

POWERGRID Technical Specification for Civil Works

(Pages 65 to 111, 140 to 145)

SECTION 8: CIVIL WORKS

8.1 GENERAL

The civil works to be provided by the Contractor, in accordance with the Specification, shall include the design & construction of all the items required, in each of the converter stations, including site and general services; buildings; foundations; structures; noise, fire and blast walls etc. The supply of steel and cement required for the civil works shall also be in the scope of the Contractor.

All civil works shall satisfy the requirements specified in other Sections of this Specification and as detailed below. They shall be designed to the required service conditions/loads as specified elsewhere in this Specification and implied as per national/international Standards.

All civil works shall be carried out as per applicable Indian Laws, Standards and Codes. The Contractor shall furnish all design, drawings, labour, tools, equipment, materials, temporary works, constructional plant, fuel supply, transportation and all other incidental items not shown or specified but as may be required for complete performance of the Works in accordance with approved drawings, specifications and directions of the Employer.

All the Works shall be carried out according to the design/drawings to be developed by the Contractor, and approved by the Employer. For all buildings, structures, foundations etc. necessary layout and details shall be developed by the Contractor keeping in view the functional requirement of the plant and facilities and providing enough space and access for operation, use and maintenance. Certain minimum requirements are indicated in this Specification for guidance purpose only; however, the Contractor shall provide according to the complete requirements.

All quality standards, fabrication and erection check lists, welding standards and other technical requirements as covered in the Specification shall be strictly adhered to by the Contractor.

8.2 CIVIL WORKS DESIGN BASIS

8.2.1 GENERAL

The Contractor shall design and construct all civil works to meet the requirements of the Specification and to be suitable for the intended use at the specified locations. In particular the Contractor shall be responsible for obtaining all data not specifically detailed herein which is required to ensure compliance with the Specification.

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The foundations and structures shall be designed to ensure that relative movement over the specified life of the installation does not result in stresses in any part of the Works which exceed the maximum design levels.

A design intent memorandum (DIM) to the effect shall be submitted by the Contractor for the Employer's specific approval giving details regarding his assumed data, loading for all civil design.

Any variation in design data shall not constitute a valid reason for any additional cost & shall not affect the terms & condition of the Contract. No extra payment what so ever, shall be paid to the Contractor on account of any variation in soil properties/conditions.

8.2.2 **GEOTECHNICAL INVESTIGATION** **NOT APPLICABLE**

Levelled site shall be handed over to the Contractor. The finished ground level shall be the finished formation level furnished by the Employer. The compaction of finish formation shall be approx 95% on proctor scale. In case it is found to be lower, then the Contractor shall redo the job without any additional cost to the Employer. The Contractor shall perform a detailed soil investigation to arrive at sufficiently accurate, general as well as specific information about the soil profile and the necessary soil parameters of the Site in order that the foundation of the various structures can be designed and constructed safely and rationally.

A report to the effect shall be submitted by the Contractor for Employer's specific approval giving details regarding data proposed to be utilised for civil structures design.

8.2.3 **SCOPE OF WORK**

This specification covers all the work required for detailed soil investigation and preparation of a detailed report. The work shall include mobilisation of necessary equipment, providing necessary engineering supervision and technical personnel, skilled and unskilled labour etc. as required to carry out field investigation as well as, laboratory investigation, analysis and interpretation of data and results, preparation of detailed Geo-technical report including specific recommendations for the type of foundations and the allowable safe bearing capacity for different sizes of foundations at different founding strata for the various structures of the substation. The Contractor shall make his own arrangement for locating the co-ordinates and various test positions in field as per the information supplied to him and also for determining the

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reduced level of these locations with respect to the benchmark indicated by the Employer.

All the work shall be carried out as per latest edition of the corresponding Indian Standard Codes.

