

CIVIL WORKS

1. INTRODUCTION

This section comprises the Standards and Specifications pertaining to the fundamental requirements of design, material, workmanship, construction, testing, inspection and maintenance of the Civil Works required or specified under the Contract. The Contractor shall perform the work in accordance with these specifications and other specifications supplemental to these specifications as may be specified by the Engineer from time to time. Should the Contractor follow other specifications, the Engineer prior to carrying out these works must approve these.

1.1 Works:

The Contractor shall carry out all the works required for the design, construction, completion and maintenance of the Civil Works required under the Contract including foundations, cable trenches, pavements, roads, buildings, drainage and other allied works as required or specified in the Contract and as shown in the drawings.

The prices of all additional works, which are not shown in "Price Schedule" but specified in the Contract Documents, shall be included in the prices of other items of "Prices Schedule". The Contractor shall not claim additional cost for any item, which is required to be executed as per Contract Documents but not specially mentioned in the "Price Schedule".

1.2 Materials:

The Contractor shall furnish all materials and equipments for the performance of civil work. Materials to be used for civil work shall conform to the relevant ASTM standards and specifications. However in case of using other standards, the Contractor shall obtain prior approval of the Engineer. In all matters relating to the acceptance or otherwise of the equipment and offered under this contract the decision of the Engineer shall be final. The Engineer shall have the right to reject any material and/or equipment, which do not meet the requirements of the Contract Documents. All rejected material or equipment shall be removed from the Site as soon as possible.

The Engineer reserves the right to witness any test on material if necessary. The Contractor shall provide proper facilities to witness tests and shall also bear all the expenses on this account. Should the Engineer require the detailed data on material, the Contractor shall furnish the same in writing to the Engineer.

2.0 DESIGN CONDITIONS

2.1 General

All drawings and statements shall be in English language and metric system of measurements shall be used. The following design conditions shall be used for the design of civil work and shall not be deviated unless approved by Engineer.

2.2 Design Condition

The values used in this project are as follows:

- | | | |
|-----|-----------------------------|---------------|
| i) | Seismic Coefficient: | |
| | Vertical | $K_v = 0.0$ |
| | Horizontal | $K_h = 0.1$ |
| ii) | Wind Load: | |
| | Wind pressure | $F_w = C_x q$ |

Where $q = 1/2 \rho V^2$

$p = \text{Air density/ acc.}(0.125 \text{ kg sec}^2/\text{m}^4)$

$V = \text{Wind velocity}$
(45m/sec)

$c = \text{Shape factor}$
(for circular equipment 0.8 & for Angular equipment)

2.3 Design of Foundations:

1) Geotechnical Investigations

The Contractor shall carry out the Geotechnical investigations at Site just after award of the Contract under the supervision of the Engineer to design the foundations. For this purpose the Contractor shall submit his proposal regarding the type of tests and their locations at Site for review/approval of the Engineer. After performing Geotechnical investigations, the Contractor shall submit Geotechnical investigation report and his recommendations for design of civil works for review/approval of the Engineer.

2) Foundations

All foundations shall be designed upto 200 mm or as shown in the drawings from top of gravel level, appropriate slope shall be provided on the top end of the foundation in order to ensure sufficient drainage. The load for design of foundation shall be taken from the foundation reactions calculated in the design of gantries and respective equipments after applying appropriate load factors. The Contractor shall submit to the Engineer for his approval calculations and load analysis used for design of gantries, equipment foundations and building works. The size and type of foundations i.e. spread footing, mat footing or pile foundations including soil replacement if any shall be based on Geotechnical Investigation Report. The gantry stubs and anchor bolts shall be available at Site before pouring of concrete for gantry and equipment foundations. If block outs are to be provided in the foundations due to any constraint, pre-mixed non-shrink grout shall be used for the embedment of stubs and anchor bolts as per approval of the Engineer.

3) Leveling Concrete

A leveling concrete shall be placed in thickness of 100mm or as shown in drawings.

2.4 Design Standard and Code

For foundations and building designs, the Contractor shall conform to the applicable requirements of the latest revisions of following standards and publications, in principle.

- 1) ASTM (American Society for Testing and Material)
- 2) ACI (American Concrete Institute)
- 3) BS (British Standards) – where specified only

2.5 Testing

In addition to following tests on coarse and fine aggregate to be used for constructions;

- (i) Specific gravity of aggregates
 - Coarse grading
 - Fine grading
- (ii) Unit weight
- (iii) Gradation analysis
- (iv) Flakiness and elongation indices
- (v) Log Angle Abrasion:
 - Coarse grading

- Fine grading
- (vi) Soundness
- (vii) Crushing
- (viii) Water absorption
- (ix) Aggregate impact value
- (x) ASR test for aggregates
- (xi) Petrographic test:
 - Fine aggregates
 - Coarse aggregates

The following chemical analysis shall be carried out for water to be used in concrete, ground water and for soils which are to come in contact with concrete:

- pH
- Chloride mg/litre
- Magnesium, mg/litre
- Ammonium, mg/litre
- Sulphate, mg/litre
- Potassium permanganate, mg/litre
- Total hardness milli equivalent/litre
- Non carbonates
- Carbonic acid

Cement to be used shall have an alkali content less than 0.5% of soda equivalent. Test reports for the tests carried out to verify the alkali contents shall be submitted to the Engineer for review and approvals.

The Contractor shall compare chemicals found in water, soil and construction material with those values allowable in design code and submit report for Engineer's approval. The Contractor shall take precautions in designing civil works and shall add admixture in concrete and take remedial measures to prevent structure from any expected attack from chemicals observed.

3.0 TEMPORARY WORK

3.1 General

- i) This clause covers the furnishing of all appliances, labour, materials tools, transportation and services required to perform and complete all preliminary work and temporary construction.
- ii) Immediately after award of the Contract, the Contractor shall submit to the Engineer in writing the schedules for machinery and equipment to be supplied and temporary work to be constructed by the Contractor in connection with the execution of the permanent work. Even though such schedules have been submitted to the Engineer, by no means the Contractor shall be relieved from any liabilities and responsibility to be borne by him in accordance with the Contract. However, the schedules for minor and simple work may not be submitted if allowed by the Engineer.
- iii) Any drawing and design calculation sheets for the equipment to be used and for the temporary work specified in the specifications shall be submitted to the Engineer for his approval.

