of compacted concrete gradually and not suddenly so that no hollow is left in concrete.
- g) One spare vibrator and two spare needles shall be placed at site while concreting is in progress.

2.4.3.9 CURING

- a) Curing is the process of preventing the loss of moisture from concrete and promoting the hydration of cement while preventing high temperature gradient within concrete.
- b) The concrete is kept saturated or as nearly saturated as possible until the originally water filled space in fresh cement paste has been occupied by the products of hydration of cement.
- c) Hydration of cement can take place only in presence of water. Thus loss of water by evaporation shall be prevented. Permeability is reduced and durability and strength of concrete is increased by curing.
- d) After 6 hours of laying of concrete, the surface shall be suitable protected with moist gunny bags or by any other methodology against quick drying for 24 hours. The surface shall then be cured by flooding it with water in a minimum depth of 25 mm. The curing shall be done for a minimum period of 14 days.
- e) Curing is best done with water. In case of any difficulty due to water availability, curing compounds may be used with approval of Engineer-in Charge. Curing by curing compounds may be suitable particularly for section profiles. Cost of curing compound shall be borne by the contractor.

2.4.3.9 JOINTS

In canal lining contraction joints shall be provided to accommodate expansion and contraction of the concrete or to provide continuity between the breaks in construction work. Joints shall be provided as shown on the drawings or as directed by Engineer-in-charge.

2.4.3.9.1 CONSTRUCTION JOINTS

- a) When concreting is to be done in lifts, proper shear keys should be provided while concreting in the top surface of previous lift to ensure proper bond.
- b) Concreting shall be done continuously in a slab or a footing. In case the concrete has to be discontinued due to some reason for some time, a construction joint shall be provided as directed by Engineer-in-charge. Such joints shall be minimum as far as possible.
- c) Construction joints shall be provided at accessible location to permit cleaning of laitance, cement slurry and unsound concrete by using wire brush on the surface of joint. This shall be done immediately after initial setting of concrete.
- d) In case of construction joints at locations where previous concrete has been cast against shattering, the concrete surface is roughened by exposing the aggregate with a high pressure water jet.
- e) Fresh concrete shall be brushed and air water jet shall be applied to expose the top surface of aggregate so that bonding with fresh concrete shall be good and leak proof.

2.4.3.9.2 CONTRACTION JOINTS

Contraction joints shall be provided and treated as show in the drawings or as directed by the engineer. Longitudinal contraction joints shall be provided in center of the bed. The shape, spacing and dimensioning of contraction joints shall be as shown in the drawing, broadly, the joints shall extend to 1/3 of lining thickness (viz 2.5 cm for 7.5 cm thick lining) with a top width of 12mm maximum and tapering to 9mm to join a 45° groove at bottom. The contractor must ensure that the grooves are of specified dimensions, acceptable to the SWIM QA Engineer in Charge. After casting of strips, thermal sheet shall be placed in the joint to protect the edges and check the filling of joint by waste material. When the joints have to be filled by the filler material these sheets will be removed and joints shall be clean by applying air water jet, air jet etc. Before filling the joint, joint must be well cleaned and dried. So bituminous primer and other filling material stick to the concrete.

2.4.3.9.3 FILLING OF JOINTS

Filling of joints shall be taken up only after a minimum of 28 days setting period of CC lining. The grooves shall be cleaned thoroughly to their full depth and width by brush, air jet, water jet etc. All loose particles and foreign matter shall be removed, and the grooves shall be thoroughly clean and dry to the satisfaction of Engineer in Charge or his representative so as to ensure good adhesion to the sealant. The primer shall then be applied by means of brush or any other suitable applicator to cover the sides completely before the application of sealing compound mix. Primer shall be as per IS code 3384-1986.

2.4.3.9.4 COMPOSITION

The mastic used should be composed of

Very fine sand - 60% by wt;

Suitable grade of Asphalts - 30% by wt;

Cement - 8 % by wt;

Chopped hemp - 2% by wt;

The sand should be heated in a large flat pan to a temperature of 400 F. The binder should be heated separately, in a suitable container, to a temperature of about 3600 F. The requisite quantity of binder should then be added to the heated sand and thoroughly stirred. The weighed quantities of cement and chopped hemp are to be added again mixed thoroughly and mixture should be immediately poured in to moulds before it has time to cool appreciably

2.4.3.10 SAMPLING & TESTING

- a) The samples of fresh concrete shall be taken, cubes are made, cured and tested at 28 days
- b) In order to get a relativity quicker idea of the quality of concrete, compressive strength tests at 7 days may be carried out in addition to 28 days compressive strength test.
- c) In all cases, the 28 days compressive strength shall alone be the criterion for acceptance/rejection of the concrete.
- d) The sampling should be spread over the entire period of concreting and cover all mixes.
- e) The minimum frequency of sampling of concrete of each grade shall be

Quantity of concrete in work (M ³)	Number of samples
1-5	1
5-15	2
15-30	3
30-50	4
51 and above	4 plus one additional sample for each additional 50m ³ or part there of

- f) Three test specimens shall be made for each sample for testing at 28 days.
- g) The test results of the sample shall be the average of the strengths of three specimens. The individual variation should not be more than ± 15 percent of the average. If more, the test results are invalid.

2.4.3.10.1 CASTING OF CUBES

The concrete cubes are to be cast in the following manner:

- a) The cube moulds should be cleaned and well-oiled/or greasing from all sides.
- b) The cube moulds should be placed on smooth surface before casting and should be free from vibration.
- c) The cube moulds shall be filled in three layers, each layer tamped with 25 strokes of standard tampers.
- d) After filling and rodding of final layer the excess concrete should be removed by tamping bar by applying rubbing.
- e) The cubes will be finished by trowel after 30 minutes from casting.
- f) After 20 hours of casting of cubes, identification marks, dates etc. be written on the upper portion of cubes.
- g) The cubes shall be de-moulded within 22-24 hours from the time of mixing water in the ingredients.

2.4.3.10.2 CURING OF CUBES

- a) After demolding of cubes from cube moulds, the cubes shall be transferred in the curing tank for curing at various ages.
- b) The water for curing shall be potable. The curing temperature of water shall be $27 \pm 2^{\circ}\text{C}$.
- c) The water of curing tank should be changed once in a week.

2.4.3.10.3 TESTING OF CUBES

As soon as the curing of cubes is complete, the testing of cubes will be done in the following manner

- a) Cubes should be tested in a moist condition.
- b) Cubes shall be tested at right angle to the direction in which they are filled.
- c) The rate of application of load is usually $14\text{N/mm}^2/\text{min}$.

2.4.3.10.4 ACCEPTANCE CRITERIA

Compressive Strength: The concrete shall be deemed to comply with the strength requirements when both the following conditions are met:

- a) The mean strength determined from any group of four consecutive test results complies with the appropriate limit in column 2 of Table below.
- b) Any individual test result complies with the appropriate limit in col 3 of Table below.

Characteristics Compressive Strength Compliance Requirement

Specified Grade	Mean of the Group of 4 Non-Overlapping Consecutive Test Results in N/mm ²	Individual Test Results in N/mm ²
M 15	$f_{ck} + 0.825 \times \text{established standard deviation (rounded to nearest 0.5 N/mm}^2\text{) or } f_{ck} + 3 \text{ N/mm}^2$, which is greater.	$f_{ck} - 4 \text{ N/mm}^2$ Where f_{ck} - characteristic cube compressive strength of concrete
M 20 or above	$f_{ck} + 0.825 \times \text{established standard deviation (rounded to nearest 0.5 N/mm}^2\text{) or } f_{ck} + 4 \text{ N/mm}^2$, which is greater	$f_{ck} - 4 \text{ N/mm}^2$ Where f_{ck} - characteristic cube compressive strength of concrete

NOTE – In the absence of the established value of standard deviation, the values given in IS: 456 may be assumed, and attempt should be made to obtain results of 30 samples as early as possible to establish the value of standard deviation.

Grade of concrete	Assumed standard Deviation
M 10 } M 15 }	3.5N/mm ²
M 20	4.0 N/mm ²

2.4.3.10.5 TEST AND THEIR FREQUENCY:

The various tests and their frequencies for concrete work shall be carried out as per following Table

S.N	Name of Test	Frequency	Purpose
1			
	Sieve analysis	One test for every 150m ³ or less	To know the gradation
	Specific gravity, bulk density, moisture content and absorption	- do -	To assess the suitability of aggregate and to utilized data for mix design
	Soundness (Sodium sulphate method)	- do -	To assess the quality of materials
	Abrasion, impact & crushing method	- do -	- do -
	Organic impurities		
	Petrographic Properties	Twice in one season	To know the extent of deleterious material & silt content
2			
	Sieve analysis	One test for every 150 m ³ of sand used in concrete	To know grain size and fineness modulus of sand
	Unit weight and	-do-	To know suitability of

	Bulkage		sand and to utilize data for mix design
	Specific gravity, moisture content	-do-	To utilize data for mix design
3			
	Fineness test	One test for each brand of cement used during the working season, preferably at 3 months interval	To know the quality of cement used in construction
	Normal consistency	-do-	-do-
	Setting time	-do-	-do-
	Soundness	-do-	-do-
	Compressive Strength	-do-	-do-
	Chemical analysis	-do-	-do-
4			
	Slump test	One test in each shift or at frequent intervals to check workability	To check workability of Concrete/water cement ration.
	Compressive Strength	Refer sampling & strength or designed mix concrete	To know the strength of Concrete

2.4.3.11 MEASUREMENT AND PAYMENT:

- a) Measurement of concrete will be made only to the neat lines of the structures as indicated on the drawing or as established by the Engineer-in-charge. Dimensions shall be measured nearest to 1 cm. The areas shall be worked out to nearest 0.01 square meter. The cubic contents shall be worked out to nearest 0.01 cubic meter. The rate shall include the cost of all materials, labour, necessary tools & plants involved in above operations. This shall also include laying, compaction and curing but excluding centering & shuttering.

2.5 PLAIN AND REINFORCED CONCRETE FOR CANAL STRUCTURES

The specification covers the requirements of plain and reinforced concrete for use in various components of canal structures. The work covered under this section consists of furnishing all materials including formwork, equipment, labour for the manufacture, transport, placing, vibrating, finishing and curing of the concrete for the structures and performing all the operations necessary and ancillary thereto including dewatering and desilting etc., as required. For the reinforced concrete structures, granite, quartzite, dolerite or trap shall only be used as coarse aggregate.

2.5.1 COMPOSITION

(a) Concrete shall be composed of cement, fine aggregate (natural sand or manufactured sand or both), coarse aggregates (manufactured or natural gravel) admixtures and water, well mixed in proportion and brought to the proper consistency. The design mix proportions shall be adjusted to produce a durable and workable concrete, suitable for specified conditions of placements and design strength.

(b) For all items of concrete in any portion of the structure or its associated works, controlled concrete shall be used where specified.

(c) Controlled concrete shall be used for the canal structures in two grades designated as M-20 (1:1.5:3) for plain cement concrete (PCC) and M-25 (1:1:2) for reinforced cement concrete (RCC). The mix shall be designed using representative samples of available coarse and fine aggregate as well as cement and water to achieve the required workability strength and durability standards.

2.5.2 MATERIALS

2.5.2.1 CEMENT

(a) Only ordinary Portland cement shall be used for R.C.C. constructions conforming to ASTM C150

(b) Immediately, upon receipt at the site of the work, cement shall be stored separately in dry, watertight and properly ventilated structures. All storage facilities shall be subject to approval and shall be such as to permit easy access for inspection and identification. Sufficient cement shall be kept in stock for completion of concreting undertaken. Cement shall be used in order of receipt and cement older than 90 days shall not be used unless the test results satisfy the minimum strength requirements. The provision made in para 2.4.2.1 shall also apply.

2.5.2.2 FINE AGGREGATES

The provisions made under para 2.4.2.2 shall apply.

2.5.2.3 COARSE AGGREGATES.

(a) coarse aggregates shall consist of hard, strong, durable particles of crushed stone or gravel and shall be free from thin elongated soft pieces, organic or other deleterious matter. It shall have no adherent coating. It shall be from a source, approved by the Engineer-in-charge.

(b) Coarse aggregates shall be washed if necessary, to remove all vegetations and other perishable substances and objectionable amounts of other foreign matter. The cost of washing and screening shall be borne by the contractor.

(c) Following table gives an indication of the maximum size of coarse aggregate for the different items of work. However maximum size of coarse aggregate shall be adopted as indicated on the drawings

:

Sl. No. Item of work

Maximum Nominal size
of coarse Aggregate (MSA)

(i)	Foundation floor and gravity retaining walls (mass concrete)	40 mm / 80 mm
(ii)	R.C.C. Rafts, piers, Abutments Barrels, cutoff walls, Breast walls Staunching rings etc.	40 mm
(iii)	R.C.C. work in main and cross girders, Deck slab, wearing coat, kerb, parapet walls, approach slab, pier caps, diaphragm wall and other thin walled members and in zones of congestion	20 mm

(d) For heavily reinforced concrete members, as in the case of ribs of main beams, maximum size of aggregate shall usually be restricted to 5 mm. less than the minimum lateral cellular distance between the main bars or 5 mm less than the minimum cover to the reinforcement, whichever is smaller. However, if required under special circumstance, the Engineer may permit an aggregate of maximum size 25% more than this/critical spacing / cover, provided that proper vibration is ensured. The other provision of section

2.5.2.4 REINFORCEMENT STEEL

The provisions of **SECTION – 2.6** shall apply.

2.5.2.5 WATER

The provision of para **3.5.4** shall apply.

2.5.3 STRENGTH REQUIREMENT OF CONCRETE

The compressive strength requirement for the various grades of controlled concrete shall be as per Table given below :

Grade of concrete	Compressive test strength in N/Sq mm of 150 mm cube conducted	
	Min. at 7 days	Min. at 28 days
M-10	7	10
M-15	10	15
M-20	13.5	20

Note : in all cases, the 28 days compressive strength specified in table shall alone be the criteria for acceptance or rejection of the concrete on the basis of its strength. Where the strength of a concrete mix as indicated by tests lies in between the strength for the two grades specified in table, such concrete shall be classified for all purpose as concrete belonging to the lower of the two grades between which its strength lies.

2.5.4 PROPORTIONING CONCRETE

(a) Concrete mix of M25 grade (1:1.2) shall be designed on the basis of preliminary test. The proportion of ingredients shall be such that concrete has adequate workability for conditions prevailing on the work in question and can be properly compacted with the means available. Samples of construction material required for evolving design mix shall be supplied 3 months in advance.