8.2.3.1 BORE HOLES

Bore holes of 150 mm diameter in accordance with the provisions of IS: 1892 at the rate of minimum one number bore hole per hectare up to 10 meter depth into virgin soil or to refusal which ever occurs earlier shall be drilled. In any case number of boreholes shall not be less than five. By refusal it shall mean that a standard penetration blow count (N) of 100 is recorded for 30 cm penetration. Number of boreholes may be increased in case soil strata are varying from borehole to borehole in order to have fair idea of soil profile. In case of pile foundations soil investigation is to be carried out up to 25 m depth from virgin ground level or refusal whichever is earlier. In case rock is encountered, coring in all the boreholes shall be carried out up to 3 meter in rock.

The Contractor shall carry out Standard Penetration Tests at approximately 1.5 m interval in the borehole starting from 1.5 m below ground level onwards and at every change of stratum. The disturbed samples from the standard penetrometer shall also be collected for necessary tests.

Amendment II SI No 171

~~The Contractor shall collect undisturbed samples of 100/75 mm diameter 450 mm long from the bore holes at intervals of 2.5 m and every change of stratum starting from 1.0 m below ground level onwards in clayey strata.~~

The Contractor shall collect undisturbed samples of 100/75 mm diameter 450 mm long from the bore holes at intervals of 2.5 m and every change of stratum starting from 0.5 m below ground level onwards in clayey strata.

The depth of Water Table, if encountered, shall be recorded in each borehole. In case the soil investigation is carried out in winter/summer, the water table for rainy season shall be collected from reliable sources and recorded in the report.

All samples, both disturbed and undisturbed, shall be identified properly with the borehole number and depth from which they have been taken.

The sample shall be sealed at both ends of the sampling tubes with wax immediately after the sampling and shall be packed properly

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and transported to the Contractor's laboratory without any damage or loss.

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The logging of the boreholes shall be compiled immediately after the boring is completed and a copy of the bore log shall be handed over to the Engineer-in-charge.

8.2.3.2 TRIAL PITS

Trial pits shall be carried out at minimum one location per hectare as directed by the Employer. The trial pits shall be 2 m x 2 m in size extending to 4 m depths, or as specified by the Employer. Undisturbed samples shall be taken from the trial pits as per the direction of the Employer.

8.2.3.3 ELECTRICAL RESISTIVITY TEST

This test shall be conducted to determine the Electrical resistivity of soil required for designing safety-grounding system for the entire station area. The specifications for the equipments and other accessories required for performing electrical resistivity test, the test procedure, and reporting of field observations shall confirm to IS: 3043. The test shall be conducted using Wagner's four electrode method as specified in IS: 1892, Appendix-B2. Unless otherwise specified at each test location, the test shall be conducted along two perpendicular lines parallel to the coordinate axis. On each line a minimum of 8 to 10 readings shall be taken by changing the spacing of the electrodes from an initial small value of 0.2 m up to a distance of 50.0 m.

8.2.3.4 PLATE LOAD TEST

Plate load test shall be conducted to determine the bearing capacity, modulus of sub grade reaction and load/settlement characteristics of soil at shallow depths by loading a plane and level steel plate kept at the desired depth and measuring the settlement under different loads, until a desired settlement takes place or failure occurs. The specification for the equipment and accessories required for conducting the test, the test procedure, field observations and reporting of results shall conform to IS: 1888. Modulus of sub grade reaction shall be conducted as per IS: 9214. The location and depth of the test shall be at the Converter Building location at the proposed foundation depth below finished ground level for determining the bearing capacity.

Amendment II SI No 172

~~Undisturbed tube samples shall be collected at 1.0 m and 2.5m depths from natural ground level for carrying out laboratory tests.~~

Undisturbed tube samples shall be collected at 0.5 m and 2.5m depths from natural ground level for carrying out laboratory tests

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The size of the pit in plate load test shall not be less than five times the plate size and shall be taken up to the specified depth. All provisions regarding excavation and visual examination of pit shall apply here.