3.2 Scaffoldings and Path

In order to complete the construction, the Contractor shall furnish and maintain all required scaffolding, stairways, plat forms and other necessary pertinent.

- c) The gradation of the general fill material shall conform to the following limits:

<u>Material Size</u> <u>U.S. Shieve Series</u>		<u>Percent Finer Than</u> <u>by Weight</u>
No.	10	100
No.	50	70-95
No.	100	25-75
No.	200	0-15

However, for the engineered fill under the light structures i.e. foundations, proposal of well graded gravelly sand shall be submitted by the Contractor for approval of the Engineer.

- d) No stones or the like shall be used for filling and back-filling.
- e) Impermeable clay shall not be used for back-filling of a structure which is susceptible to earth pressure.

Location of borrow pits and method of obtaining materials for banking shall be reported to the engineer in advance for the approval.

- 3) If the inflow of water exists at the site of filling and back-filling, it shall be appropriately handled at the expense of the Contractor.
- 4) The compaction shall be made in the filed by ramping machines or other mechanical means as approved by the Engineer. The layer of compacted earth filling shall not be more than 5 cm per lift, and it shall be graded at horizontally as possible, and shall be sufficiently compacted to produce not less than 95% o laboratory maximum dry density as determined by ASTM Designation D1557-00 "Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort". Field dry density shall be measured according to ASTM D-1556-00 – Standard Test Method for Density and Unit Weight of Soil in Place for Sand – Cone Method or ASTM D-2937-00 "Standard Test Method for Density of Soil in Place by the Drive – Cylinder Method" or other methods as approved by the Engineer.
- 5) If there is any surface or buried structure owned by the public or the third party at the site of filling and back-filling, care shall be taken so as to cause no harmful effect to them and the execution of the work shall be carried out following instructions by the Engineer.
- 6) For back-filling adjacent to a structure, compaction and back-filling shall be carried out in such a manner that will prevent damage to the structure.

4.5 Disposal of Excavated Materials

- 1) Spoils produced by excavation shall be piled, graded, sloped or disposed of at the locations as directed by the Engineer.
- 2) In transporting the spoils, care shall be taken so as to neither hamper traffic nor cause trouble to the third party by scattering the spoil over the road.

4.6 Inspection:

The instructions and tests specified herein shall include the following:

- 1) Volume of work executed

- 2) Inspection of test of construction materials
- 3) Inspection of excavation (including bed surface)
- 4) Inspection of disposal of excavated materials
- 5) Inspection of compaction test of back-filling

Other tests and inspections which the Engineer deems necessary

Other tests and inspections required according to pertinent regulations, codes and standards.

The works for which the Engineer deems inspection necessary, shall be executed in the present of the Engineer.

5.0 REINFORCED CONCRETE WORK

5.1) General

- 1) This clause covers the performance of all reinforced concrete work for permanent structures in accordance with the drawings and these specifications.
- 2) The Contractor shall furnish all materials and equipment for the performance of concrete work.
- 3) Reinforced concrete work and plain concrete work shall comply with all requirements of ACI 318-02 (latest revision). Also test on material shall, in principle, follow relevant ASTM Standard or equivalent approved by the Engineer.
- 4) Concrete shall have the uniform quality with the required strength, durability water lightness etc.

Strength:

- a) The strength of concrete shall generally be based on 28 days compressive cylinder strength
- b) Compression tests for concrete shall be performed in accordance with relevant ASTM standards or approved equivalent.

$\sigma_{28} = 350 \text{ kg/cm}^2$

For grouting under base plate of equipment steel structure with mixing of non-shrinking agent.

$\sigma_{28} = 280 \text{ kg/cm}^2$

For water retaining structures.

$\sigma_{28} = 211 \text{ kg/cm}^2$

For foundation of each equipment gantry towers, cable trenches, buildings and other structures as specified.

The minimum cement contents shall be 350 kg per cubic meter of concrete.

$\sigma_{28} = 71 \text{ kg/cm}^2$ For leveling concrete.

Where σ_{28} means concrete compressive cylinder strength at the age of 28 days.

Table-1 – Basic Mix Data

Design Strength of 28 kg/cm ²	Max Size of Aggregate (mm)	Slump Air (cm) (%)	E/ment	Description
350	As per table 3	4 ± 2	4 ± 1	Grouting under base plates of equipment
280	As per table 3	10 ± 2	4 ± 1	Water retaining structure
210	As per table 3	6 ± 2	4 ± 1	Foundation building and other structure
140	As per table 3	10 ± 2	4 ± 1	Leveling concrete

- Note: 1. Specific gravity in design
Cement – 3.15, Fine Aggregate – 2.62, Coarse Aggregate and Crushed Stones – 2.62.
2. The Contractor shall submit proposal of mix design for approval of the Engineer.
3. Maximum size of coarse aggregate may be reduced for columns, beams and slabs etc. as directed by the Engineer.

5.2) Material

1) Material for Reinforced Concrete

(a) Cement

Classification shall be Ordinary Portland Cement to be complied with British Standard 12:1971 "Specifications for Ordinary and Rapid Hardening Portland Cement" or to ASTM Designation C150-99a Standard Specification for Portland Cement for Type-I", or equivalent and Sulphate Resistant (SR) cement shall be used in water logged area and as per requirements of Geotechnical investigations and this shall be according to ASTM C150-99a Type-V.

(b) Water

- (i) Water shall be clean and free from injurious amounts of oils, acids, alkalis, salts, organic materials or other substances deleterious to concrete or reinforcement.
- (ii) Sea, river or canal water shall not be used in mixing concrete for reinforced or plain concrete.
- (iii) Test as described in clause 2.5 shall be within acceptable limits.
- (iv) Non-potable water shall not be used in concrete unless specifically approved by the Engineer.

(c) Fine Aggregate

(i) General

Fine aggregate shall be clean, strong, hard, durable, suitably graded and free from injurious amounts of dust, mud, organic impurities, salts etc. Beach sand shall not be used for concrete.

(ii) **Grading**

Fine aggregate shall consist of large and small particles suitably mixed, and its grading shall, as a standard, be within the range shown in Table-2.