(b) Unless it can be shown to the satisfaction of the Engineer-in-charge that supply of properly graded aggregates of uniform quality can be maintained till the completion of the work, grading of aggregate shall be controlled by obtaining the coarse aggregate in different sizes and blending them in the right proportions as required. Different sizes shall be stacked in separate stockpiles. Required quantity of materials shall be stock piled at least 3 days in advance before use. Grading of coarse and fine aggregates shall be checked as frequently as possible, frequency for a given job being determined by the Engineer-in-charge to ensure that the supplies are maintaining the uniform grading as approved for samples used in the preliminary tests. In proportioning concrete the quantity of both cement and aggregate shall be determined by weight. Water shall either be measured by volume in calibrated tank or weighed. All measuring equipment shall be maintained in a clean serviceable condition. Their accuracy shall be periodically checked.

(c) It is most important to maintain the specified water cement ratio. To this end, moisture content in both fine and coarse aggregates shall be periodically determined and the amount of mixing water shall be adjusted to compensate for any variations in the moisture content. Suitable adjustment shall also be made in the batched weight of the aggregate depending upon the variations in their moisture content.

(e) Actual cement level required for the aggregates to be used shall be determined by Laboratory tests. The mix proportions shall be selected to ensure that the workability of the fresh concrete is suitable for the conditions of handling and placing, so that after compaction it surrounds all reinforcements and completely fills the formwork. When concrete is hardened, it shall have the required strength, durability and surface finish.

(f) The quantity of water shall be just sufficient to produce a dense concrete of required workability and strength for the job. An accurate and strict control shall be kept on the quantity of water.

(g) In case of reinforced concrete work, workability shall be such that the concrete surrounds and properly grips all reinforcement. The degree of consistency, which shall depend upon the nature of work and methods of vibration of concrete, shall be controlled by regular slump tests. Following slumps shall be adopted for different types of works :

	Type of work	Slump Allowed
i.	Mass concrete for RCC foundations, footing and retaining walls	40 mm to 50 mm
ii.	Beams, slabs and columns	40 mm. to 50 mm.
iii.	Thin RCC section with congested steel	50 mm. to 60 mm.

2.5.5 PRODUCTION OF CONCRETE

2.5.5.1 PRODUCTION OF AGGREGATES

- a) Production of aggregates may include quarrying of the raw material and processing viz. transporting, crushing, screening and washing. Water used for washing aggregates shall be clean and free from alkali, salts and other impurities. After washing, fine aggregates must be stored in stock piles with a free draining base for at least 3 days to ensure that sand, delivered to the batching plant will have a reasonably uniform moisture content. The storage and handling shall be in such a manner as to prevent intermingling of various sizes of aggregates required separately for grading purposes. No foreign matter shall be allowed to mix with aggregate.

2.5.5.2 BATCHING

- a) The prescribed amount of the various materials of concrete, including water, cement, admixtures the groupings of fine aggregates and each individual size of coarse aggregates shall be measured and controlled within the specified limits of accuracy. The amount of water, cement and aggregates shall be determined by weighing. In the case of coarse aggregates, percentage of free water shall be determined by weighting representative sample, then surface drying each particle individually with a clean piece of cloth and reweighing.
- b) The batching equipment shall be constructed and operated so that the combined inaccuracies in feeding and measuring the materials shall not exceed 1% for water and cement and 2% for each size of aggregate.
- c) The operating performance of each scale or other measuring device shall be checked by test weight and the test shall cover the ranges of measurements involved in the batching operations. Tests of equipment in operation shall be made at least once every fortnight and adjustment, repairs or replacement, be made as necessary to meet the specified requirements for accuracy of measurement.
- d) Aggregate shall not be batched for concrete or mortar when free water is dripping from the aggregate.
- e) In case uniformity in the materials used for concrete has been established over a period of time, proportioning may be done by volume batching, provided periodical checks are made on mass / volume relationship of the material. When weighing is not practicable, quantities of fine and coarse aggregate (not cement) may be determined by volume.

2.5.5.3 MIXING

- a) The concrete ingredients shall be mixed thoroughly in batch mixers of satisfactory type and size, which are so designed as to ensure uniform distribution of all the constituent materials throughout the mass at the end of mixing period. The plant shall be so designed and operated that all materials entering the mixer can be accurately proportioned and readily controlled. The entire batch within the mixer shall be discharged before re-charging. The volume of mixed materials per batch shall not exceed the rated capacity. A mixer will be considered unsatisfactory, if from three tests of any one batch, a range in slump exceeding 25 mm or a range in air content exceeding one percent is noticed between representative samples taken at different portions of the mixer discharge.
- b) For any one batch, uniformity of fresh concrete weight of air free mortar of two samples one taken at the front and one at the end of the mixer discharges, when determined in accordance with the

provisions of the mixer performance test, designation 26 in the appendix of the seventh edition of the United States Bureau of Reclamation concrete manual, shall not exceed 1.6 percent of the mean value. Excessive variation on the unit weight of air free mortar indicates that mixing time should be increased. Mixer efficiency test shall be made at the start of a job and at such intervals as may be necessary to ensure compliance with the requirements for effective mixing. The minimum mixing time specified herein may be reduced if mixer efficiency test conform that the reduced time permits satisfactory mixing.

- c) The first concrete batch at the start of continuous mixing operation or after a lapse of 30 minutes in continuous mixing operation shall be made richer by the addition of extra cement as directed.
- d) For any one batch, the difference between the unit weight of coarse aggregate from concrete samples from the front and end of the mixer or mixer discharge, when determined in accordance with the above-mentioned mixer performance test shall not exceed 10% of the mean value.
- e) The actual time of mixing shall be checked at least twice during each shift and in the case of central batching plant where the timing device is provided, the same shall be adjusted if there is error. The timing device shall be so interlocked with the discharge gate of the batch hopper that timing does not start until the discharge gate is fully closed and all ingredients are in the drum. A suitable record shall be kept of the average time consumed in charging, mixing and discharging a batch during each run.
- f) The full contents of the drum shall be discharged quickly to avoid segregation.
- g) The minimum periods specified are conditional on the materials being fed into the mixer in a manner which will facilitate efficient mixing and an operation of the mixer at its designed speed. The following sequence of charging the mixer may be adopted.
- h) Five to ten percent of the total quantity of water required for mixing adequate to wet the drum thoroughly, shall be introduced before the other ingredients in order to prevent any caulking of the cement on the blades or sides of the mixer.
- i) All dry ingredients (cement and the fine and coarse aggregate) shall be simultaneously fed into the mixer in such a manner that the period of flow for each ingredient is about the same. Eighty to ninety percent of the total quantity of water required for mixing shall be added uniformly along with the dry ingredients.
- j) The remaining quantity of water shall be added after all the other ingredients are in the mixer.
- k) Portion of the coarse aggregate, however, may be added last. This will facilitate clearance of the chutes and removes any fine aggregates or cement adhering to the sides.
- l) Excessive mixing, requiring additions of water to preserve the required concrete consistency will not be permitted.
- m) When the mixer is stopped, before placing again any ingredients in the mixer, all hardened concrete or mortar shall be removed from the inner surface of the mixer.
- n) The tampering of partially hardened concrete or mortar requiring renewed mixing with or without the addition of cement aggregate or water shall not be permitted.

2.5.6 TEMPERATURE OF CONCRETE AND WEATHER CONDITIONS

- a) The temperature of concrete at the time of placement shall not exceed 35degree C. concreting operations shall be temporarily suspended during excessively hot weather when their temperature inside the form exceeds 45degree C. or when conditions are such that the concrete cannot be placed at the required temperature. Wherever necessary, exposed surfaces of fresh or green concrete shall be adequately shaded from the direct rays of the

sun and protected against premature setting or drying by curing under continuous fine spray of water.

2.5.7 TRANSPORTING OF CONCRETE

- a) Concrete shall be transported from the mixing plant to the placing position as rapidly as practicable by methods that will prevent segregation or loss of ingredients, or slump loss in excess of 25 mm and or a loss in air content of more than one percent before the concrete is placed in the works. Whenever the length of haul, from the mixing plant to the place of deposit is such that the concrete unduly compacts or segregates, suitable agitators or transit mixers shall be used for conveying concrete.
- b) Where the tie of haul exceeds 20 minutes, mixed concrete shall be transported in suitable agitators or transit mixers as stated herein above.
- c) If buckets are used for conveying low-slump concrete, they shall be capable of promoting discharge in controlled quantities without splashing or segregation and shall be of such capacity that there is no splitting of batches in loading buckets. Buckets shall be of the bottom dump type permitting an even, controlled flow into the forms or hopper without undue splashing or segregation. Conveying vehicles shall be designed to facilitate uniform delivery rather than quick dumping.
- d) Chutes used for conveying concrete shall be of such size and shape as to ensure a steady uniform flow of concrete in a compact mass without separation or loss of ingredients and shall be protected from wind and sun where necessary to prevent loss of slump by evaporation and shall be furnished with a discharge hopper. Free fall or drop of concrete shall be limited to 150 cms. Chute sections shall be made of or lined with metal and all runs shall have approximately the same slopes not flatter than 1 vertical to 2.5 horizontal. The required consistency of concrete shall not be changed in order to facilitate chuting. Where it becomes necessary to change the consistency, the concrete mix shall be completely redesigned. Wherever there is free fall within the conveying system, suitable baffle plates, splash board, or down spouts shall be provided to prevent segregation, splashing or loss of ingredients. Whenever it is necessary to hold the discharge end of a chute more than 3 meters above the level of the fresh concrete, a flexible down spout shall be used to break the fall and confine the flow. The lower end of the spout shall be held close to the place of deposit. Whenever depositing is intermittent, a discharge hopper shall be provided. All chutes shall be thoroughly cleaned before and after each run. All washer and debris shall be disposed off outside the forms.
- e) Equipment used for transporting concrete from the mixer to the forms shall be maintained free from deposits of stiff concrete and leakage of mortars. Batch containers, transit mixers, agitators, chutes, concrete pumps. Pipelines and discharge hoppers shall be thoroughly cleaned after each run. All wash water and debris shall be disposed of outside the forms.

2.5.8 PREPARATION FOR PLACING CONCRETE

2.5.8.1 GENERAL

- a) Concrete shall not be placed until all form work required is completed, embedded parts if any installed and checked and surface prepared for placing. No concrete shall be deposited until the foundation has been inspected and approved.
- b) All surfaces of forms and embedded materials that have become encrusted with dried mortar or grout from concrete previously placed shall be cleaned of all such mortar or grout before fresh

concrete is placed and shall be oiled with a commercial form oil or alternatively covered with LDPE film.

2.5.8.2 FOUNDATION SURFACES

- a) Immediately before placing concrete, all surfaces of foundations upon or against which the concrete is to be placed shall be free from standing water, mud and debris. All surfaces of rocks upon or against which concrete is to be placed shall in addition to the foregoing requirements be cleaned and free from all lubricants, objectionable coating and loose semi-detached or unsound fragments. The surface of absorptive foundations upon or against which concrete is to be placed shall be moistened thoroughly and kept sufficiently wet for at least 24 hours prior to placing concrete so that the moisture will not be drawn from the freshly placed concrete. The cleaning and roughening of the surfaces of rock shall be performed by the use of high velocity air water jets, wet sand blasting, stiff brooms, picks or by other effective means. The washing and scrubbing process shall be continued until the wash water collected in puddles is clear and free from dirt. In the final cleaning process the wash water may have to be removed by sponges. If any drilled holes are left in the foundation surface which are no longer needed, the same shall be cleared with air water jetting and filled up completely with cement slurry.
- b) In the case of earth or shale foundations, all soft or loose mud and surface debris shall be scraped and removed. The surface shall be moistened to a depth about 15 cms (6 inches) to prevent the sub grade from absorbing water from the fresh concrete. Just before placing the concrete, the surface of the earth shall be tamped or otherwise consolidated sufficiently to prevent contamination of concrete during placing. If subsoil water is met within the foundation, it shall be dewatered as directed till the placing and setting of concrete. All concrete shall be placed upon clean damp surface free from standing water and never upon soft mud, dried porous earth or upon fills that have not been subjected to approved rolling and desired compaction.
- c) Foundation of porous or free draining material shall be thoroughly compacted by flushing and by subsequent tamping or rolling, if necessary. The finished foundation surface shall then be blanketed with a layer of tar paper or closely woven burlap carefully lapped and fastened down along the seems so as to prevent the loss of mortar from the concrete.

2.5.8.3 SURFACE OF CONSTRUCTION AND CONTRACTION JOINTS

- a) The surface of construction / contraction joints shall be clean, rough and damp but free from standing pools of water when receiving the next lift. Clean up shall comprise removal of all laitance, loose or defective concrete coating, sand, curing compounds if used and other foreign materials, if necessary by scrapping, chipping or other suitable means.
- b) The surface of construction / contraction joints shall be cleaned by use of high pressure water jet or by wet sand blasting and swashed thoroughly. Water jetting and blasting and washing shall be performed just prior to the placing of concrete.

- c) The method used in disposing of water employed in cutting, washing and rinsing of concrete surface shall be such that the wastewater does not stain, discolour or effect exposed surfaces of the structures. Methods of disposal of wastewater shall be subject to approval.