Unless otherwise specified the reaction method of loading shall be adopted. Settlement shall be recorded from dial gauges placed at four diametrically opposite ends of the test plate.

The load shall be increased in stages. Under each loading stage, record of Time vs. Settlement shall be kept as specified in IS: 1888.

Backfilling of the pit shall be carried out as per the directions of the Employer. Unless otherwise specified the excavated soil shall be used for this purpose. In cases of gravel-boulder or rocky strata, respective relevant codes shall be followed for tests.

8.2.3.5 WATER SAMPLE

Representative samples of ground water shall be taken when ground water is first encountered before the addition of water to aid drilling of boreholes. The samples shall be of sufficient quantity for chemical analysis to be carried out and shall be stored in air-tight containers.

8.2.3.6 BACK FILLING OF BORE HOLES

On completion of each hole, the Contractor shall backfill all bore holes as directed by the Employer. The backfill material can be the excavated material.

8.2.3.7 LABORATORY TEST

1. The laboratory tests shall be carried out progressively during the field work after sufficient number of samples has reached the laboratory in order that the test results of the initial bore holes can be made use of in planning the later stages of the field investigation and quantum of laboratory tests.
2. All samples brought from field, whether disturbed or undisturbed shall be extracted/prepared and examined by competent technical personnel, and the test shall be carried out as per the procedures laid out in the relevant I.S. Codes.

The following laboratory tests shall be carried out

- a) Visual and Engineering Classification
- b) Liquid limit, plastic limit and shrinkage limit for C-Ø soils.

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- c) Natural moisture content, bulk density and specific gravity.
- d) Grain size distribution.
- e) Swell pressure and free swell index determination.
- f) California bearing ratio.
- g) Consolidated drained test with pore pressure measurement.
- h) Chemical tests on soil and water to determine the carbonates, sulphates, nitrates, chlorides, Ph value, and organic matter and any other chemical harmful to the concrete foundation.
- i) In case of rock samples following tests shall also be conducted:
 - Rock quality designation (RQD), RMR.
 - UCC test.
 - Point load index test.

8.2.3.8 TEST RESULTS AND REPORTS

- i) The Contractor shall submit the detailed report in four (4) copies wherein information regarding the geological detail of the site, summarised observations and test data, bore logs, and conclusions and recommendations on the type of foundations with supporting calculations for the recommendations. Initially the Contractor shall submit draft report and after the draft report is approved, the final report in four (4) copies shall be submitted. The test data shall bear the signatures of the Investigation Agency, Vendor and also site representative of Employer.
- ii) The report shall include, but not limited to the following:-
 - a) A plan showing the locations of the exploration work i.e. bore holes, dynamic cone penetration tests, trial pits, Plate load test etc.
 - b) Bore Logs: Bore logs of each bore holes clearly identifying the stratification and the type of soil stratum with depth. The values of Standard Penetration Test (SPT) at the depths where the tests were conducted on the samples collected at various depths shall be clearly shown against that particular stratum.

Test results of field and laboratory tests shall be summarised strata wise as well in combined tabular form. All relevant graphs, charts tables, diagrams and photographs, if any, shall be submitted along with report. Sample illustrative reference

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calculations for settlement, bearing capacity, pile capacity shall be enclosed.