Table - 2 - Standard Grading of Fine Aggregate

Sieve Designation U.S. Standard Square Mesh	Percent Passing
0.375 in (9.5 mm)	100
No. 4 (4.75 mm)	95 to 100
No. 8 (2.36 mm)	80 to 100
No. 16 (1.18 mm)	50 to 85
No. 30 (600 mm)	25 to 60
No. 50 (300 mm)	10 to 30
No. 100 (150 mm)	02 to 10

The sand equivalent value of the fine aggregate, as determined by ASTM Designation D-2419-02 "Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate", shall not be less than 75. The Fitness Modules shall range between 2.3 to 3.1.

(d) **Coarse Aggregate**(i) **General**

Coarse aggregate shall be clear, strong, hard, durable, suitable graded and free from injurious amount of flakes, elongated pieces, organic impurities, salts etc.

(ii) **Crushed Stones**

Coarse aggregate shall consist of large and small particles suitably mixed and its grading shall be within the range shown in Table-3 as a standard.

Sieve analysis shall be performed in accordance with ASTM Designation C33-02a, or equivalent.

Table - 2 - Standard Grading of Coarse Aggregate

Percent by weight finer than each laboratory sieve

US Standard Sieve Size	1.5 in. to 0.75 in.	0.75 in. to No. 4	0.5 in. to No. 4
2 in.	100	-	-
1.5 in.	90 to 100	-	-
1 in.	20 to 55	100	-
0.75 in.	0 to 15	90 to 100	100
0.5 in.	-	-	90 to 100
0.375 in.	0 to 10	20 to 55	40 to 70
No. 4	-	0 to 10	0 to 15
No. 8	-	0 to 5	0 to 5

(e) **Reinforcement**

- (ii) Admixture material shall be carefully handled.
- (iii) Admixture material shall be stored in silos or warehouses which are damp-proof and shall be used in the same order as they are received.
- (iv) Admixture stored for a long period or found to have changed shall be tested prior to its use. Should it be found in the test that admixture does not possess the required characteristics, its use shall not be allowed.

5.3) Mix Proportions

- 1) Mix proportion for concrete shall be determined in such a manner that the unit quantity of water its minimized while the required strength, durability, water tightness and the workability suitable or the work are secured.
- 2) Mix proportion for concrete and results of tests mixing shall be determined so as to provide the required strength, workability, uniformity and durability. The scheme of mix proportion shall be submitted to the Engineer for approval. The form of submission as per Table-4 shall be used. The design strengths of the concrete shall be the classes indicated below.

$\phi 28 = 350 \text{ kg/cm}^2$ For grouting under base plate of equipment steel structure
 $\phi 28 = 280 \text{ kg/cm}^2$ For water retaining structures.
 $\phi 28 = 211 \text{ kg/cm}^2$ For foundation and buildings
 $\phi 28 = 71 \text{ kg/cm}^2$ For leveling concrete.

Where $\phi 28$ means concrete compressive cylinder strength at the age of 28 days.

The Contractor shall prepare concrete mix design according to basic design data for mixing as indicated in the Table-1 herein.

Table-4 (Concrete Mix Design Report)

Mix Size of Aggregate	Slump (cm)	Air-Entrainment (%)	Max Water/Cement w/c (%)	Sand percent s/a (%)	Quantity (per Mixed 1m ³)				Admixture gm/cm ³
					Water (W) kg	Cement (C) kg	Fine Aggre(S) kg	Coarse Aggre. kg	

Note: The quantity of admixture shall be indicated in cm³ or gram without solution or dilution.

5.4) Batching

Each material to be used in concrete shall be obtained through batching.

1) Batching Equipments

- a) Batching method and batching equipment for each material shall be subject to the approval of the Engineer in advance.
- b) Batching equipment for each material shall be inspected and adjusted if necessary, prior to the commencement of the construction work and periodically during the construction.

2) Batching of Materials

- a) Batching shall be made in accordance with the mix design approved by the Engineer. Test for surface water of the aggregate shall be in accordance with relevant ASTM Designation of equivalent or as directed by the Engineer. Test for the quantity of the effective absorption of water, in case of dried aggregate, shall be as directed by the Engineer.
- b) Volume of one batch shall be determined as directed by the Engineer.
- c) Each material shall be batched by weight and/or by volume as approved by Engineer except the water and the solution of admixture, which may be measured by only volume.
- d) Error in the measurement in each batch shall be within the permissible error range given in Table-5.

Table-5 Permissible Error in Measurement

Type of Materials	Permissible Error (%)
Water	± 1
Cement & admixture material	± 2
Aggregate	± 3
Solution of admixture agent	± 3

5.5) Mixing

Materials for concrete shall be thoroughly mixed until the mixed concrete becomes uniform in quality.

1) Mixers

- a) Mixers shall be either tilting batch mixers or forced batch mixers
- b) Any concrete mixers to be used under this project shall be subject to approval of the Engineer.
- c) Mixers shall be such that they will not cause any separation of materials at the time of discharging.

2) Mixing

- a) When charging a mixer, all the materials shall be charged uniformly and simultaneously in principle.
- b) Mixer shall be rotated at a speed recommended by the manufacturer. Mixing time shall, in principle, be determined based on tests. As a standard, it shall be at least 1 minute and 30 seconds for tilting type mixers and 1 minute for forced mixers.
- d) Mixing shall not be continued for more than three times the specified mixing time.
- e) Materials for new batch shall not be charged into the mixer until all the concrete in the mixer is discharged.

- f) Mixers shall be thoroughly cleared before and after their use.
- g) Concrete which is left mixed and has commenced setting shall not be used after re-tempering.
- h) Hand mixing shall not be allowed

5.6) Conveying and Placing

(1) General

- a) Prior to the commencement of the construction work, a plan of conveying and placing shall be made, and this shall be subject to the approval of the Engineer.
- b) Concrete shall be conveyed by methods which will prevent separation and loss of materials, shall be placed immediately and then, shall be thoroughly compacted. Even when it is impossible to place the concrete immediately due to some special reasons, the time between mixing and the completion of placing shall not exceed 30 minutes.
- c) When segregation is observed in concrete during its delivery or placement, it shall be made uniform in quality by remixing.

(2) Conveying Equipment

Equipments to be used in conveying concrete shall be those, which can easily deliver the concrete to its required place. Should the delivery distance be long, they shall be equipped with such facility as an agitator.

(3) Buckets

Structure of buckets shall be such that they will not cause any separation of materials when charging or discharging concrete, and that the concrete can be easily and swiftly deposited from them.