2.5.8.4 PLACING AND COMPACTING CONCRETE

- a) After the surfaces have been cleaned and dampened as specified, surfaces or rock and construction joints shall be covered, wherever practicable, with a layer of mortar approximately 10 mm to 15 mm thick. The mortar shall have the same proportions of water, air entraining agent if any, cement and fine aggregate as the concrete mixture which is to be placed upon it. The water cement ratio of the mortar which is placed shall not exceed that of the concrete to be placed upon it and the consistency of the mortar shall be suitable for being spread uniformly and worked thoroughly into all irregularities of the surfaces.
- b) In so far as it is practicable, concrete shall be placed directly in its final position and shall not be caused to flow in a manner to permit or cause segregation. Methods and equipment employed in placing concrete will ensure that aggregate is not separated from the concrete mass.
- c) In placing mass concrete in a lift successive batching of concrete shall be placed in a systematic arrangement in order to avoid exposure of parts of the live surface of a concrete layer.
- d) In mass concrete placement, delay may occur resulting in cold joints within a lift. When placement is resumed while concrete is so green (and therefore capable of ready bonding) that it can be dug out with a hand pick, the usual contraction joint treatment will not be required if the surfaces are kept moist and the concrete placed against the surface is thoroughly and systematically vibrated over the entire area adjacent to the older concrete. If the delay is short enough to permit penetration of the vibrator into the lower layer during routine vibration of successive layers, the vibration will assure necessary bonding.
- e) If for any cause, the working surface is left exposed until it has hardened to a considerable extent, it shall be left to set and cured for not less than 56 hours or longer. If for any reason a strength greater than 15.2 kg/sqm (500 PSI) has been attained before completing the lift, the surface thus interrupted shall be given a thorough clean up as for normal lift joint surface and the work shall be commenced with a mortar layer as specified.
- f) In placing mass concrete, the exposed area of fresh concrete shall be maintained at the practical minimum by first building up the concrete in successive approximately horizontal layers to the full width of the block and full height of the lift over a restricted area at the downstream end of the block and then continuing upstream in similar progressive stages to the full area. The slope formed by the unconfined upstream edge of the successive layers of concrete shall be kept steep as practicable in order to keep its area minimum. Concrete along these edges shall not be vibrated until adjacent concrete in the layer is placed, except that it shall be vibrated immediately when weather conditions are such that the concrete will be harden to an extent the later vibration may not fully consolidate and integrate in with more recently placed adjacent concrete.

- g) Retampering of concrete shall not be permitted. Any concrete which has become so stiff that proper placing without retampering cannot be ensured shall be wasted.
- h) In formed work, structural concrete placement shall generally be started with an over sanded mix containing 20 mm maximum size aggregate and an extra sack of cement for one cubic meter and having a 125 mm slump placed several centimeters deep on the joins at the bottom of the form. Concrete placement shall commence immediately thereafter.
- i) Concrete shall be compacted to the maximum practicable density, in such a manner that it is free from pockets of coarse aggregate and is in intimate contact with surface of forms and embedded materials. Unless otherwise permitted, all concrete shall be compacted by mechanical vibrator.
- j) Compaction of concrete shall whenever practicable be carried out by use of immersion type vibrators having vibrating heads of 100 mm or more in diameter shall be operated at speed of at least 6,000 revolutions per minute when immersed in the concrete.
- k) Vibrators having vibrating heads less than 100 mm. in diameter shall be operated at speed of at least 7,000 revolutions per minute in the concrete. Normally formwork shall be designed to provide for the insertion and operation of mechanical vibrators in the placed concrete. Form vibrator shall be used wherever internal vibration is not possible or would be inadequate.
- l) In compacting each layer of concrete, the vibrator shall be operated in almost vertical position and the vibrating head shall be allowed to penetrate and vibrate the concrete in the upper portion of the underlying layer. In the area where freshly placed concrete in each layer joins previously placed concrete, more vibration than usual shall be performed the vibrators penetrating deeply at close intervals along these contacts, Layers of concrete shall not be placed until layers previously placed have been vibrated thoroughly as specified. Contacts of the vibrating head with surface of the forms shall be avoided.
- m) During placing and until curing is completed, the concrete shall be protected against the harmful effect of exposure to sunlight, wind and rain as directed.

2.5.9 FORM WORK

- a) Forms shall be used wherever necessary to confine the concrete and to shape it to the required lines. Normally all exposed concrete surfaces having a slope steeper than 2H:1V shall be formed. The condition of forms influences appearance as well as quality of the concrete in the structure. Form work shall be designed and constructed to the shape, lines and dimensions shown in the drawing with following tolerances. The tolerances shall apply to concrete dimensions only.

S.N	Description	Tolerance (mm)
1.	Linear outline	
	In 6m of length	±12
	In 12m of length	±18
2.	Plumb, specified slope or curved surface of structures.	
	In 3m of height	±12
	In 6 m of height	±18
	In 6 m of height	±30
3.	Dimensions of cross sections of structures	+12

		- 6
4	Dimensions of footing	
	Dimensions of plan	+50 -12
	Eccentricity	0.02 times the width of footing in the direction of deviation but not more than 50mm
	Thickness	±0.05 times the specified thickness

2.5.9.1.1 Workmanship, cleanliness and strength of form work

- a) The form work and its supports shall be of steel. Timber forms shall not be allowed. Contractor shall provide details of proposed formwork to Engineer-in-Charge for his approval before its use.
- b) All rubbish particularly chippings, shavings, cement mortar and grout etc. shall be removed from the interior faces of the forms. Cleaned faces will be checked before use. Inner faces of forms in contact with concrete shall be oiled / greased to provide a thin uniform coating to the forms, without coating reinforcement, before concreting.
- c) Forms shall have sufficient strength to withstand all pressures during placement and vibration of concrete including all dead and live loads in construction without any deflection from the prescribed lines. Forms shall be made sufficiently rigid by use of adequate supports.
- d) The joints in the formwork shall be made watertight to prevent loss of slurry from the concrete.
- e) The forms required to be used more than once shall be maintained in a good condition, thoroughly cleaned & repaired if required before re-use. All forms shall be checked for proper shape, cleanliness and strength before re-use.
- f) The contractor shall inform SWIM QA Engineer-in-Charge well in time before starting placement of concrete in the forms to enable him to inspect the formwork for its adequacy, alignment, strength & overall fitness.
- g) The holes / recesses in the concrete resulting from removal of the end of the she-bolts, ties in the forms and any damage to concrete surface caused by removal of forms shall be filled / repaired in accordance with the provisions for Repair of Concrete and shall be finished flush with concrete surface by contractor at his own cost.
- h) Forms shall not be released until the concrete has achieved adequate strength. In normal circumstances, where ambient temperature does not fall below 15°C, ordinary Portland cement is used and adequate curing is done, following striking period of forms will be adopted.

S.N	Type of Formwork	Minimum Period Before Striking Formwork
1.	Vertical formwork to columns, walls & beams	16-24 hours
2.	Soffit formwork to slabs (props to be re-fixed just removal of formwork)	3 days
3.	Props to slab	
	Spanning up to 4.5m	7 days
	Spanning over 4.5m	21 Days
4.	Props to beams and arches	
	Spanning up to 6m	14 days
	Spanning over 6m	21 days

- i) Care shall be taken that the forms are stripped off without any injury to the concrete surface.
- j) The contractor shall ensure that the number of props left-under, their sizes and disposition shall be such as to be able to safely carry full dead load of slab, beam or arch together with any live load likely to occur during curing or further construction.
- k) If the inspection of forms reveals that forms are not strong enough to hold the concrete or are not braced sufficiently to stay in alignment, SWIM QA Engineer-in Charge shall immediately notify the contractor to set right the deficiencies and concrete shall not be placed before the forms are re-inspected and found O.K.
- l) A very common blemish on formed concrete surfaces is the offset found at horizontal construction joints at the bottom of new lift. Such off-sets shall be prevented by setting the forms to fit snugly against the top of concrete in previous lift and securing them so as to remain in tight contact during the placement of the concrete to prevent any leakage of cement slurry / mortar.
- m) The anchoring of forms shall be done by using ample number of ties and bolts above and near the construction joints.
- n) Forms shall overlap the hardened concrete in the previous lift by not more than 50mm.
- o) Occasionally, spalling may occur from the face of the concrete when forms are struck. This is often caused by rough spots on the inner faces of the form where mortar adheres strongly to overcome tensile strength of green concrete.
- p) Such areas on the faces of the form shall be cleaned, polished and then covered with a thin layer of suitable form oil.
- q) The following common deficiencies resulting in failure of form work shall be inspected and addressed:
 - Inadequate cross / horizontal bracings.
 - Unequal horizontal filling of forms with concrete
 - Abnormal displacement in the forms during and after placement of concrete.
 - Lack of adequate inspection of form work.

2.5.9.1.2 Measurement and Payments:

- a) Measurement of the form work (centering and shuttering) will be made only to the neat lines of the structures as indicated on the drawing or as established by the Engineer-in-charge. Dimensions shall be measured nearest to 1 cm. The areas shall be worked out to nearest 0.01 square meter. The rate is included in concreting and shall include the cost of all materials, labour, necessary tools & plants involved in above operations.

2.5.10 FINISHES AND FINISHING OF CONCRETE SURFACES

2.5.10.1 FORMED SURFACES

- (a) Allowable deviation from plumb or level and from the alignment profile, grades and dimensions shown on the drawings is defined as 'tolerance' and is to be distinguished from the irregularities in finishes as described herein.
- (b) The classes of finish and requirements for finishing of concrete surface shall be as shown on the drawing or as hereinafter specified. In the event of finishing not being definitely specified herein or on the drawings the finishes to be used shall be as directed by the SWIM QA Engineer-in-charge. Finishing of concrete surface shall be performed only by skilled workmen.

(c) Completed concrete surfaces will be tested where necessary to determine whether surface irregularities are within the limits hereinafter specified.

(d) Surface irregularities are classified as 'Abrupt' or 'gradual' offsets caused by displaced or misplaced form sheathing or lining or form sections or by loose knots or otherwise defective timber form will be considered as abrupt irregularities and shall be tested by direct measurements. All other irregularities shall be considered as gradual irregularities and will be tested by use of template, consisting of a straightedge or the equivalent thereof for curved surfaces. The length of the template shall be 150 cms for testing of formed surfaces and 300 cms for testing unformed surfaces.

(e) The clauses of finish for formed concrete surface are designated by one of the symbols F1, F2, F3 and F4. The jute bags rubbing, or sand blasting will not be required on formed surfaces and grinding will not be required on formed surfaces other than that necessary for the repair of surface imperfections. Unless otherwise specified or indicated on the drawings, the classes of finish which will apply are as follows :

i) Finish F1

This finish applies to surfaces where roughness is not objectionable, such as those upon or against which fill material, masonry or concrete will be placed, the upstream face of the structure that will permanently be under water or surface that will otherwise be permanently concealed. The surface treatment shall be the repair of defective concrete, correction of surface depression deeper than 25 mm and filling of the tie rod holes. Form sheathing will not leak mortar when the concrete is vibrated. Forms may be built with a minimum of refinement.

ii) Finish F2

This finish is required on all permanently exposed surface for which other finishes are not specified, such as in Head Regulators, Cross Regulators, Drainage syphons, Bridges and Retaining Walls not prominently exposed to public view except wherein F1 finishes are permitted. Forms shall be built in a workmanlike manner to the required dimensions and alignment, without conspicuous offsets or bulge. Surface irregularities shall not exceed 5 mm for abrupt irregularities and 10 mm for gradual irregularities measured with 1.5 m template.

iii) Finish F3

This finish is designated for surface of structures prominently exposed to public view where appearance is also of special importance. This shall include inside of drainage barrels, piers of bridges and beams and slabs of cross regulators, syphons, aqueducts, drops, parapets, railings and decorative features on the structures and on the bridges. To meet with the requirements for the F3 finish forms shall be built in a skillful, workmanlike manner, accurately to dimensions. There should be no visible offsets, bulges, or misalignment of the concrete. At construction joints the forms shall be tightly set and securely anchored close to the joint. Abrupt irregularities shall not exceed 5 mm for irregularities parallel to the directions of flow and 2.5 mm for irregularities in other directions. Gradual irregularities shall not exceed 5 mm. Irregularities exceeding this limit shall be reduced by grinding on a bevel of 1 to 20 ratio of height to length.

iv) Finish F4

This finish is required for formed concrete surface at the cut and ease waters of the pier's portions of outlets, draft tubs, high velocity flow surfaces of outlet work downstream from gates and spillway tunnels of dams and where evenness of surface is essential. The forms must be strong and held - rigidly and accurately to the prescribed alignment. For wrapped surface the forms shall be built up in section cut to make tight smooth form surfaces after

which the form surfaces are dressed and sanded to the required curvature. Gradual irregularities shall not exceed 5 mm. Abrupt irregularities shall not be permitted. Formations of air holes on the surface of the concrete designated to receive finish shall be minimised and where such air holes are found, they shall be repaired in accordance with the provisions of relevant paragraph.

2.5.10.2 UNFORMED SURFACES

(a) The classes of finish for unformed concrete surfaces are designated by the symbols, U1, U2, U3 and U4. Unless otherwise specified or indicated on the drawings, these classes of finish shall apply as follows :

i) Finish U1

This finish applies to unformed surfaces that will be covered by fill material, masonry or concrete, or where a screened surface meets the functional requirements. Finish U1 is also used as the first stage of finishes for U2 and U3. Finishing operations shall consist of sufficient leveling and screening to produce an even uniform surface. Surface irregularities measured as described in this section, shall not exceed 10 mm.

ii) Finish U2

a. This is a floated finish and used on all outdoor unformed surfaces not specified to receive finishes U1 and U3. It may be used for such surfaces as apron and floors of cross regulators and head regulators, drainage barrels, aqueducts and escapes and inside of slopping aqueduct troughs.

b. Finish U2 is also used as the second stage of finish for U3. Floating may be performed by hand or power-driven equipment. Floating shall be started as soon as the screened surface has stiffened sufficiently to prevent the formation of laitance and shall be the minimum necessary to produce a surface that is free from screed marks and is uniform in texture. If finish U3 is to be applied, floating shall be continued until a small amount of mortar without excess water is brought to the surface, so as to permit effective troweling. Surface irregularities measured as described in this section shall be removed as directed.

iii) Finish U3

This is a troweled finish and may be specified for tops of parapets prominently exposed to view and conduit invert immediately downstream of regulating gates and valves. When the floated surface has hardened sufficiently to prevent excess of fine material from being drawn to the surface, steel troweling shall be started. Steel troweling shall be performed with firm pressure, that will flatten the sandy texture of the floated surface and produce a dense uniform surface free from blemishes and trowel marks. Surface irregularities, measured as described in relevant parts of this section, shall not exceed 5 mm where hard steel troweled finish is specified, the regular U3 finish shall be troweled again after the surface has nearly hardened using firm pressure and troweling until the surface is hard and has a slightly glossy appearance.

iv) Finish U4

a. This is a steel troweled finish similar to finish U3 except that light surface pitting and light trowel marks such as obtained from the use of machine troweling or lining machine will be acceptable, provided the surface irregularities do not exceed the limits specified for finish U3.

b. Unformed surfaces which are nominally level shall be sloped for drainage as shown on the drawings or as directed, unless the use of other slopes or level surface is indicated on the drawing, narrow surface such as tops of parapets, tops of walls and kerbs shall be sloped approximately half centimeter per 30 cms of width.

For canal lining the finish U4 shall be adopted.