- c) The report should contain specific recommendations for the type of foundation for the various structures envisaged at site. The Contractor shall acquaint himself about the type of structures and their functions from the Employer. The observations and recommendations shall include but not limited to the following:
 - i) Geological formation of the area, past observations or historical data, if available, for the area and for the structures in the nearby area, fluctuations of water table etc.
 - ii) Recommended type of foundations for various structures. If piles are recommended the type, size and capacity of pile and groups of piles shall be given after comparing different types and sizes of piles and pile groups.
 - iii) Allowable bearing pressure on the soil at various depths for different sizes of the foundations based on shear strength and settlement characteristics of soil with supporting calculations. Minimum factor of safety for calculating net safe bearing capacity shall be taken as 3.0 (three). Recommendation of liquefaction characteristics of soil shall be provided.
 - iv) Recommendations regarding slope of excavations and dewatering schemes, if required.
 - v) Comments on the Chemical nature of soil and ground water with due regard to deleterious effects of the same on concrete and steel and recommendations for protective measures.
 - vi) If expansive soil is met with, recommendations on removal or detainment of the same under the structure, road, drains, etc. shall be given. In the latter case detailed specification of any special treatment required including specification of materials to be used, construction method, equipments to be deployed etc. shall be furnished. Illustrative diagram of a symbolic foundation showing details shall be furnished.
 - vii) Recommendations for additional investigations beyond the scope of the present work, if considered such investigation as necessary.

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- viii) In case of foundation in rocky strata, type of foundation and recommendation regarding rock anchoring etc. should also be given.

8.3 SITE PREPARATION

The layout and levels of all structure etc shall be made by the Contractor at his own cost from the general grids of the plot and benchmarks set by the Contractor and approved by the Employer. The Contractor shall give all help in instruments, materials and personnel to the Employer for checking the detailed layout and shall be solely responsible for the correctness of the layout and levels.

8.3.1 SCOPE

This clause covers the design and execution of the work for site preparation, such as clearing of the site, the supply and compaction of fill material, excavation and compaction of backfill for foundation, road construction, drainage, trenches and final topping by stone (broken hard stone).

8.3.2 GENERAL

- .1 The Contractor shall develop the site area to meet the requirement of the intended purpose. The site preparation shall conform to the requirements of relevant sections of this specification or as per stipulations of standard specifications.
- .2 If fill material is required, the fill material shall be suitable for the above requirement. The fill shall be such a material and the site so designed as to prevent the erosion by wind and water of material from its final compacted position or the in-situ position of undisturbed soil.
- .3 Backfill material around foundations or other works shall be suitable for the purpose for which it is used and compacted to the density described under Compaction. Excavated material not suitable or not required for backfill shall be disposed off in areas as directed by Employer upto a maximum lead of 2 km.

8.3.3 EXCAVATION AND BACKFILL

- .1 Excavation and backfill for foundations shall be in accordance with the relevant code.
- .2 Whenever water table is met during the excavation, it shall be dewatered and water table shall be maintained below the bottom

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of the excavation level during excavation, concreting and backfilling.

- .3 When embankments are to be constructed on slopes of 15% or greater, benches or steps with horizontal and vertical faces shall be cut in the original slope prior to placement of embankment material. Vertical faces shall measure not more than 1 m in height.
- .4 Embankments adjacent to abutments, culverts, retaining walls and similar structures shall be constructed by compacting the material in successive uniform horizontal layers (not exceeding 15 cm in thickness). (of Loose material before compaction). Each layer shall be compacted as required by means of mechanical tampers approved by the Employer. Rocks larger than 10 cm in any direction shall not be placed in embankment adjacent to structures.
- .5 Earth embankments of roadways and site areas adjacent to buildings shall be placed in successive uniform horizontal layers not exceeding 20 cm in thickness in loose stage measurement and compacted to the full width specified. The upper surface of the embankment shall be shaped so as to provide complete drainage of surface water at all times.

8.3.4 COMPACTION

- .1 The density to which fill materials shall be compacted shall be as per relevant IS and as per direction of Employer. All compacted sand filling shall be confined as far as practicable. Backfilled earth shall be compacted to minimum 95% of the Standard Proctor's density at OMC. The sub grade for the roads and embankment filling shall be compacted to minimum 95% of the Standard Proctor's density at OMC. Cohesion less material sub grade shall be compacted to 70% relative density (minimum).
- .2 At all times unfinished construction shall have adequate drainage. Upon completion of the road's surface course, adjacent shoulders shall be given a final shaping, true alignment and grade.
- .3 Each layer of earth embankment when compacted shall be as close to optimum moisture content as practicable. Embankment material which does not contain sufficient moisture to obtain proper compaction shall be wetted. If the material contains any excess moisture, then it shall be allowed to dry before rolling. The rolling shall begin at the edges overlapping half the width of the roller each time and progress to the centre of the road or

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towards the building as applicable. Rolling shall also be required on rock-fills. No compaction shall be carried out in rainy weather.