(4) Conveyer Belts

Should conveyer belts be used, they shall be suitably located so that they will not impair the quality of the concrete and the end of the line shall be provided with baffle plates and an elephant trunk so that the segregation of concrete can be prevented.

(5) Buggies and Trolleys

Should buggies or trolleys be used, a level runway or path shall be constructed so that separation of material will not occur in conveying concrete.

(6) Chutes

- a) Should any chute be used, it shall be drop-chute in principle. The drop chute shall be connected to an elephant trunk so that the separation of materials is minimized.
- b) Open chutes may be used, only when approved by the Engineer. Each open chute shall be inclined at uniform angle all along its length and the slope shall be such that it will not cause any separation of materials of the concrete to be

placed. The distance between the bottom end of the chute and the surface on which concrete is to be deposited, shall be at most 1.5 m. The discharging end shall be equipped with a suitable elephant trunk.

(7) **Preparation of Placing**

- a) Prior to the placement, the arrangement of reinforcement, forms etc. shall be approved by the Engineer.
- b) Prior to the commencement of the placement, it shall be certified that conveying equipments and placing equipments are in conformance to the plan of placing specified in the relevant clause.
- c) Prior to the placement, conveying equipments, placing equipments and the inside of forms shall be thoroughly cleaned to prevent foreign materials from being mixed into the concrete. Portions expected to face concrete and to absorb water shall be moistened in advance.
- d) Water in pits and sumps shall be removed prior to the placement of the concrete. Suitable protective measures shall be taken so that water running into these pits and sumps will not wash the concrete just placed.

(8) **Placing**

- a) Concrete shall be placed in accordance with the plan of placing should it be inevitable to change the placing method, it shall be so done as directed by the Engineer.
- b) When concreting is done in hot weather, special attention may absorb the water in concrete shall be given to the materials, placement, curing etc.
- c) Portions such as the ground and foundations which may absorb the water in concrete shall be thoroughly wetted prior to the placement of concrete.
- d) Temperature in concrete at the time of placing shall be at most 25 deg. C for gantry foundations and 32 deg. C for equipment foundations and other structures. If the temperature goes up, precautionary measures approved by the Engineer have to be taken.
- e) Conveying equipments for concrete shall be such that they will protect concrete from being dried or heated.
- f) Concrete shall be protected as soon as the placement is completed or interrupted. Special care shall be exercised to keep the surface of the concrete moist.
- g) During the concreting operation, attention shall be paid not to disturb the arrangement of the reinforcement.
- h) Concrete shall be placed in such a manner that it will not be required to be moved after being deposited.
- i) Should any notable separation of materials be observed during concreting, the concrete shall be remixed to obtain the uniform quality and necessary measures to prevent separation shall be taken before the placing operation is resumed.
- j) Concrete for one section shall be placed continuously until it is complete.
- k) Concrete shall, in principle, be placed in such a manner that the surface of the placed concrete will be horizontal within the section. One lift in placement shall

be at most 30 cm, in principle, if the length of the vibratory rod is larger than the concrete lift.

- l) Should concrete be placed in layers, each succeeding layer shall be placed while the one below it is still plastic. Should it become necessary to place concrete on top of layer which has started setting, it shall be done in accordance with clause.
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- m) When height of the form work is great, it shall be provided with openings for concrete placing or the placement shall be done using droop chutes in order to prevent the concrete from being segregated or from adhering to the reinforcement or to the forms above the layer to be placed.
- n) The height of the end of buckets and hoppers shall be at most 1.0 m above the level of placement.
- o) Should there be any water coming out and accumulated during the placement, the concrete shall not be placed further until the water is removed by suitable means.
- p) When concreting high structures such as walls and columns continuously, the consistency of the concrete and the rate of lifting shall be controlled, in such a manner that separation of materials during the placement and the compaction is minimized.

5.7) **Compaction**

- 1) In principle, internal vibrators shall be used to compact the concrete. When it is difficult to use internal vibrators in the case of thin walls suitable means shall be adopted. Vibrators to be used shall be subject to the approval of the Engineer.
- 2) Concrete, shall be thoroughly compacted immediately after placement, and shall be thoroughly worked around the reinforcement and into the corners of the form. Where conditions make compaction difficult, batches of mortar containing the same proportions of cement, sand and water as used in the concrete shall first be deposited to ensure the compaction.
- 3) When compaction is achieved by vibrators, it shall be inserted into the layer below the one just placed by about 10 cm. The vibrators shall be pulled out very slowly so that no hole will form in the concrete.
- 4) When concreting is to be compacted by internal vibrators the spacing and the time of their application shall be as directed by the Engineer.

5.8) **Additional Placing**

Should additional placing be made on top of a layer which has already started to harden, it shall be thoroughly and carefully worked on as directed by the Engineer so that the top and the lower layer becomes monolithic.

5.9) **Curing**

(1) **General**

- a) Concrete, after being placed, shall be sufficiently cured without being subjected to injurious effects caused by low temperature, drying, sudden change in temperature etc. The Contractor shall report the said method to the Engineer and obtain his approval.

- b) Concrete shall be protected from vibrators, impacts and loads while it is hardening.

(2) **Wet Curing**

- a) Concrete being placed and compacted shall be protected from the sun, wind, showers etc. until it starts hardening.
- b) Any exposed surface of concrete which has hardened to a degree that works can be done without impairing it shall be either covered with wet mats, canvas, sand etc. or directly watered and shall be kept moistened continuously for at least seven (7) days after the placement in case Ordinary Portland Cement is used.
- c) When sheathing boards are expected to become dry, they shall be watered.

5.10) **Joints**

(1) **General**

- a) Location and structure of joints including expansion joints shall be as per relevant standards and codes and shall be shown and specified in the drawings.
- b) Should any joint not specified in the design be made, its location, direction and method of construction shall be determined in the plan of construction so that it will not impair the strength and the appearance of the structure, and this shall be subject to the approval of the Engineer.

(2) **Construction Joints**

- a) Construction joints shall be located where the shear forces are minimum and with their faces in perpendicular, in principle, to the direction of compression in the member as approved by the Engineer.
- b) Should it be unavoidable to make a construction joint at a location where large shear is acting, it shall be reinforced by forming tendons or grooves, or embedding suitable steel as approved by the Engineer.