2.5.11 REPAIR OF CONCRETE

2.5.11.1 GENERAL

(a) Repair of concrete shall be performed by skilled workers and in the presence of an experienced Engineer. The Contractor shall correct imperfections on the concrete surfaces as necessary to produce surface that conform with requirements of the paragraph "finishes and finishing of concrete surfaces". Repairs on formed concrete shall be completed as soon as practicable after removal of forms and within 24 hrs after removal of forms. Concrete that is damaged from any cause and concrete that is honeycombed, fractured or otherwise defective and concrete which because of excessive surface depressions has to be excavated and built up to bring the surface to the prescribed lines shall be removed and replaced by dry pack mortar or concrete as hereinafter specified. Where bulges and abrupt irregularities protrude outside the limits specified in the paragraph 'finishes and finishing of concrete surfaces', the protrusions shall be reduced by bush hammering and grinding so that the surfaces are within the specified limits.

(b) Before repair is to commence, the methods proposed for the repair shall be approved by the Engineer -in charge. Routine curing should be interrupted only in the area of repair operations.

2.5.11.2 METHODS OF REPAIRS

For new works four methods are used as under :

i) DRY PACK METHOD

This method should be used for holes having a depth nearly equal to, or greater than the least surface dimensions, for cone bolt, she bolt and grout insert holes, and narrow bolts cut for the repair of cracks. Dry pack should not be used for relatively shallow depressions where lateral restraint cannot be obtained, for filling in back of considerable lengths of exposed reinforcement ; nor for filling holes which extend entirely through the wall, beam, etc.

ii) CONCRETE REPLACEMENT METHOD

Concrete replacement should be used when holes extend entirely through the concrete section, when holes in unreinforced concrete are more than 1,000 sqcms in area and 100 cms or more in depths and when holes in reinforced concrete are more than 500 sqcms in area and deeper than the reinforcement steel.

iii) MORTAR REPLACEMENT METHOD

This should be used for holes too wide to dry pack and too shallow for concrete replacement and for all comparatively shallow depressions, large or small, which extend no deeper than for side of the reinforcement bars nearest to surface.

iv) EPOXY METHOD

A thermosetting plastic known as epoxy can be used as a bonding medium whenever long time curing of conventional concrete cannot be assured. Also epoxy mortars of fine sand as well as plain epoxy are suitable for concrete repair work and should be used whenever very thin patches are to be placed or immediate reuse of the area is required or where moist curing cannot be effectively accomplished. Preparation for epoxy bonded repairs should in general be identical to that for other concrete repairs except that every effort should be made to provide surfaces thoroughly dry. Drying of the immediate surface for at least 24 hrs. and warming to temperature between 18 degree C to 27-degree C. are essential for proper application of epoxy bonded repairs. Preparation for the use of epoxy

mortars should include thorough cleaning and drying of the areas to be repaired. A wash of dilute 1:4 muriatic acid rinsing with clean water and subsequent drying is desirable, where feasible. If acid wash is not feasible, preparation may be accomplished as for other concrete repairs with final cleanup being by means of sandblast method, followed by air water jet washing and thorough drying, epoxy repairs shall be carried out only by trained personnel. The type of epoxy to be used shall be got approved by the Engineer-in charge.

2.5.11.3 PREPARATION OF CONCRETE FOR REPAIRS

- a) All concrete of questionable quality should be removed. It is better to remove too much concrete than too little because affected concrete generally continues to disintegrate and while the work is being done it costs but little more to excavate to ample depth. Moistening, cleaning, surface drying and complete curing are of utmost importance when making repairs which must be thoroughly bonded, watertight and permanent. Surfaces within trimmed holes should be kept continuously wet for several hours, preferably overnight prior to placing new concrete. Immediately before placement of the filling, the holes should be cleaned so as to leave a surface completely free from chipping dust, dried grout and all other foreign materials. Preliminary washing as soon as the chipping and trimming are completed is desirable to remove loose material. Final cleaning of the surfaces to which the new concrete is to be bonded should be done by wet sandblasting followed by washing with air water jet for thorough cleaning and drying with an air jet. Care should be taken to remove any loose materials embedded in the surface by chisels during the trimming and to eliminate all shiny spots indicating free surface moisture. Cleaning of the steel if necessary, should be accomplished by sand blasting. The prepared surface shall be approved by the Engineer-in charge.

I. DRY PACKING OF CONCRETE

For this method of repair, the holes should be sharp and square at the surface edges, but the corners within the holes should be rounded, especially when water tightness is required. The interior surfaces of holes left by cone bolts; she bolts etc. should be roughened to develop an effective bond. Other holes should be under-cut slightly in several places. Holes for dry pack should have minimum depth of 25 mm.

ii) CONCRETE REPLACEMENT

Preparation for this method should be as follows :

- a) Holes should have minimum depth of 100 mm. in new concrete and the minimum area of repair should be 500 sqcms for reinforced and 1,000 sqcms for unreinforced concretes.
- b) Reinforcement bars should not be left partially embedded. There should be a clearance of at least 25 mm around each exposed bar.
- c) The top edge of the holes at the face of the structure should be cut to a fairly horizontal line. If the shape of the defect makes it advisable, the top of the cut may be stepped down and continued on a horizontal line. The top of the hole should be cut to 1 to 3 upward slopes from the back towards the face of the wall or beam. It may be necessary to fill the hole from both sides, in which case the slope of the top of the cut should be modified accordingly.
- d) The bottom and sides of the holes should be cut sharp and approximately square with the face of the wall when the hole goes entirely through concrete section, spalling or feather edges shall be avoided by having chippers worked from both faces. All interior corners should be rounded to a minimum radius of 25 mm.

iii. MORTAR REPLACEMENT

When mortar gun is used with this method , comparatively shallow holes should be flattered outwardly at about 1 to 1 slope to avoid inclusion of rebound. Corner within the holes should be rounded. Shallow imperfections in concrete may be repaired by mortar replacement if the work is done promptly after removal of the forms and while the concrete is still green, for instance when it is considered necessary to repair the peeled areas resulting from surface material sticking to steel forms the surfaces may be filled using mortar gun without further trimming or cutting. Whenever hand placed mortar replacement is used, edges of chipped out areas should be squared with the surface leaving no feather - edges.

iv. USE OF DRY PACK MORTAR

The surface after preparing should be thoroughly brushed with a stiff mortar or grout barely wet enough to thoroughly wet the surface after which the dry pack material should be immediately packed into place before the bonding grout has dried. The mix of bonding grout shall be 1 to 1 cement and fine sand mixed to a consistency like thick cream. Under no circumstance should bonding coat be wet enough or applied heavily enough to make the dry material more than very slightly rubbery. Dry pack is usually a mix (by dry volume or weight) of one part of cement to 1.50 parts of sand that will pass No. 16 ASTM Screen.

2.5.11.4PROCEDURE OF REPLACEMENT OF CONCRETE, CURING OR REPAIRS ETC.

2.5.12 CURING OF CONCRETE

2.5.12.1GENERAL

(a) All equipment, material etc., needed for curing and protection of concrete shall be at hand and ready for installing before actual, concreting begins. Detailed plans, methods and procedures whereby the various phases of curing and protection shall firmly be established, shall be settled and got approved in writing from the SWIM AQ Engineer - in charge sufficiently in advance of the actual concreting . The equipment and method proposed to be utilized shall provide for adequate control and avoid interruption or damage to the work of other agencies. All Concrete shall be cured by water.

2.5.13.2 WATER CURING

(a) Uniform top surfaces of walls and piers shall be moistened by covering with water saturated material or by other effective means as soon as the concrete has hardened sufficiently to prevent damage by water i.e. normally after 24 to 36 hrs of placement of concrete. Exposed finished surfaces of concrete shall be protected against heating and drying from the Sun for at least 72 hrs after placement in location. When finishing or repairs are involved, concrete shall not be disturbed by workmen walking on it or by storing materials on the surface or otherwise for at least 10 hours after placing. These surfaces and steeply sloping and vertical formed surfaces shall be kept completely and continuously moist, prior to and during form removal, by water applied on the unformed top surfaces and allowed to pass down between the forms and formed forms and formed concrete faces. This procedure shall be followed by the specified water curing and membrane curing.

(b) concrete cured with water shall be kept wet for at least 21 days immediately following placement of the concrete or until covered with fresh concrete by covering with water saturated material or by a system of perforated pipes, or mechanical sprinklers or porous hoses or by any other

suitable method, which will keep all surfaces continuously (not periodically) wet. For uncovered portions curing should continue for specified period.

(c) The contractor shall make arrangements at work site for storing the water required for at least 3 days curing. The concrete work shall not be started until the water required for 3 days curing is stored in advance.

2.5.13 REQUIREMENT OF CONCRETE CONSTRUCTION

2.5.13.1 GENERAL

All concrete construction shall conform to the permissible tolerance and technical provisions as described in this section and to the detailed requirement of the following paragraphs. All structures shall be built in a workmanlike manner or to the lines, grades and dimensions shown in the drawing or as prescribed by the Engineer-in-charge. The location of all the construction joint shall be subject to the approval of the SWIM AQ Engineer-in-charge. The dimensions of each structure shown on the drawings are tentative and shall be subjects to such change as may be found necessary by the Engineer-in-charge due to design considerations.

2.5.14.2 CONCRETE IN VARIOUS COMPONENTS OF BRIDGES, DRAINAGE SYPHON AQUEDUCTS, RETAINING WALLS, CULVERTS, ETC.,

(a) The items of the schedule BOQ for concrete in aforesaid structures include all concrete in the various components of the structure

(b) Expansion joints shall be constructed as shown on the drawing or as directed. Premoulded bituminous fiber type expansion joint material shall be placed in the expansion joints. Lighting recesses shall be constructed in the parapets as directed by the Engineer-in-charge. Open joints or false joints shall be constructed as shown on the drawings or as directed by the Engineer-in-charge. Performed expansion joint filler shall be placed in the side walls where shown on the drawing or as directed by the Engineer-in-charge.

2.5.14 CONSTRUCTION JOINTS IN UNREINFORCED CONCRETE WALLS

(a) Concreting shall be carried out continuously up to the construction joints, the position and details of which shall be as shown on approved Drawing or as directed by the Engineer-in-charge.

(b) For vertical construction joints stopping boards shall be fixed previously at a predetermined position and shall be properly stayed for sufficient lateral rigidity to prevent its displacement or bulging when concreting is completed against it. Concreting shall be continued right up to the board. The board shall not be removed before expiry of the specified period for removal of vertical forms.

(c) Before resuming work at any construction joints when concrete has not yet fully hardened, all laitance shall be removed thoroughly, care being taken to avoid dislodgement of coarse aggregates. The surface shall be thoroughly wetted, and all free water removed from the surface shall then be coated with cement slurry. On this surface, layer of concrete not exceeding 150 mm in thickness shall first be placed and shall be well rammed against old work particular attention being paid to corners and closed spots, work thereafter shall proceed in a normal way.

(d) When work has to be resumed on a surface, which has hardened, it shall be thoroughly raked, swept clean, wetted and covered with a layer of neat cement grout. The neat cement grout shall be followed by a 15 mm thick layer of mortar mixed on the same proportion as in concrete and concreting resumed immediately thereafter. The batch of concrete shall be rammed against the old work to avoid formation of any stone pockets, particular attention being paid to corners and close spots.

In all cases, the position and detailed arrangements of all construction joints shall be predetermined and got approved by the Engineer-in-charge.

2.5.15 TEST AND ACCEPTANCE CRITERIA

2.5.15.1 GENERAL

NOTE : For relatively small and isolated works in which quantity of concrete is less than 15 cum the strength tests may be waived by the Engineer-in-charge at his discretion.

In order to get a relatively quicker ideas of the quality of concrete, optional tests on beams for modulus of rupture at 72 + hrs. or at 7 days, or compressive strength tests at 7 days may be carried out in addition to 28 days compressive strength tests. For this purpose, the values given in Table below may be taken for general guidance in the case of concrete made with ordinary Portland cement. If however, from tests carried out in a particular job over a reasonably long period, it has been established to the satisfaction of the Engineer-in-charge that a suitable ratio between 28 days compressive strength at 7 days may be accepted, the Engineer-in-charge may suitably relax the frequency of 28 days compressive strength provided the expected strength values at the specified early age are consistently met.

Grade of Concrete	Compressive strength On 15 cms Cubes Min. At 7 days N/sqmm	Modules of Rupture Min. at 72+ hrs. N/sqmm.	by Beam Test Min at 7 days N/sqmm
1	2	3	4
M 10	7.0	1.2	1.7
M 15	10.0	1.5	2.1
M 20	13.5	1.7	2.4
M 25	17.0	1.9	2.7
M 30	20.0	2.1	3.0
M 35	23.5	2.3	3.2
M 40	27.0	2.5	3.4

2.5.16.2 FREQUENCY OF SAMPLING

Sampling Procedure :

A random sampling procedure shall be adopted to ensure that each concrete batch shall have a reasonable chance of being tested ; that is, the sampling should spread over the entire period of concreting and cover all mixing units.

Frequency :

The minimum frequency of sampling of concrete of each grade shall be in accordance with the following :

Quantity of Concrete in the work, Cum.	Number of Samples
1 to 5	1
6 to 15	2
16 to 30	3
31 to 50	4
51 and above	4 plus one additional sample for each additional 50 cum or part thereof.

NOTE : At least one sample shall be taken from each shift.

2.5.15.2 TEST SPECIMEN

Three test specimens shall be made from each sample for testing at 28 days. Additional cubes may be required for various purposes, such as to determine the strength of concrete at 7 days or at the time of striking the formwork, or to determine the duration of curing or to check the testing error.

2.5.15.3 TEST STRENGTH OF SAMPLE :

The test strength of the sample shall be the average of the strength of three specimen. The individual variation should not be more than plus or minus 15 percent of the average.

2.5.16 STEEL REINFORCEMENT

The provision made under **SECTION – 2.6** shall apply.

2.5.17 TOLERANCE IN CONCRETE CONSTRUCTION

2.5.17.1 GENERAL

(a) Permissible surface irregularities for the various classes of concrete surface finishes specified in the relevant portion of the paragraph of "Finishes and Finishing of Concrete Surfaces", are defined as "finishes" and are to be distinguished from "Tolerance" as described in this section. Deviation from the established lines, grades and dimensions shall be permitted to the extent set forth in this clause, provided that lesser tolerance than that set forth in this clause may be prescribed at site

if such tolerances are considered to impair the structural action or operational action or operational function of the structure.