(3) **Construction of Horizontal Construction Joints**

- a) Sides of the surface of a horizontal construction joint intersecting the forms shall be kept as horizontal and straight as possible.
- b) When new concrete is placed, the surface of the old concrete shall be removed of all laitance, interior concrete, loosened aggregate etc. and shall be thoroughly wetted.
- c) Prior to the placement of new concrete, the forms shall be tightened, standing water removed and either cement paste or mortar with the same mix proportion as in concrete shall be applied on the surface of the old concrete.

(4) **Construction Method for Vertical Construction Joints**

- a) When a vertical construction joint is to be made, the forms at the joint shall be rigidly supported and the concrete in the vicinity of the joint shall be thoroughly compacted by vibrators.
- b) Fresh concrete shall be placed after the surface of the aged concrete at the joint is removed of the surface film or is roughened and thoroughly wetted or after the surface is treated as directed by the Engineer.

- c) Fresh concrete shall be thoroughly compacted at the time of placement so that the fresh and aged concrete is in tight contact with each other.

5.11) Reinforcement Work

(1) Processing of Reinforcement

- a) Reinforcement shall be processed to the shape and the dimensions as shown in the drawings by a method which will not impair the quality of the material.
- b) Reinforcement shall be processed in ordinary temperature. When it is unavoidable to heat for processing, the whole process shall be subject to the approval of the Engineer.

(2) Placing of Reinforcement

- a) Prior to fabrication and at time concrete is placed, reinforcement shall be thoroughly cleaned and free from must, oil, loose rust and any other non-metallic coatings which may impair the bond between the reinforcement and the concrete.
- b) Reinforcement shall be accurately placed to the designated position, and shall firmly be supported so that it will not be dislocated during the placement of concrete. Erection bars, if required, shall be used for this purpose. Important crossing of reinforcement shall be fastened by either annealed wire of at least 0.9 mm in diameter or binding wire.
- c) Clearance between reinforcement and sheathing board shall be maintained correctly by use of spacers.
- d) Reinforcement shall always be inspected by the Engineer before placing of concrete.

(3) Covering of Concrete

- a) The covering shall be at least one diameter of the reinforcement.
- b) In general, the minimum covering shall be as shown in Table-6, unless otherwise noted on the drawings.

Table – 6 Minimum Covering (cm)

<u>Conditions</u>	<u>Slabs, Walls</u>	<u>Beams, Columns</u>
When not directly exposed to severe weather or ground	2.0	4.0
When effective coating is not applied on the portion which may be subjected to injurious chemical reaction due to smoke, acid, alkali, oil, deicing salts, brackish water etc.	5.0	6.5

- c) In case of footings and important members of a structure, it is recommended that the covering be at least 7.5 cm when concrete is placed directly facing the ground, and at least 5 cm for bars with diameter or more than 19 mm and 4 cm for bars with the diameter of less than 19 mm when the concrete is buried and directly facing the ground or when it is subjected to severe weather conditions. However, the covering at the bottom side of slabs may be at least 2.5 cm even if the portion of it is subjected to extreme weather conditions.

The covering in structures which are required to be specially fireproof shall be determined based on the temperature of the fire, duration, characteristics of aggregate to be used etc.

(4) **Joints of Reinforcement**

- a) Lap joints of reinforcement shall be made by lapping the required lengths and fastening them together at several points with annealed wire of at least 0.9 mm in diameter. Lap length shall be according to ASTM Designations.
- b) Reinforcement projecting from the structure and exposed for future jointing shall be protected from damage, corrosion, etc.

5.12) **Forms and Timbering**

Forms and timbering shall be so designed and constructed as to have the required strength and rigidity, to secure correct position, shape, lines dimensions of the structure and to secure the satisfactory quality in concrete.

(1) **Design of Forms**

- a) Forms shall be those which can easily be fabricated and stripped; joints of sheathing boards and panels shall be forced in parallel with or perpendicular to the axis of the member so that it will have to structure which is tight against mortar.
- b) The structure form shall be such that the corners of concrete can be mould even when it is not particularly specified.
- c) Temporary openings, if necessary, shall be made at suitable locations to facilitate cleaning and inspection of the forms and the placing of concrete.

(2) **Design of Timbering**

- a) Suitable type of timbering shall be selected and the load carried by them shall be correctly transferred to the foundation by appropriate means.
- b) As design of timbering for important structures is concerned they shall be subjected to the approval of the Engineer.

(3) **Construction of Forms**

Stripping agents shall be applied on the inside of the sheathing board.

(4) **Construction of Timbering**

- a) Timbering shall be constructed so as to have sufficient strength and stability.

- b) An amount of the settlement of the form works due to the weight of the placed concrete shall be estimated and a camber shall be introduced, if necessary, in the shoring.

(5) **Removal of Forms and Timbering**

- a) Forms and timbering shall not be removed until the concrete reaches a strength required to carry the concrete weight and the load applied during the construction work.
- b) Time and sequence of the removal of the forms and timbering shall be subject to the approval of the Engineer.

Loading on a structure immediately after the removal of the forms and timbering shall be subject to the approval of the Engineer.

5.13) **Finishing**

1) **General**

When the uniform appearance should be obtained on the exposed surface, special attention shall be given to place the concrete for the predetermined section continuously without changing the materials, proportions and the method of the placement.

2) **Surface Note Facing Sheathing Boards**

- a) Surface of the concrete compact and approximately leveled to the required level and shape shall not be finished until the water coming out ceases and is removed.
- b) Cracks formed after finishing but before hardening shall be removed by tamping or re-finishing.

3) **Surface Facing Sheathing Boards**

- a) Concrete which will be exposed shall be placed and compacted in such a manner that the surface solely composed of mortar will be secured.
- b) Projections and lines formed on the surface of concrete shall be removed to ensure surface flatness. Honeycombs and chipped places shall be removed and the surface shall be moistened and patched with appropriately proportioned concrete or mortar to be finished flat.
- c) Cracks formed after the removal of the forms due to temperature stress, drying, shrinkage, etc. shall be repaired as directed by the Engineer.

5.14) **Tests**

Contractor shall submit to the Engineer six copies of reports as directed by the Engineer.

1) **Test of Material**

- a) All the materials (cement, water, fine aggregate, coarse aggregate, reinforcement, admixture, etc.) to be used shall be approved by the Engineer after the Contractor submits the test results.
- b) The testing method shall comply with relevant ASTM Designation or equivalent.