(b) Where tolerances are not stated in the specifications or drawings for any individual structure or feature thereof, permissible deviations shall be interpreted in conformity with the provisions of this Clause.

(c) Concrete work that exceeds the tolerance limits specified in this section shall be either remedied satisfactorily or removed.

2.5.18 UNACCEPTABLE WORK

All defective concreting work, including those due to honeycombing, under sizing, under-strength etc. shall be demolished and rebuilt by the contractor at his cost. In exceptional cases where such work is accepted by the SWIM QA Engineer-in-charge after the contractor has made specified repairs, all cost of repairs shall be borne by the contractor. In the event of the work being accepted, allowing under sizing commensurate with higher materials strength and accepting materials not fully meeting the specifications etc. the contractor shall be paid for the work actually carried out by him at a reduced rate derived from the tendered rate as approved by the SWIM QA Engineer-in-charge.

2.5.20 MEASUREMENTS AND PAYMENTS

(a) Except otherwise specially provided for in the specifications, measurements of concrete for payment shall be made on the basis of the volume of concrete measured and calculated as being contained within the prescribed concrete outlines shown on the relevant drawings.

(b) Measurement, for payment, for the concrete laid in pockets in the foundation shall be made on the basis of the volume of the pockets filled.

(c) No measurements shall be made for the concrete backfill beyond the minimum lines of excavation shown on the drawings except where such payment is specifically authorized. Measurement of concrete shall be made after deducting the volume of all recesses, passageways, chambers, openings, cavities and depression but without deductions for round or beveled edges or space occupied by electrical conduits and reinforcement.

(d) Concrete in retaining walls, culverts, and turnouts shall be measured on the basis of volume of concrete calculated as being contained within the concrete outlines shown on the relevant drawings.

(e) The unit rate for concrete shall include the cost of all materials, labour, tools and plant required for mixing placing in position, vibrating and compacting, finishing as per directions of the Engineer-in-charge, curing and all other incidental expenses for producing concrete of specified strength to complete the structure of its components as shown on the drawings and according to these specifications. The rate shall also include the cost of providing, fixing and removing of all centering and form work required for the work unless otherwise specified in the contract.

(f) The unit rate also includes the cost of dewatering, desilting, diversion and protection work as may be necessary during and after concreting work.

(g) All expenses likely to be incurred by the Contractor in transporting materials supplied to him, if any, to the site of work, the expenses incurred in improving the quality of materials to acceptable levels (such as screening, washing, etc.) and the expenses incurred in proper storage of materials as directed by the Engineer-in-charge etc. are deemed to be included in the unit rate.

(h) Payment for the various classes of concrete shall be made on the basis of unit rate per cubic meter entered in respect of items in BOQ

(i) No extra payment shall be made towards authorized variations in cement content per cubic meter of concrete.

2.6 REINFORCEMENT

2.6.1 GENERAL

- a) All reinforcement shall be procured from genuine manufacturers. Re- rolled steel shall not be used in any component of work.
- b) The contractor shall make his own arrangement to procure high yield strength deformed bars and in quantity/ size as shown in the drawing.
- c) Tested quality of steel reinforcement bars shall be used. Requisite test certificates from manufacturers are to be provided by contractor to the SWIM QA Engineer before use of reinforcement steel on the work.
- d) Steel bars shall be stored in such a manner as to avoid distortion or deterioration by rusting / corrosion.
- e) To protect reinforcement steel from exposure to saline atmosphere, surface of bars shall be treated with cement wash or any other suitable method shall be used.
- f) The mass per meter run in Kg of reinforcement steel bars shall be as tabulated below

S. No.	Nominal Size of bar (mm)	Cross sectional area (mm ²)	Mass per meter (kg)
1.	8	50.3	0.395
2.	10	78.6	0.617
3.	12	113.1	0.888
4.	16	201.2	1.58
5.	18	254.7	2.00

6.	20	314.3	2.47
7.	22	380.3	2.98
8.	25	491.1	3.85

2.6.2 CUTTING AND BENDING OF REINFORCEMENT

- a) The bars shall be bent by hand or power cold, correctly and accurately to the size and shape as shown in drawings or as directed by SWIM Engineer-In-Charge.
- b) The radii of the bends in the main reinforcement bars shall not be less than 6 times bar diameter. The radii of the bends of stirrups shall not be less than twice the diameter of the bar.
- c) Bars bent during transport and handling shall be straightened before being used on work. Bars shall not be heated to facilitate bending.
- d) Reinforcement bars from any rejected lot shall not be used.
- e) Where reinforcement bars are bent aside at construction joints and after wards bent back into their original position, care shall be taken to ensure that at no time radius of the bend is less than 6 bar diameter. Care shall also be taken when bending back the bars to ensure that concrete around bars is not damaged.
- f) Reinforcement bars at the construction joints shall not be bent or re-bent and afterwards straightened without the approval of Engineer.

2.6.2.1 PLACING OF REINFORCEMENT

- a) Rough handling, prior to placement shall be avoided. Reinforcement shall be secured against displacement beyond the specified limits.
- b) Before the reinforcement is placed, surface of bars and the surface of any metal supports shall be cleaned of rust, loose mill scale, dirt or coats of paints, oil or other coatings which may reduce bond with concrete.
- c) Reinforcement steel bars shall be placed accurately to the dimensions and shape given in the bar bending schedule shown on the relevant drawings.
- d) Reinforcement bars shall not be allowed to sag between supports.
- e) Unless otherwise specified by engineer in charge, reinforcement shall be placed with-in the tolerances of $\pm 10\text{mm}$ for effective depth of 200 mm or less and $\pm 15\text{mm}$ for effective depth more than 200mm.
- f) Reinforcement bars shall be placed in position as shown in drawings. The bars crossing one another shall be tied together at every intersection with annealed mild steel binding wire of 16 SWG by twisting the strands tight to make the skeleton of the steel bars rigid so that the reinforcement is held in position and does not get displaced during the deposition of concrete.
- g) Minimum distance between individual bars will be kept as per drawing. However following guidelines shall be adopted.
- h) Horizontal distance between two parallel main bars shall usually be the greater of the twice diameter of the larger bar and 5mm more than nominal size of coarse aggregate.
- i) The size of coarse aggregate may be reduced, with the permission of SWIM QA Engineer-in-Charge around congested reinforcement to comply with these provisions.

- j) All supports used for positioning of bars shall be of non-corrodible material. Metal supports shall not extend to the surface of concrete except where shown in the drawing. Pieces of broken stone or brick or wooden block shall not be used.
- k) Special care shall be taken to prevent any displacement of reinforcement embedded in freshly placed concrete.
- l) The bars shall be kept in position by using pre-cast cement concrete cover blocks, spacer bars, supporting bars and templates as directed by SWIM QA Engineer-in-Charge to provide specified nominal clear cover to the reinforcement. Spacers / chairs shall be placed at a maximum spacing of 1 m. c/c.
- m) Cover blocks shall be of same grade as that of main concrete or of PVC.

2.6.2.2 SPLICING

- a) Preferably, bars of full length shall be used. Overlapping length of bars shall be as shown in the drawing. The lap length of a bar shall not be less than 30 diameter of bar. The overlapping bars shall be tied with binding wire.
- b) Reinforcement bars with diameter of 28mm or greater may be butt welded. These bars will be connected by overlapping, only when it is more practical than butt welding and overlapping does not hinder concrete / reinforcement placement.
- c) Reinforcement bars with diameter of 28mm or less may be connected by overlapping or butt welding whichever is considered more practical by SWIM QA Engineer-in-Charge.
- d) Welding pieces of reinforcement shall be tested at the rate of 0.5% of the total no. of joints welded or as decided by Engineer-in-Charge. Specimen shall be taken from the actual site of work. No extra payment shall be made.

2.6.2.3 NOMINAL COVER TO REINFORCEMENT

- a) Unless specified otherwise, actual concrete cover to the reinforcement shall not deviate from the required nominal cover by (+) 10 mm.
- b) The following Table may be referred to for the concrete cover for reinforcement unless otherwise specified.

1	Thin slabs and walls	Not less than diameter of bar minimum 15mm.
	(i) Beam sides	Not less than diameter of bars minimum 25 mm.
2	Beam top and bottom ends	2 times dia of bars ; diameter of bars minimum 25 mm.
3	Columns	Not less than diameter of bars minimum 25 mm up to 200mm sides
4	Footings	Minimum 50 mm

5	Foundations	40mm
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2.6.2.4 PAYMENT

- a) The rate in the bill of quantities for reinforcement shall include cost of steel, binding wire or welding material, its cutting bending cleaning, placing, binding work and fixing in position as shown on drawings and as directed by the Engineer-in-charge. The unit rate shall also include cost of all devices for keeping reinforcement in approved position, cost of jointing as per approved methods and all wastage, overlaps, dowels, binding wire or welding material and spacers and cost of all incidental operations necessary to complete the work as per specifications. The rate shall be added to overall rate of reinforced concrete.

2.7 RUBBLE MASONARY

The work covered under this section consists of furnishing all material, equipment and labour for providing and laying uncoursed rubble masonry in substructure and superstructure and performing all functions necessary and ancillary thereto and including pointing of exposed surfaces and curing. This also includes dewatering if required.

2.7.1 MATERIAL

2.7.1.1 CEMENT

The provisions of sub - para 2.4.2.1 shall apply.

2.7.1.2 SAND

(a) Sand to be used in mortar shall conform to the gradation limits given below :

Sieve designation		Percentage by weight passing sieve
4.75 mm	100	
2.36 mm	90-100	
1.18 mm	70-100	
600 Micron	40-100	
300 Micron	5-70	
150 Micron	0-15	

(b) Before collecting the sand required for mortar for the masonry work, the contractor shall ensure that the sample of sand proposed to be used are supplied to the project laboratory for casting the mortar cubes, and material shall be collected only after ascertaining the results of the test on the mortar cubes. During the execution of the work sand collected at site shall also be tested for all specification requirements.

2.7.1.3 RUBBLE (STONES)

- a) Stone shall be hard, sound free from cracks, decay and weathering. Stone shall be used from surplus usable excavated rubble or from the approved quarries, if required. Stone with round surface shall not be used. Stones when immersed in water for 24 hours shall not absorb water by more than one percent of their dry weight when tested.
- b) The length of stone shall not exceed three times its height and the breadth on the base shall not be greater than three fourth of the thickness of wall and in any case not less than 15 cm. Minimum crushing strength of stones shall not be less than 600 Kg/Sqcm.

2.7.2 UNCOURSED RANDOM (U.C.R) MASONRY

2.7.2.1 MORTAR

- a) The mortar shall consist of cement, sand and water thoroughly mixed in the proportion as specified. Proportion of cement and sand shall be 1:4 on weight basis as specified in BOQ. Due allowance shall be made for the moisture content in sand. Mixing water shall be added to achieve required workability.

2.7.2.2 MIXING

(a) The mortar shall be mixed in mechanical mixers of tilting type having calibrated water tank for storing water. The first batch of the mortar at the commencement of work with any mixer shall be made richer by adding 10 percent more cement over and above that required for the particular mix. In case of mechanical mixing, the mortar shall be mixed for at least 3 minutes after addition of water. Hand mixing shall not be allowed. However, in exceptional circumstances such as mechanical breakdown of mixer, work in remote areas or when the quantity of work is very small, mixing in hand operated mixers shall be permitted.

(b) All ingredients shall be fed to the mixer simultaneously. The quantity of water to achieve the required consistency shall be predetermined by trial mixes, and proportion of water from 5 to 10 percent shall precede and the like quantity shall follow the introduction of other materials. The remainder of water quantity shall be added during mixing operation.

(c) The wet mortar shall be used within 30 minutes of mixing, mortar remaining unused, after above time shall be rejected and shall not be allowed to be used.

2.7.2.3 MODE OF LAYING

- a) Stone shall be sufficiently wetted before laying to prevent absorption of water from mortar. All stones shall be laid full in mortar both in bed and in vertical joints and settled carefully in place with a wooden mallet immediately on placement so that it is firmly bedded in before the same has set. Clean chips and spalls shall be wedged into the mortar joints and beds wherever necessary to avoid thick beds or joints of mortar. Whenever foundation masonry is laid directly on rock, the face stones of the first course shall be dressed to fit into the rock snugly when pressed down in the mortar bedding over the rock. No dry or hollow space shall be left anywhere in the masonry and each stone shall have all the embedded faces completely covered with mortar. Vertical joints shall be staggered. Transverse bond shall be provided by the use of bond stones extending from the front to the back of the masonry. In case of thick walls beyond 60 cm, bond stones shall overlap each other in their arrangement. Overlap shall not be less than 15 cms. Bell shaped bond stones or headers shall not be used. Bond stone shall be stacked separately and marked to distinguish it from other stones. Masonry work shall be started after sufficient number of bond stones are collected on site as directed by the SWIM QA Engineer-in-charge. Bond stones shall be inserted at the rate of one per square meter and shall be staggered.
- b) At all angular junctions, stones at each alternate course shall be well bonded into the respective course of the adjacent wall. All connected masonry in structures shall be carried up at one uniform level throughout as far as possible, but when breaks are unavoidable the masonry shall be in sufficient long steps to facilitate jointing of new work with old. Stepping shall not be more than 45 degrees with the horizontal. Masonry work shall be carried out to truly plumb or to the specified batter. Face work and hearting shall be brought up evenly. The top of each course, however, shall not be levelled up by use of flat chips. Chips and spalls of stones may be used wherever necessary to avoid thick mortar beds or joints and it shall also be ensured that not hollow spaces are left anywhere in the masonry. Chips shall not be used below hearting stones to bring these up to level of face stones. Use of chips shall be restricted to filling of interstices between the adjacent stones in hearting and they shall not exceed 20 percent of the quantity of stone masonry.
- c) Hearting or interior filling of water face shall consist of rubble stones, not less than 15 cm. in any direction carefully laid, hammered down with a wooden mallet into position and firmly bedded in mortar. Hearting should be laid nearly level with facing and backing.
- d) The joint shall not be more than 25 mm thick but shall be sufficiently thick to prevent stone to stone contact and shall be completely filled with mortar. The total content of mortar in masonry shall not be less than 40% and not more than 48% of the volume of masonry.
- e) When fresh masonry is to be placed against existing surface of structure, the old surface shall be cleaned of all loose material, roughened and wetted as directed by the Engineer-in-charge so as to achieve a good bond with the new work.
- f) The scaffolding shall be sound and strong to withstand all loads likely to come upon it. The holes which provide resting space for horizontal members shall not be left in masonry. The holes left in the masonry work for supporting the scaffolding shall be filled.