2) **Tests of Concrete**

Materials of concrete, reinforcement, equipments, and workmanship shall be controlled to produce reinforced concrete of the required quality economically.

- a) During construction the following tests shall be carried out as directed by the Engineer.
 - i) Slump test
 - ii) Temperature test
 - iii) Compression test of concrete

Samples for compression tests of each class of concrete placed each day shall be taken not less than once a day, nor less than once for each 100m³ of concrete, nor less than once for each 450m² of surface area for slabs or wall.

- b) In order to determine the suitability of the curing method and the time to remove the forms, and in order to certify the safety for early loading, strength tests shall be performed on specimens cured under the conditions as similar as possible to those of the concrete at the site. Should the result of the test indicate that the obtained strength of the specimen is much smaller than that of the specimens cured under the control condition, the method of curing at the site shall be changed as directed by the Engineer.
- c) For compression test of concrete, minimum six (6) test specimens shall be required with a minimum of one set of sample per concrete, pour from a randomly selected batch of concrete, taken at point of discharge from mixer or truck, cured under standard conditions.

Three (3) specimens shall be tested for seven (7) or fourteen (14) days strength, the remained three (3) specimens shall be tested for twenty eight (28) days strength.

- d) Should it become necessary after the completion of the work, non destructive test of concrete or tests on concrete specimens cut out from the structure shall be carried out.

The expenses for the above tests shall be included in the unit prices.

3) Control of Concrete by Compressive Strength

- a) Control of concrete by compressive strength shall be based on 28 days compressive strength. Specimens, in this case, shall be taken in such a manner that they will represent the concrete of the structure for at least each separate pour.
- b) Test results of compressive strength to be used for the control of concrete shall generally be considered satisfactory if arithmetic average of strength tests for specimens taken from the same batch, equals or exceeds specified compressive strength and not individual strength test falls below specified compressive by more than, 35 kg/cm².

4) Inspection of Quality of Concrete

- a) The Contractor shall submit to the Engineer the results of the tests of concrete obtained according to the quality control test in the preceding paragraph 4.05.14. and obtained approval of the Engineer.
- b) When the results of tests show that the strength of any concrete is below the minimum specified, Engineer may give instructions for the whole or part of the

work concerned to be removed and be replaced at the expense of Contractor. The Contractor's Works which has to be removed and replaced as a result of the defective concrete. If any concrete is held failed, Engineer may order the proportions of that class of concrete to be changed in order to provide the specified strength.

5) **Test of Reinforcement Bars**

In the case where there is no test certificate of reinforcement bars (mill sheet) or in case the Engineer deems necessary, the Contractor shall carry out the characteristics and strength test of reinforcement bars and obtained approval from the Engineer for its use.

a) **Test Method**

Test method shall conform to the relevant ASTM Designation or equivalent, unless directed otherwise by the Engineer.

b) **Report**

The result of the tests shall be reported to the Engineer without delay.

5.15)

(1) **General**

The inspection and tests specified herein shall include the following:-

- a) Volume of work executed
- b) Inspection and test of construction materials
- c) Inspection of reinforcement bar assembly
- d) Inspection of forms
- e) Inspection of the lines, grades and dimensions of the structures
- f) Identification test of the quality of concrete at site (cast-in-place concrete).
- g) Other tests and inspections required according to pertinent regulations, codes and standards or as deemed necessary by the Engineer.

The following tests and inspections shall be executed in the presence of the Engineer.

- i) Strength test of reinforcement steel
- ii) Compression test of concrete
- iii) Other tests and inspections the Engineer deems necessary.

2) **Inspection of Reinforcement Bar Assembly**

Prior to placement of concrete, the Engineer shall inspect reinforcement bar assembly to confirm the classification and diameter of reinforcement bar, space between reinforcement, length of lap joint and covering etc. are according to the Drawings.

3) **Inspection of Forms**

Prior to placement of concrete, the Engineer shall inspect the form work and shall give approval for concreting.

4) **Inspection of the Dimensions of the Structure**

Inspection of the dimensions of the structures shall be made as required by the Drawings.

Concrete work shall not exceed, in general, the tolerance limits specified below:

- a) Variation from plumb or specified batter for surface of stems and lines.

	i)	In any 3.0 m of length	5 mm
	ii)	Maximum for the entire length	15 mm
b)	Variation from the level for slabs		
	i)	In any 3.0 m of length	5 mm
	ii)	In any 6.0 m of length	8 mm
	iii)	Maximum for the entire length	15 mm
c)	Variation in cross sectional dimensions of stems and thickness of slabs.		
	i)	Minus	5 mm
	ii)	Plus	10 mm
d)	Variation and level specified at top of foundations.		
	i)	Minus	10 mm
	ii)	Plus	10 mm
e)	Variation in protective covering of reinforcement steel.		
	i)	With cover of 40 mm or less	-5 mm
	ii)	With cover more than 40 mm	-10 mm
f)	Variation from effective depth of reinforcement steel.		20 mm

5.16

CABLE TRENCH WORK1) **General**

The Contractor shall provide all cable trenches leading from the outdoor equipment in the switchyard to the indoor equipment in the buildings as shown in the Drawings.

The design shall cover the following requirement.

- 1) The design of cable trenches shall be similar to the design shown in bidding documents and with draining system.
- 2) Cable trenches shall be made of complete monolithically reinforced concrete work. Each type of cable trench shall be provided with expansion joint at intervals of max. 20 linear meter.
- 3) All trench covers shall be of reinforced concrete to withstand a load of 300 kg at the centre except those at road crossing which should withstand a load of 5 tons at the centre.
- 4) The trench covers shall be of such size as to facilitate their handling by manual labour.
- 5) Trenches in substation will be built with the top of the trench cover 150 mm above the gravel level or as shown in the bid drawings.