- g) Green work shall be protected from rain by suitable cover. Masonry work in cement mortar shall be kept consistently moist on all faces for a minimum period of twenty-one days after 24 hours of construction and continuous for 21 days. Watering should be done carefully so as not to washout the mortar, joints or disturb the masonry in any manner. During hot weather all finished or partly completed work shall be covered or wetten in such a manner as to prevent drying . The raking of joints where necessary, shall be done at the end of day's work when mortar is green.

2.7.3 MEASUREMENT AND PAYMENT

(a) Cross-section at 3 mtrs. or closer intervals shall be taken to determine the quantity of masonry. Payment shall be made on the basis of the volume of the masonry work calculated as being contained within the pay lines shown on the drawing.

(b) No allowance shall be made for the masonry backfill beyond the pay lines of excavation shown on the drawings except where such payment is specifically authorized. Payment for masonry shall be made on the basis of the unit rate for the respective items in Schedule - B. The unit rate for stone masonry shall include the cost of all labour, materials, tools, plant, and scaffolding, curing etc. and other expenses incidental to the work. The unit rate also includes dewatering and desilting required, if any.

2.7.4 POINTING

2.7.4.1 GENERAL

(a) For a surface, which is to be subsequently pointed, the joints shall be squarely raked out to a depth of 20 mm. While the mortar is still green. The raked joints shall be well brushed to remove dust and loose particles and the surface shall be thoroughly washed and cleaned.

(b) Mortar required for pointing shall be prepared in accordance with the provisions of para 2.7.2.1. The cement and sand shall be 1:3 proportion as specified in the respective items or as directed by the Engineer-in-charge.

(c) For pointing, mortar shall be filled and pressed into the raked-out joints before giving the required finish. Superfluous mortar shall be cut off from the edges of the lines and the surface of the masonry shall also cleared of all mortar.

(d) Curing shall be started as soon as the mortar used for finishing has hardened sufficiently not to be damaged when watered. It shall be kept wet for a period of at least 21 days. During this period, it shall be suitably protected from all damages.

2.6.6 MEASUREMENT AND PAYMENT

Measurement for payment of the pointing work shall be on square meter basis. Payment will be made at the unit rate for pointing as per BOQ which shall include the cost of all labour, materials, tools, scaffolding curing and other expenses incidental to the work.

2.7.5 TEST FOR MORTAR FOR CONSTRUCTION OF MASONRY

(a) At least one set of test cubes of cement mortar used shall be taken for each day's work and it shall be tested for 28 days strength.

(b) From the design mortar mix, cubes using the material shall be cast in the laboratory at suitable intervals and their strength be determined. This strength shall be deemed as the standard strength for that mortar. The strength of the test cubes shall be found out and shall not be less than 80% of the standard strength mentioned above. For acceptance, the 28 days strength of test cubes shall be the criteria, 80 percent of the test cubes should satisfy the above criteria. All laboratory testing work shall be carried out by the department as per relevant Indian standards and the contractor shall be permitted to watch the test if he so desires. The Cost of testing be borne by the Department.

2.8 REVETMENT AND PITCHING

2.8.1 GENERAL

- a) The bed or slope to receive the pitching or revetment shall be prepared true to line and grade and shall be moistened and well rammed so as to present a clear uniform compact surface.
- b) The stones shall be hard, sound and durable and as regular in shape as possible and with length not less than specified. Each stone shall not be less in size than 0.015 cum unless otherwise specified or ordered by the Engineer-in-charge, having regard to nature of the stone obtainable in the approved source. For revetment only the size stones shall be used.
- c) The stones shall be laid closely in position on the prepared bed and firmly set with their narrowest end downwards, and level with the finished surface of the pitching. The stones shall be laid breaking joint as far as possible, in the direction of flow of water. The stones are to be placed perpendicular to the finished surface. i.e. perpendicular to the slope for revetments and to the specified thickness.
- d) The interstices between adjacent stones shall be filled in with stone spalls of the, proper size, well driven in with crowbars to ensure tight packing and complete filling of all interstices. Such filling shall be carried on simultaneously with the placing in position of the large stones and shall in no case be permitted to fall behind. The final wedging shall be done only after obtaining the orders of the Engineer-in-charge. The final wedging shall be done with the largest sized chips practicable;

each chip being well driven with a hammer so that no chip is possible at being picked up or removed by hand.

- e) Profiles of string and pegs are to be put up to ensure that the pitching is done true, straight, and to the proper slope throughout and revetments in all cases are to be built up from the foot of the bank to be reverted.
- f) On completion, the surface presented by the apron or revetment shall be even throughout, free from irregularities, to the required length, breadth and slope specified as shown in the drawings.
- g) When use of rubble of canal spoils is specified, rubble required for the work shall be issued at the nearest available stacks of the excavated materials of the canal in the reach concerned or in any of the adjoining reaches if available. The contractor shall sort out useful rubble, hammer dress to the required size shape and convey the same to the work spot at his cost.

2.8.2 MEASUREMENT AND PAYMENT

Payment shall be made on volumetric basis in cum of the pitching and revetment as in BOQ. The unit rate quoted shall include the cost and conveyance of rubble, preparation of bed, laying and packing of rubble in accordance with the above specification to specified thickness, and all other incidental charges.

2.9 BACK-FILL IN FOUNDATION TRENCHES AND AROUND STRUCTURES

2.9.1 GENERAL

- a) The type of material used for backfilling and manner of depositing the material, shall be subject to approval. As far as practicable, backfill material shall be obtained from the excavating for structures or from adjacent canal excavation or from excavation of other ancillary works.
- b) Back-fill material shall contain no stones larger than 7.5 cms. size, or as prescribed by Engineer-in-charge.
- c) The backfill material shall be placed to the lines and grades as shown on the drawings or as prescribed in this paragraph or as directed by the Engineer-in-charge.
- d) The backfill material shall be placed carefully and spread in uniform layers of specified thickness and each layer will be moistened and compacted to required degree of compaction at specified moisture contents. The backfill shall be brought up as uniformly as practicable on the both sides of walls and all sides of structures to prevent unequal loading. The backfill material shall be placed at about the same elevation on both side of the pipe portions of the structures and culverts and difference in elevation shall not exceed 15 cms. at any time. The contractor shall be responsible for providing adequate earth cover wherever necessary such as over the pipes or pipe culverts, to prevent damage due to loads of construction equipment.
- e) If a haul road is built over a pipe, all backfill around and over the pipe shall be placed to a uniform surface and no humps or depressions shall be permitted at the pipe crossings.

2.9.2 COMPACTION OF BACKFILL

- a) When compacting soil against abutment of masonry or concrete structures, width to an extent of 0.6 mtr. shall be compacted with pneumatic tampers. Roller shall not be used close to structures to avoid damage. The size and weight of compacting equipment shall depend on nature of material, the height and load assumed in design of a structure. The backfill close to the structure up to the rolled layer shall be compacted in suitable uniform layers, using pneumatic tampers to a dry density of at least 80% of standard proctor. The moisture content of the earth fill placed against the rock or the structures shall be about 2% higher than O.M.C. to allow for penetration into cavities. Compaction at joints of earthwork and backfill around structures shall be carried out with special care without claiming any extra cost.
- b) The back filling above the structure shall be done initially by spreading layers not exceeding in thickness compaction has to be done by pneumatic tamper .this method of back filling is to be continued till the filling reaches a height of not less than 0.6 mts above the highest level on the structure . it is only after this back filling in regular layers and compaction by power rollers in the case of embankment will be permitted.

2.9.3 MEASUREMENT AND PAYMENT

- a) Measurement for payment, for backfill in foundation trenches and around structures shall be made restricting to the pay lines shown on the drawings. Any over excavation and consequent extra backfill outside pay lines will be at the cost of the contractor. The payment shall be made on a volumetric basis under the relevant items of schedule BOQ.

2.10 QUALITY CONTROL

- a) Upon the award of the contract, SWIM will provide all the necessary Quality Control related plans, checklists and forms which shall be firmly followed by the vendor during the implementation of this project. The vendor shall provide Quality Control Manager responsible for Quality Control and Management related activities of the project. The SWIM QA/QC Manager and specifically the SWIM QA/QC/field/site engineer will make sure that all QA/QC related activities are fully enforced by the vendor at the SWIM project site.

2.11 HEALTH & SAFETY AND ENVIRONMENTAL REQUIREMENTS

- a) The vendor shall strictly follow the SWIM Health & Safety and Environmental & Social related procedures, plans, forms, checklist to mitigate any safety and environmental & social issues at the project site which will be provided by SWIM after the award of contract. The vendor shall provide and equip the construction workers with Personal Protective Equipment (PPE) and other tools and equipment's necessary for Health and Safety at the project site during the canal rehabilitation. The vendor is required to hire and allocate Health & Safety and Environmental Compliance Manager to look after the day to day activities for this purpose. The SWIM Health and Safety and Environmental

Compliance Specialist and specifically the SWIM field/site engineer will make sure that the environmental and social aspects are fully enforced by the vendor at the SWIM project site.

ATTACHMENT B

3. BILL OF QUANTITIES

3.1 GENERAL CONDITIONS FOR SETTING PRICES

- a) Unit prices set by the Contractor in the price schedule are considered to include all constraints, particularly:
- Consequences relating to conditions, instructions, obligations, commitments and constraints of any nature appearing in the contract documents and annexes.
 - Services of any nature defined in this document.
 - Expenditures and allowances of any nature which will result from provisional works and provisional installations that are compulsory for the execution of the contract, including supply, installation, maintenance, supervision and the removal of installations from the site, as well as the cleaning and refurbishment of the places at the completion of works. Such works and installations include the following, the list being non-exhaustive: access roads, provisional setting of concrete, stocks for materials, building sites, offices, accommodation houses for the personnel, sickroom, workshops, canteen.
 - Costs for setting up longitudinal profiles, execution plans and detailed plans used on the building site as well as the names of steels for the formwork of the reinforced concrete based on drawings annexed to the present tender document, as well as possible amendments or adaptations which will be suggested by the SWIM; the setting up of longitudinal and transversal profiles and their surveys, and the external boundary marking of the site.
 - Topographic surveys, which are needed for the completion of works and for all verifications and controls of works apart from the ones provided in the price schedule.
 - Costs for elaboration and submission of 3 copies of a detailed qualitative and quantitative progress of works carried out during the month to the Project Owner, at the end of every month, accompanied by a detailed plan of activities which the Contractor intends to carry out during the next month. Those documents will be written English language.

- All expenses such as: general expenses, office expenses, building site expenses, incidental expenses, insurances, taxes, dues, social contributions, advances, interests, DBA costs
 - All expenses generally incurred by full completion of works in accordance with regulations indicated in contract documents or their annexes, according to art regulations and with the satisfaction of the Engineer, and possible repairs during the guarantee period, as stipulated in the contract documents or in their annexes.
- b) It is clearly specified that, whatever the way the unit prices are described in the price schedule, or in articles below, the prices of the Contractor must include expenses of all kinds and must take into account unforeseen expenses and risks of all kinds resulting from full completion of works. The Contractor will claim for any allowance, additional payment, and extension of time, for any work or method of execution which was supposed to be described in the contract and in its annexes, or which could reasonably be concluded from reading these documents and their annexes, but which does not explicitly appear in the price schedule and in the detailed estimates. The prices corresponding to mixed operations or works will have to take into account the full execution of all operations or their constituting parts, even if they are not specifically described in the contract documents and their annexes.
- c) The Contractor's attention is drawn to the fact that the quantities that appear in the detailed estimates are only provisional quantities, which should not be regarded as lower or higher limits of works carried out by the Contractor. The real quantities used will be measured and paid in accordance with regulations of contract documents and their annexes, which will be adjusted accordingly.
- d) The Contractor will have to write down the unit price he / she requests for every heading of detailed estimates and price schedule, as well as the total amount obtained by multiplying this price by the quantity mentioned in the corresponding heading, except for fixed amount for which the Contractor will write down the overall sum which remunerates the corresponding works or services.
- e) The fixed amount written by the Contractor will be considered to cover all the expenses and charges related to the full execution of works mentioned under those headings, the Contractor being held responsible to have determined all constraints and risks corresponding to such natures of works.
- f) The Contractor will not modify the provisional quantities registered by the Administration for the estimated period. He / she will

imperatively have to take them into account while estimating the total amount for works. If the Contractor thinks that the quantity indicated in the detailed estimates is not correct, he / she will mention it in an additional note.

- g) If the Contractor leaves out one or several unit prices in the detailed estimates which he / she would have indicated in the price schedule, the Administration will automatically do the corresponding carry-over and will accordingly modify the total amount of the bid provided by the Contractor.
- h) For the same price, in case of difference between the amount in letters and the amount in figures, only the amount in letters prevails and necessary corrections will be made if need be.
- i) By elaborating his/her bidding documents, the Contractor is supposed to be informed about the places and to have examined and estimated his/her points of view on all conditions and constraints relating to works to be carried out and in general on whatever can have influence on the execution costs. The methods applied to bills of quantities and to payment of the executed works, which are specified in the price schedule, will be the only ones to be applied for the evaluation of works done by the Contractor.
- j) Except in cases mentioned clearly in the parts of the contract, the quantities which will be considered for the payment of works will be the ones resulting from the implementation plans approved by the Engineer and from the topographical surveys of the original ground carried out contradictorily between the Engineer and the Contractor. In any case, it will neither take into account the specific estimation methods which would have been adopted locally for works of the same nature, nor the out-profiles and/or work which would not have been, preliminary, subject to a written authorization of the Engineer.
- k) The Contractor shall submit the Bill of Quantities and Summary:

3.2 FORMAT OF BILL OF QUANTITIES

- a) The Offeror shall complete the pricing format detailing the cost elements that comprise the fixed-price offer prepared in accordance with the instructions, terms and conditions, scope of work and specifications herein.
- b) The quantities set forth in the Bill of Quantities (BOQ) are believed to represent the character of the work to be carried out and are given for the purpose of enabling SWIM to compare Tenders on an equal basis. There is no guarantee to the Offeror that it will be required to carry out the quantities of work indicated under any one particular Item or group of Items in the Bill of Quantities, although in the Subcontract as a whole the quantities are believed to represent the overall value of the work

to be carried out. If specific items are missing from the BOQ, the Offeror is required to identify and price accordingly.

- c) The prices and rates proposed by the Offeror and inserted in the Bill of Quantities will be used for valuing the work proposed and may be used by SWIM to measure additional requirements to the scope of work of the subcontract.
- d) The prices and rates proposed by the Offeror and inserted in the Bill of Quantities are to be the full inclusive costs of the work described under the Items, complete in place and in accordance with the Specifications, including all costs and expenses which may be required in and for the construction of the work described, together with any temporary work and installation which may be necessary and all general risks, liabilities, and obligations set forth or implied in the documents on which the tender is based.
- e) The brief description of the Items given in the Bill of Quantities are purely for the purpose of identification and in no way modify or supersede the detailed descriptions given in the Scope of Work, Specifications, Drawings, and subcontract terms and conditions. When pricing Items, reference is to be made to the Scope of Work, Specifications and Drawings, and subcontract terms and conditions for the full directions and descriptions of work and materials.



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SUB-BoQ FOR CHOCHMAN MAIN CANAL REHABILITATION IN KHULM DISTRICT, SAMANGAN PROVINCE.

BILL NO:1 Sub-BoQ, Structure (1 of 12): Foot Culvert Deh-Naw Branch

SI	Item Description	Unit	Quantity	Unit Cost (AFS)	Total Cost (AFS)	Remarks
1	Soil Excavation: Excavation in ordinary soil (in Canal/Riverbed etc.) in all kind of soil including, dewatering and transferring the disposal of surplus material away from the site to a distance as recommended by the engineer. Earthwork in excavation in foundation, ramming the bottom, stacking to the excavation all complete.	M ³	21.00			
2	Compacted Backfilling: Backfilling with selected material from excavation or borrow pits from approved source including compaction (The percentage of compaction shall be not less than 95% of MDD for load bearing structures and at least 80% of MDD for structures in agricultural areas.) of modified proctor in layers not more than 15 cm thick in accordance to the specification and satisfaction of the SWIM engineers.	M ³	23.00			
3	Reinforcement Cement Concrete 25Mpa Supplying, placing, compacting and curing including formworks rebar cutting bending & binding by G.I wire of reinforcement steel bars for RCC works as per relevant drawings, specification and to the complete satisfaction of the engineer. This activity will also include the demolishing of existing concrete structures, disposal of surplus material etc. as per Engineer direction.	M ³	2.00			
4	2" Galvanized Guardrail: Supply/Fabrication and Installation of steel gate including three coats of enamel paint (one coat of red oxide two coat of enamel paint), Labor and \material as per relevant drawing, Technical specification with all required activities	M ²	13.00			
Grand Total Sub-BoQ						



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SUB-BoQ FOR CHOCHMAN MAIN CANAL REHABILITATION IN KHULM DISTRICT, SAMANGAN PROVINCE.

BILL NO:2_Sub-BoQ, Structure (2 of 12): Box Culvert Deh-Naw Branch

SI	Item Description	Unit	Quantity	Unit Cost (AFS)	Total Cost (AFS)	Remarks
1	Soil Excavation: Excavation in ordinary soil (in Canal/Riverbed etc.) in all kind of soil including, dewatering and transferring the disposal of surplus material away from the site to a distance as recommended by the engineer. Earthwork in excavation in foundation, ramming the bottom, stacking to the excavation all complete.	M ³	97.00			
2	Compacted Backfilling: Backfilling with selected material from excavation or borrow pits from approved source including compaction (The percentage of compaction shall be not less than 95% of MDD for load bearing structures and at least 80% of MDD for structures in agricultural areas.) of modified proctor in layers not more than 15 cm thick in accordance to the specification and satisfaction of the SWIM engineers.	M ³	107.00			
3	Reinforcement Cement Concrete 25Mpa: Supplying, placing, compacting and curing including formworks rebar cutting bending & binding by G.I wire of reinforcement steel bars for RCC works as per relevant drawings, specification and to the complete satisfaction of the engineer. This activity will also include the demolishing of existing concrete structures, disposal of surplus material etc. as per Engineer direction.	M ³	30.00			
4	Water Stopper: Provide all necessary materials, equipment , labors and other required tools for supply and installation of best quality PVC water stopper with (W≥20cm) width as per relevant design drawings, technical specification and with all required activities.	M	16.00			
5	Joints: Joint filler and joint sealer as specified in drawing and technical specification.	M	16.00			
6	Wheep Hole: Provide and installation of PVC pipe weep holes in stone masonry in accordance to the drawings, specification and complete satisfaction of the SWIM engineers	M	8.00			
Grand Total Sub-BoQ						



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SUB-BoQ FOR CHOCHMAN MAIN CANAL REHABILITATION IN KHULM DISTRICT, SAMANGAN PROVINCE.

BILL NO:3_Sub-BoQ, Structure (3 of 12): Public Utility Structure Deh-Naw Branch

SI	Item Description	Unit	Quantity	Unit Cost (AFS)	Total Cost (AFS)	Remarks
1	Reinforcement Cement Concrete 25Mpa: Supplying, placing, compacting and curing including formworks rebar cutting bending & binding by G.I wire of reinforcement steel bars for RCC works as per relevant drawings, specification and to the complete satisfaction of the engineer. This activity will also include the demolishing of existing concrete structures, disposal of surplus material etc. as per Engineer direction.	M ³	3.00	1		
2	Gravelling: Supplying, laying, moistening and compacting course aggregates under PCC on the bottom of the foundation in accordance to the relevant design drawings, technical specification with all required activities.	M ³	2.00			
Grand Total Sub-BoQ						



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SUB-BoQ FOR CHOCHMAN MAIN CANAL REHABILITATION IN KHULM DISTRICT, SAMANGAN PROVINCE.

BILL NO:4 Sub-BoQ, Structure (4 of 12): Lining Deh-Naw Branch

SI	Item Description	Unit	Quantity	Unit Cost (AFS)	Total Cost (AFS)	Remarks
1	Soil Excavation: Excavation in ordinary soil (in Canal/Riverbed etc.) in all kind of soil including, dewatering and transferring the disposal of surplus material away from the site to a distance as recommended by the engineer. Earthwork in excavation in foundation, ramming the bottom, stacking to the excavation all complete.	M ³	26697.00			
2	Compacted Backfilling: Backfilling with selected material from excavation or borrow pits from approved source including compaction (The percentage of compaction shall be not less than 95% of MDD for load bearing structures and at least 80% of MDD for structures in agricultural areas.) of modified proctor in layers not more than 15 cm thick in accordance to the specification and satisfaction of the SWIM engineers.	M ³	23730.00			
3	Reinforcement Cement Concrete 25Mpa Supplying, placing, compacting and curing including formworks rebar cutting bending & binding by G.I wire of reinforcement steel bars for RCC works as per relevant drawings, specification and to the complete satisfaction of the engineer. This activity will also include the demolishing of existing concrete structures, disposal of surplus material etc. as per Engineer direction.	M ³	3390.00			
4	Stone Pitching: Supplying and placing the stone of approved quality, in accordance to the relevant drawings, specification and as per the complete satisfaction of the engineer.	M ³	1			
5	Plain Cement Concrete 20Mpa : Supplying, placing, compacting and curing PCC Class 20Mpa including formworks as per relevant drawings, specification and to the complete satisfaction of engineer.	M ³	859.00			
6	Gravelling: Supplying, laying, moistening and compacting course aggregates under PCC on the bottom of the foundation in accordance to the relevant design drawings, technical specification with all required activities.	M ³	752.00			
7	Water Stopper: Provide all necessary materials, equipment , labors and other required tools for supply and installation of best quality PVC water stopper with (W≥20cm) width as per relevant design drawings, technical specification and with all required activities.	M	1508.00			
8	Joints: Joint filler and joint sealer as specified in drawing and technical specification.	M	1508.00			
Grand Total Sub-BoQ						



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SUB-BoQ FOR CHOCHMAN MAIN CANAL REHABILITATION IN KHULM DISTRICT, SAMANGAN PROVINCE.

BILL NO:5 Sub-BoQ, Structure (5 of 12): Turnout Deh-Naw Branch

SI	Item Description	Unit	Quantity	Unit Cost (AFS)	Total Cost (AFS)	Remarks
1	Soil Excavation: Excavation in ordinary soil (in Canal/Riverbed etc.) in all kind of soil including, dewatering and transferring the disposal of surplus material away from the site to a distance as recommended by the engineer. Earthwork in excavation in foundation, ramming the bottom, stacking to the excavation all complete.	M ³	163.00			
2	Compacted Backfilling: Backfilling with selected material from excavation or borrow pits from approved source including compaction (The percentage of compaction shall be not less than 95% of MDD for load bearing structures and at least 80% of MDD for structures in agricultural areas.) of modified proctor in layers not more than 15 cm thick in accordance to the specification and satisfaction of the SWIM engineers.	M ³	136.00			
3	Plain Cement Concrete 20Mpa : Supplying, placing, compacting and curing PCC Class 20Mpa including formworks as per relevant drawings, specification and to the complete satisfaction of engineer.	M ³	7.00			
4	Reinforcement Cement Concrete 25Mpa: Supplying, placing, compacting and curing including formworks rebar cutting bending & binding by G.I wire of reinforcement steel bars for RCC works as per relevant drawings, specification and to the complete satisfaction of the engineer. This activity will also include the demolishing of existing concrete structures, disposal of surplus material etc. as per Engineer direction.	M ³	67.00			
5	Stone Pitching: Supplying and placing the stone of approved quality, in accordance to the relevant drawings, specification and as per the complete satisfaction of the engineer.	M ³	17			
6	Gravelling: Supplying, laying, moistening and compacting course aggregates under PCC on the bottom of the foundation in accordance to the relevant design drawings, technical specification with all required activities.	M ³	6.00			
7	Steel Gate size (115*80) cm: Supply/Fabrication and Installation of Steel gate including three coats of enamel paint (one coat of red oxide+ two coat of enamel paint), Labor and Material as per relevant drawing, Technical specification with all required activities.	Pcs	6.00			
	Steel Gate size (155*100) cm: Supply/Fabrication and Installation of Steel gate including three coats of enamel paint (one coat of red oxide+ two coat of enamel paint), Labor and Material as per relevant drawing, Technical specification with all required activities.	Pcs	6.00			
Grand Total Sub-BoQ						



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SUB-BoQ FOR CHOCHMAN MAIN CANAL REHABILITATION IN KHULM DISTRICT, SAMANGAN PROVINCE.

BILL NO:6 Sub-BoQ, Structure (6 of 12): Lining Chochman Branch

SI	Item Description	Unit	Quantity	Unit Cost (AFS)	Total Cost (AFS)	Remarks
1	Soil Excavation: Excavation in ordinary soil (in Canal/Riverbed etc.) in all kind of soil including, dewatering and transferring the disposal of surplus material away from the site to a distance as recommended by the engineer. Earthwork in excavation in foundation, ramming the bottom, stacking to the excavation all complete.	M ³	16354.00			
2	Compacted Backfilling: Backfilling with selected material from excavation or borrow pits from approved source including compaction (The percentage of compaction shall be not less than 95% of MDD for load bearing structures and at least 80% of MDD for structures in agricultural areas.) of modified proctor in layers not more than 15 cm thick in accordance to the specification and satisfaction of the SWIM engineers.	M ³	13792.00			
3	Plain Cement Concrete 20Mpa: Supplying, placing, compacting and curing PCC M20 Mpa including formworks as per relevant drawings, specification and to the complete satisfaction of engineer.	M ³	699.00			
4	Reinforcement Cement Concrete 25Mpa: Supplying, placing, compacting and curing including formworks, rebar cutting bending & binding by G.I wire of reinforcement steel bars for R.C.C works as per relevant drawings, specification and to the complete satisfaction of the engineer. This activity will also include the demolishing of existing concrete structures, disposal of surplus material etc. as per engineer direction.	M ³	2760.00			
5	Stone Pitching: Supplying and placing the stone of approved quality, in accordance to the relevant drawings, specification and as per the complete satisfaction of the engineer.	M ³	1			
6	Gravelling: Supplying, laying, moistening and compacting course aggregates under PCC on the bottom of the foundation in accordance to the	M ³	612.00			
7	Water Stopper: Provide all necessary materials, equipment, labors and other required tools for supply and installation of best quality PVC water stopper with (W≥20cm) width as per relevant design drawings, technical specification and with all required activities.	M	1228.00			
8	Joints: Joint filler and joint sealer as specified in drawing and technical specification.	M	1228.00			
Grand Total Sub-BoQ						



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SUB-BoQ FOR CHOCHMAN MAIN CANAL REHABILITATION IN KHULM DISTRICT, SAMANGAN PROVINCE.

BILL NO:7 Sub-BoQ, Structure (7 of 12): Box Culvert Chochman Branch

SI	Item Description	Unit	Quantity	Unit Cost (AFS)	Total Cost (AFS)	Remarks
1	Reinforcement Cement Concrete 25Mpa: Supplying, placing, compacting and curing including formworks, rebar cutting bending & binding by G.I wire of reinforcement steel bars for R.C.C works as per relevant drawings, specification and to the complete satisfaction of the engineer. This activity will also include the demolishing of existing concrete structures, disposal of surplus material etc. as per engineer direction.	M ³	40.00			
2	Water Stopper: Provide all necessary materials, equipment, labors and other required tools for supply and installation of best quality PVC water stopper with (W≥20cm) width as per relevant design drawings, technical specification and with all required activities.	M	20.00			
3	Joints: Joint filler and joint sealer as specified in drawing and technical specification.	M	20.00			
4	Weep Hole: Provide and installation of PVC pipe weep holes in stone masonry in accordance to the drawings, specification and complete satisfaction of the SWIM engineers	M	10.00			
Grand Total Sub-BoQ						



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SUB-BoQ FOR CHOCHMAN MAIN CANAL REHABILITATION IN KHULM DISTRICT, SAMANGAN PROVINCE.

BILL NO:8 Sub-BoQ, Structure (8 of 12): Foot Culvert Chochman Branch

SI	Item Description	Unit	Quantity	Unit Cost (AFS)	Total Cost (AFS)	Remarks
1	Reinforcement Cement Concrete 25Mpa: Supplying, placing, compacting and curing including formworks, rebar cutting bending & binding by G.I wire of reinforcement steel bars for R.C.C works as per relevant drawings, specification and to the complete satisfaction of the engineer. This activity will also include the demolishing of existing concrete structures, disposal of surplus material etc. as per engineer direction.	M ³	1.00			
2	2" Galvanized Guardrail: Supply/Fabrication and Installation of steel gate including three coats of enamel paint (one coat of red oxide two coat of enamel paint), Labor and material as per relevant drawing, Technical specification with all required activities	M ²	10.00			
Grand Total Sub-BoQ						



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SUB-BoQ FOR CHOCHMAN MAIN CANAL REHABILITATION IN KHULM DISTRICT, SAMANGAN PROVINCE.