- 6) The trenches shall be connected to a drainage system, designed and constructed by the Contractor in such a manner that sub-oil water due to water logging can not enter the trenches and rain water collecting in trenches is drained out efficiently. The drainage system for trenches shall be designed with proper slope for flow of water, entering the trenches.
- 7) All cable trenches shall set on a layer or leveling concrete of thickness 100 mm.
- 8) Cable trays shall be provided in trenches at adequate intervals horizontally and with sufficient vertical spacing between trays to freely accommodate the cables, plenty of working space shall be provided for handling the cable during installation and maintenance.
- 9) Each trench shall have two sections, one to accommodate cables for primary and other for secondary protection system. The later shall also accommodate power cables.
- 10) Trench-road & trench-trench crossings shall be culvert type and so designed that plenty of space is available for handling the cables during installation, future requirements of bays and maintenance at these crossings. Proper water drainage system shall also be designed on these crossings.
- 11) Trench entrances into the buildings shall be designed to seal off entry of any water or vermin's and pests into the building through these entrances.
- 12) The trench covers shall be upper covers type for trench-road-crossings where embedded covers shall be used.
- 13) Small openings shall be provided in the walls of cable trenches as required for entry of cable carrying pipes during construction stage which shall be sealed later with appropriate sealing compound as approved by the engineer. The appropriate measures shall be adopted to protect these pipes against corrosion and damages. All joints of these pipes shall be properly sealed to prevent/ingress of subsurface water.

2) **Inspection**

The Engineer shall inspect the cable trenches as for the compliance of the specifications and drawings approved by the Engineer.

6. **GRAVEL PAVEMENT WORK**

The Contractor shall provide a blanket of river run gravel in the switchyard area along equipments foundation and as shown in the drawings.

A 200 mm layer of hard, durable, gravel shall be provided by the Contractor in the switchyard area around the equipments above the reference ground level. The size of gravel shall generally vary from 20 to 75 mm. The material shall be placed to its full thickness of 200 mm in one layer and in such manner as to avoid displacing the under laying material. The material shall not be compacted.

The gravel shall conform to the following gradation limits, unless otherwise specified.

U.S. Standards Sieve Designation	Percentage Passing by Weight
-------------------------------------	---------------------------------

(3 inch) 75 mm	100
(2 inch) 50 mm	85-100
(3/4 inch) 20 mm	0-100

Crushed rock shall not be allowed, the gravel which shows any sort of chemical reaction as per site conditions shall also be not allowed. Contractor shall get the approval of the source of supply from the Engineer prior to placement of gravel.

7. ROAD WORK

The Contractor shall prepare roads in the substation as shown on the drawings. Proper slopes shall be maintained.

7.1 Foundation for Road

1) Sub-Grade Work

Any excavation required for sub-grade construction shall be carried out in accordance with the respective provisions in the clause of earth work.

The materials required for banking and displacement shall be so placed that the finished thickness of one layer after compaction will become 20 cm or less.

2) Sub-Base Course Work

The material to be used for sub-base course shall be as approved by the Engineer. The Contractor shall submit a report concerning the quality of materials and the method of sampling to the Engineer for approval.

3) Testing

The sub-grade surface shall be finished by proof rolling in order to obtain the contact pressure sufficient to permit smooth traffic of vehicles of 8 tons or over.

Should any defects be detected as a result of proof rolling, such defective sub-grade surface shall be finished again to the satisfaction of the Engineer.

4) Inspection

a) Sub-grade

The finished sub-grade surface shall be within ± 5 cm of the design elevation.

b) Sub-base:

The finished sub-base course shall be within -10 mm and $+ 5$ mm of the design elevation.

7.2 Asphalt Concrete Pavement

1) Material

a) Asphalt

Bituminous material shall be used in the design of Asphalt Concrete Pavement Work.

The asphalt material shall conform to the requirements of AASHTO M-20, M-81, M-82 and M-40. The type shall be as directed by the Engineer.

b) **Fine Aggregate**

Fine aggregate passed a 2.5 mm sieve and shall be clean, strong, hard, durable, suitable graded and free from injurious amounts of dust, mud organic impurities, salts etc.

c) **Coarse Aggregate**

Coarse aggregate which retained on a 2.5 mm sieve, and shall be clear, strong, hard, durable, suitably graded and free from injurious amount of flakes, elongated pieces, organic impurities, salts etc.

Coarse aggregate for pavement shall comply with the following requirements.

i)	Specific gravity	more than 2.5
ii)	Absorption value	less than 3.0%
iii)	Percentage wear	less than 35.0%
iv)	Soundness test	less than 12.0%
v)	Content of shale and soft fragment of stone	less than 5.0%
vi)	Content of slender and thin fragment of stone	less than 25.0%

Note: Ratio of longer width and the other is more than three times, and on thin fragment ratio of thickness and width is more than three times.

d) **Filler**

Particles of stone means the material which was crushed a limestone or igneous rock and water content of filler shall be less than 1%. Grading range of the filler shall comply with the following requirements.

<u>Sieve</u>	<u>Percentage Passing</u>
0.6 mm	100%
0.15 mm	90-100%
0.074 mm	70-100%

2) **Storage of Material**

a) **Asphalt**

Asphalt shall be stored in exclusive tank.

b) **Aggregate**

- i) Storage facility of aggregate shall be equipped with a suitable drainage system

- ii) Fine aggregate, coarse aggregate and other aggregate of different type and grading shall be separately stored with divides between each.
 - iii) When receiving, storing and handling aggregate facilities shall be well maintained and handling shall be carefully performed so that no segregation of large particles from small ones may occur, no foreign materials may become mixed, or in case of coarse aggregate, no particles may be crushed.
 - iv) During storage of fine aggregate, water contents should not change rapidly.
- 3) **Mix Proportions:** Mix proportions for the dense grade asphalt concrete shall be determined in such a manner that the test piece which conform stability flow value, percentage of void and degree of saturation by marshal testing of the asphalt volume at intervals of five percentage and submit such data in writing to the Engineer for approval.

Material for dense grade asphalt concrete, shall in principle, comply with the following requirements.

- a) Thickness of surface shall be 5 cm
- b) Maximum size of aggregate shall be 20 mm:

<u>Material Size</u>	<u>% age Passing</u>
25	100
20	90 - 100
13	75 - 90

- c) Weight percentage of those passing a sieve:

<u>Material Size</u>	<u>% age Passing</u>
5	45 - 65
2.5	35 - 50
0.6	18 - 29
0.3	10 - 21
0.15	6 - 16
0.075	4 - 8

- d) The volume of asphalt 5 - 7 %
- e) Penetration test 80 - 100

Percentage of passing weight:
(on permissible error)

5 mm	+ 5 %
2.5 mm	+ 4 %
0.56 mm, 0.3 mm, 0.15 mm	+ 3 %
0.075 mm	+ 1.5 %
Percentage of asphalt volume	+ 0.3 %

- 4) **Working:** Asphalt concrete shall be placed on the clean and completely dry base course. The temperature in the working area shall not be less than 20 deg. C for at least one hour prior to the commencement of operations.

Asphalt concrete layer shall be compacted upto 95% maximum dry density. Curing period shall be minimum 24 hours and during this period no traffic shall be allowed to move on the road.

- 5) **Testing:** The marshal test shall be observed in the dense grade asphalt concrete for surface.

On standard values of marshal testing.

Soundness	more than 600
Value of flow	20 – 40%
Porosity	75 – 85%
Submerged marshal retained soundness	more than 75%

- 6) **Inspection:** Inspection of surface shall comply with following requirements.

Thickness of surface	10 – 15 %
Profile index part of each work	less than 5%

The mixture shall be spread uniformly, rolled and finished into the specified thickness. Then the finished surface shall be measured in parallel to the center.

7.3 Reinforced Concrete Pavement/Service Road

1) Material

- a) Cement, water, fine aggregate and coarse aggregate shall be in accordance with the clause "Material for Reinforced Concrete".
- b) Water reducing agent shall conform to the standards for water reducing agent by relevant ASTM Designation or approved equivalent.
- c) Reinforcement steel shall be deformed bars conforming to ASTM 615-96a grade -40 or equivalent as approved by the Engineer.
- d) The Contractor shall submit the report of tests for quality of the materials as directed by the Engineer for his approval.
- e) If on receipt of tests from laboratory any change is observed in material, the matter shall be referred to the Engineer for his approval.

2) Concrete Mix: The following requirements shall be observed in concrete pavement.

- a) The bending strength at 28 days of concrete is 45 kg/cm³ and this test shall, in principle, be performed in accordance with relevant ASTM Designation or approved equivalent.

- b) Maximum size of coarse aggregate shall be 40 mm.
 - c) Consistency in concrete shall be less than 2.5 cm by slump test and initial setting time is 30 sec.
 - d) Air content shall be between 3 to 6 percent.
- 3) **Form Work** Form material shall be straight and have width for designed thickness of pavement which is more than 3m in length, and it shall be fixed on the position in accordance with the drawings.
- 4) **Detachment of Form:** It shall not be detached within 20 hours after concrete placing. However, if increase in concrete strength delays under certain conditions, approval of removing forms shall be given by the Engineer.
- 5) **Joint:**
- a) The joints shall be provided at appropriate locations as per relevant standards
 - b) Flouing of joint shall be done after form is cleaned up and dried sufficiently.
- 6) **Placing:** Placing for concrete pavement shall, in principle, be in accordance with relevant tender clause "Conveying and Placing of Reinforced Concrete".
- 7) **Installation of Reinforcement:** Mesh and reinforcement bar shall be set correctly at a position designated as shown in the drawings.
- 8) **Finishing:** Finishing of surface shall be done after leveling and compaction of concrete.
- 9) **Curing:** Curing of concrete pavement shall, in principle, be in accordance with relevant tender clause "Curing" of Reinforced Concrete Work.
- 10) **Testing:** The Contractor shall submit to the Engineer six copies of report on these tests.
- a) During placing of concrete following tests shall be carried out as directed by the Engineer.
 - i) Slump test
 - ii) Temperature of concrete
 - iii) Compression/bending test
- The test of concrete shall be executed not less than once for each one hundred (100) cubic-meters of concrete to be poured on the same day with a minimum of one set of sample per concrete pour.
- b) **Test of Material**

Coarse aggregate shall provide limit of wear reduction maximum 30 by Loss Angeles test of ASTM Designation.

- 11) **Inspection:** Finishing of concrete pavement shall meet the following requirements.

Profile index	Less than 10
Difference from maximum height	Less than 3 cm
Difference at two points picked up arbitrarily at intervals of 20 cm.	Less than 1 cm

Joints shall not have the difference of more than 3 mm between adjoining pavement slab by measurement rectangularly against inclination with a 3 m ruler and the depth of any section shall not exceed 5 mm.

8. BRICK WORK

- 1) Prior to commencing the brick masonry work, the surface of brick shall thoroughly be cleaned and sufficiently moistened in order to ensure smooth adherence of mortar to the brick surface. 1st class bricks shall be used which shall be approved by the Engineer.
- 2) The masonry joints shall in principle be 10 mm in thickness and mortar (1:3 c/s ratio or as shown in drawings) shall be filled sufficiently between each masonry joint in order to eliminate any void between brick and mortar.

9. DRAINAGE WORK

- 1) The drainage work shall be as described in the drawings and carried out in accordance with general provisions tender section "Earth Work" and tender section "Reinforced Concrete Work".
- 2) The water-plumbing facility for drainage shall be of such a system as not to cause any trouble against the surrounding area and structures. The Contractor shall submit the design and execution schedule for the water plumbing work to the Engineer for approval.

10. FENCE WORK

- 1) The design of fence shall conform to the drawing included in Volume-II of Bidding Documents.
- 2) The galvanized iron shall be used in accordance with ASTM Designation or equivalent.
- 3) Construction of fence, welding shall comply with ASTM Designation or equivalent.

11. BUILDINGS

The scope of work under this Contract includes all civil works I the existing substation buildings (control house building and mechanical services building) required to complete the scope of work under this Contract. Modifications in the buildings, dismantling and reconstruction of entry of cable trench type 1 from 500 kV switchyard, providing openings in RCC slab, providing supports for new panels, providing foundation channels for diesel generator and any other work necessary for meeting the specified requirements shall be the Contractor's responsibility.

12. PREPARATION OF SITE AREA AND DISMANTLING WORK

A number of partially constructed foundations are existing in the 500 kV switchyard area and area in which new 220 kV bays are to be constructed under this Project. The Contractor shall investigate if these partially constructed foundations can be used and submit detailed report in this regard. However, the Contract Price shall be deemed to include the cost of complete dismantling of existing of civil works and construction of new foundations. Use of existing civil works or part thereof by the Contractor will be subject to approval of the Engineer and in such case the Contract Price will be adjusted appropriately.

The Contractor shall also dismantle the concrete structures/foundations inside the outside the foundation area which are not required, cut the projecting reinforcing bars and fill up the excavated pits to level the area.

100
100