BILL NO:9 Sub-BoQ, Structure (9 of 12): Drain Inlet Chochman Branch

SI	Item Description	Unit	Quantity	Unit Cost (AFS)	Total Cost (AFS)	Remarks
1	Soil Excavation: Excavation in ordinary soil (in Canal/Riverbed etc.) in all kind of soil including, dewatering and transferring the disposal of surplus material away from the site to a distance as recommended by the engineer. Earthwork in excavation in foundation, ramming the bottom, stacking to the excavation all complete.	M ³	58.00			
2	Compacted Backfilling: Backfilling with selected material from excavation or borrow pits from approved source including compaction (The percentage of compaction shall be not less than 95% of MDD for load bearing structures and at least 80% of MDD for structures in agricultural areas.) of modified proctor in layers not more than 15 cm thick in accordance to the specification and satisfaction of the SWIM engineers.	M ³	56.00			
3	Plain Cement Concrete 20Mpa: Supplying, placing, compacting and curing PCC M20 Mpa including formworks as per relevant drawings, specification and to the complete satisfaction of engineer.	M ³	3.00			
4	Reinforcement Cement Concrete 25Mpa: Supplying, placing, compacting and curing including formworks, rebar cutting bending & binding by G.I wire of reinforcement steel bars for R.C.C works as per relevant drawings, specification and to the complete satisfaction of the engineer. This activity will also include the demolishing of existing concrete structures, disposal of surplus material etc. as per engineer direction.	M ³	10.00			
5	Stone Pitching: Supplying and placing the sone of approved quality, in accordance to the relevant drawings, specification and as per the complete satisfaction of the engineer.	M ³	7			
6	Gravelling: Supplying, laying, moistening and compacting course aggregates under PCC on the bottom of the foundation in accordance to the relevant design drawings, technical specification with all required activities.	M ³	3.00			
Grand Total Sub-BoQ						



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SUB-BoQ FOR CHOCHMAN MAIN CANAL REHABILITATION IN KHULM DISTRICT, SAMANGAN PROVINCE.

BILL NO:10 Sub-BoQ, Structure (10 of 12): Public Utility Structure Chochman Branch

SI	Item Description	Unit	Quantity	Unit Cost (AFS)	Total Cost (AFS)	Remarks
1	Reinforcement Cement Concrete 25Mpa: Supplying, placing, compacting and curing including formworks, rebar cutting bending & binding by G.I wire of reinforcement steel bars for R.C.C works as per relevant drawings, specification and to the complete satisfaction of the engineer. This activity will also include the demolishing of existing concrete structures, disposal of surplus material etc. as per engineer direction.	M ³	3.00			
2	Gravelling: Supplying, laying, moistening and compacting course aggregates under PCC on the bottom of the foundation in accordance to the relevant design drawings, technical specification with all required activities.	M ³	1.00			
Grand Total Sub-BoQ						



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SUB-BoQ FOR CHOCHMAN MAIN CANAL REHABILITATION IN KHULM DISTRICT, SAMANGAN PROVINCE.

BILL NO:11 Sub-BoQ, Structure (11 of 12): Turnout Chochman Branch

SI	Item Description	Unit	Quantity	Unit Cost (AFS)	Total Cost (AFS)	Remarks
1	Soil Excavation: Excavation in ordinary soil (in Canal/Riverbed etc.) in all kind of soil including, dewatering and transferring the disposal of surplus material away from the site to a distance as recommended by the engineer. Earthwork in excavation in foundation, ramming the bottom, stacking to the excavation all complete.	M ³	950.00			
2	Compacted Backfilling: Backfilling with selected material from excavation or borrow pits from approved source including compaction (The percentage of compaction shall be not less than 95% of MDD for load bearing structures and at least 80% of MDD for structures in agricultural areas.) of modified proctor in layers not more than 15 cm thick in accordance to the specification and satisfaction of the SWIM engineers.	M ³	792.00			
3	Plain Cement Concrete 20Mpa: Supplying, placing, compacting and curing PCC M20 Mpa including formworks as per relevant drawings, specification and to the complete satisfaction of engineer.	M ³	40.00			
4	Reinforcement Cement Concrete 25Mpa: Supplying, placing, compacting and curing including formworks, rebar cutting bending & binding by G.I wire of reinforcement steel bars for R.C.C works as per relevant drawings, specification and to the complete satisfaction of the engineer. This activity will also include the demolishing of existing concrete structures, disposal of surplus material etc. as per engineer direction.	M ³	346.00			
5	Stone Pitching: Supplying and placing the sone of approved quality, in accordance to the relevant drawings, specification and as per the complete satisfaction of the engineer.	M ³	92			
6	Gravelling: Supplying, laying, moistening and compacting course aggregates under PCC on the bottom of the foundation in accordance to the relevant design drawings, technical specification with all required activities.	M ³	35.00			
7	Steel Gate size (115*80) cm: Supply/Fabrication and Installation of Steel gate including three coats of enamel paint (one coat of red oxide+ two coat of enamel paint), Labor and Material as per relevant drawing, Technical specification with all required activities.	Pcs	31.00			
8	Steel Gate size (155*100) cm: Supply/Fabrication and Installation of Steel gate including three coats of enamel paint (one coat of red oxide+ two coat of enamel paint), Labor and Material as per relevant drawing, Technical specification with all required activities.	Pcs	31.00			
Grand Total Sub-BoQ						



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SUB-BoQ FOR CHOCHMAN MAIN CANAL REHABILITATION IN KHULMN DISTRICT, SAMANGAN PROVINCE.

BILL NO:12 Sub-BoQ, Structure (12 of 12): Slab Culvert Chochman Branch

Sl	Item Description	Unit	Quantity	Unit Cost (AFS)	Total Cost (AFS)	Remarks
1	Soil Excavation: Excavation in ordinary soil (in Canal/River bed etc.) in all kind of soil including, dewatering and transferring the disposal of surplus material away from the site to a distance as recommended by the engineer. Earthwork in excavation in foundation , ramming the bottom, stacking of the excavation, all complete.	M ³	81.00			
2	Compacted Backfilling: Backfilling with selected material from excavation or borrow pits from approved source including compaction (The percentage of compaction shall be not less than 95% of MDD for load bearing structures and at least 80% of MDD for structures in agricultural areas.) of modified proctor in layers not more than 15 cm thick in accordance to the specification and satisfaction of the SWIM engineers.	M ³	59.00			
3	Stone Masonry (1:4): Providing and laying of mineral Stone masonry with cement sand mortar 1:4 as per relevant drawings. This activity will also include the demolishing of existing concrete structures, disposal of surplus material etc. as per Engineer direction. Specifications and to the complete satisfaction of the SWIM Engineers.	M ³	30.00			
4	Plain Cement Concrete 20Mpa: Supplying, placing, compacting and curing PCC M20 Mpa including formworks as per relevant drawings, specification and to the complete satisfaction of engineer.	M ³	1.00			
5	Reinforcement Cement Concrete 25Mpa: Supplying, placing, compacting and curing including formworks, rebar cutting bending & binding by G.I wire of reinforcement steel bars for R.C.C works as per relevant drawings, specification and to the complete satisfaction of the engineer. This activity will also include the demolishing of existing concrete structures, disposal of surplus material etc. as per engineer direction.	M ³	4.00			
6	Gravelling: Supplying, laying, moistening and compacting of base course material (Crush aggregates) under PCC on the bottom of the foundation in accordance to the relevant design drawings, technical specification with all required activities.	M ³	2.00			
Grand Total Sub-BoQ					-	

Bill No 13: Miscellaneous Works

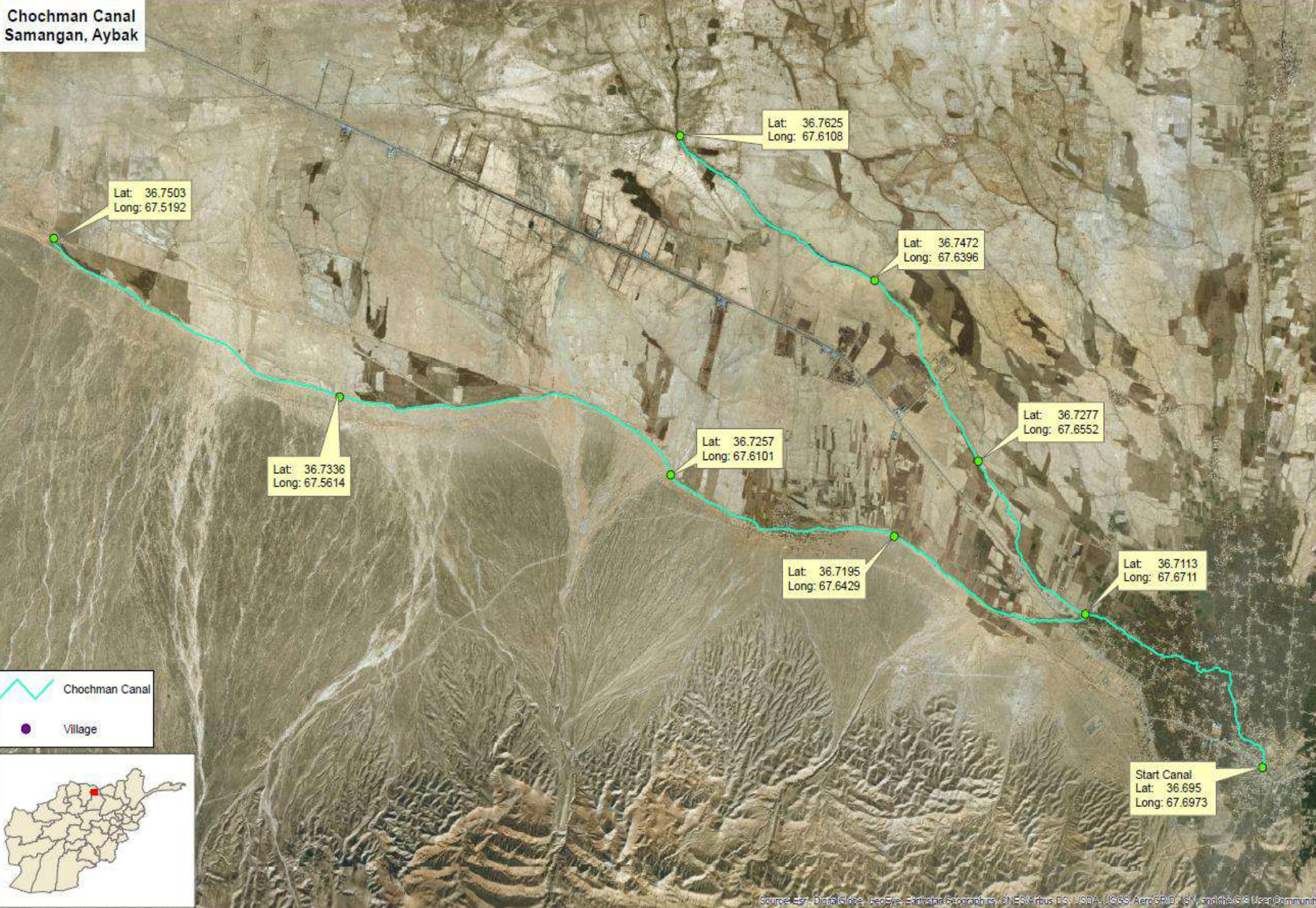
Sl	Item Description	Unit	Quantity	Unit Cost (AFN)	Total Cost (AFN)
1	Mobilization: Mobilization shall include all activities and associated tasks for transportation of contractor's personnel, equipment, and operating supplies to the site; establishment of offices, buildings, and other necessary general facilities for the contractor's operations at the construction site	LS	1		
2	Diversion and Dewatering: Diversion and dewatering throughout the sub-project during whole period of project performance as recommended by the SWIM engineer.	LS	1		
3	Health & Safety and Environmental Requirements: The vendor shall provide and equip the construction workers with Personal Protective Equipment (PPE) and other tools and equipment's necessary for Health and Safety at the project site during the canal rehabilitation	LS	1		
4	Quality Control: - The vendor shall properly control and manage the quality of the work according to the SWIM Quality Control plan and other related documents including carrying necessary tests in second party laboratory as specified in the technical specifications.	LS	1		
5	Sign Board: Supply and installation of the project sign board as per drawing dimension	Pcs	1		
6	Demobilization and site clearances: Provide all necessary labor, equipment and materials to the disposal of any materials, wastes, effluents, trash, garbage, oil, grease, chemicals, and similar extra excavated soil, shrubs, Trees, hazardous substances after completion of construction works, it must be transported to a suitable disposal site by the Contractor.	LS	1		
	SUBTOTAL Carried to Summary				

SUMMARY OF BILLS		
BILL #	BILL DESCRIPTION	AMOUNT IN AFN
1	Rehab/Cons of Foot Culvert, Deh-Naw Branch	
2	Rehab/Cons of Box Culvert Deh-Naw Branch	
3	Rehab/Cons of Public Utility Structure Deh-Naw Branch	
4	Rehab/Cons of Lining Deh-Naw Branch	
5	Rehab/Cons of Turnouts Deh-Naw Branch	
6	Rehab/Cons of Lining Chochman Branch	
7	Rehab/Cons of Box Culvert Chochman Branch	
8	Rehab/Cons of Foot Culvert Chochman Branch	
9	Rehab/Cons of Drain Inlet Chochman Branch	
10	Rehab/Cons of Public Utility Structure Chochman Branch	
11	Rehab/Cons of Turnouts Chochman Branch	
12	Rehab/Cons of Slab Culvert Chochman Branch	
13	Miscellaneous works	
	GRAND TOTAL	

ATTACHMENT C

DRAWINGS AND MAP

**Chochman Canal
Samangan, Aybak**



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

MAP INFORMATION
Map Produced : Jan 2020
Cartographer: Abdul Razaq
Projection : World Mercator
Datum : WGS 1984

Data Source
Base layer information including boundaries and place names courtesy of the Afghan Geodesy and Cartography Head Office (AGCHO).

Data Disclaimer
All boundaries and map features are approximate and should not be considered authoritative. While every effort is made to use the best available data, accuracy of features or other information cannot be guaranteed. Map prepared by the SWIM Project GIS Department.



0 0.5 1 2 3 4 Kilometers