8.3.5 ANTIWEED TREATMENT & STONE SPREADING

8.3.5.1 SCOPE OF WORK

The Contractor shall furnish all labour, equipment and materials required for complete performance of the work in accordance with the drawings, specification and direction of the Employer.

Stone spreading along with cement concrete layer shall be done in the areas of the switchyard under present scope of work within fenced area. Outside the fenced area where no equipment is envisaged, the Employer may carryout landscaping in those areas. Landscaping shall not be in the Contractors scope.

GENERAL REQUIREMENT

The material required for site surfacing/stone filling shall be free from all types of organic materials and shall be of standard quality, and as approved by the Employer.

- .1 The material to be used for stone filling/site surfacing shall be uncrushed/crushed/broken stone of 40mm nominal size (ungraded single size) conforming to Table 2 of IS:383 – 1970. Hardness, flakiness shall be as required for wearing courses are given below:

a) Sieve Analysis limits (Gradation)

(IS: 383 – Table – 2)

Sieve Size	% passing by weight
63mm	100
40mm	85-100
20mm	0-20
10mm	0-5

Amendment II SI No 173

~~"One Test" shall be conducted for every 500 cu.m.~~

"One sieve analysis test" shall be conducted for every 500 cu.m

b) Hardness

Abrasion value (IS: 2386 Part-IV) – not more than 40%

Impact value (IS: 2386 Part-IV) – not more than 30% and frequency shall be one test per 500 cu.m. (With a minimum of one test per source).

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c) Flakiness Index:

One test shall be conducted per 500 cu.m. of aggregate as per IS:2386 Part – I and maximum value is 25%.

- .2 After all the structures/equipments are erected, anti-weed treatment shall be applied in the switchyard where ever stone spreading along with cement concrete is to be done and the area shall be thoroughly de-weeded including removal of roots. The recommendation of local agriculture or horticulture department may be sought where ever feasible while choosing the type of chemical to be used. The anti-weed chemical shall be procured from reputed manufacturers. The doses and application of chemical shall be strictly done as per manufacturer's recommendation. Nevertheless the effectiveness of the chemical shall be demonstrated by the Contractor in a test area of 10MX10M (approx) and shall be sprinkled with water at least once in the afternoon everyday after forty eight hours of application of chemical. The treated area shall be monitored over a period of two to three weeks for any growth of weeds by the Engineer – in- charge. The final approval shall be given by Engineer – in –charge based on the results.

Engineer-in-charge shall decide final formation level so as to ensure that the site appears uniform devoid of undulations. The final formation level shall however be very close to the formation level indicated in the approved drawing.

After anti-weed treatment is complete, the surface of the switchyard area shall be maintained, rolled/compacted to the lines and grades as decided by Engineer-in-charge. The sub grade shall be consolidated by using half ton roller with suitable water sprinkling arrangement to form a smooth and compact surface. The roller shall run over the sub grade till the soil is evenly and densely consolidated and behaves as an elastic mass. In areas that are considered by the Engineer-in-Charge to be too congested with foundations and structures for proper rolling of the site surfacing material by normal rolling equipments, the material shall be compacted by plate compactors. Due care shall be exercised so as not to damage any foundation structures or equipment during rolling compaction.

The sub grade shall be in moist condition at the time the cement concrete is placed. If necessary, it should be saturated with water for not less than 6 hours but not exceeding 20 hours before placing of cement concrete. If it becomes dry prior to the

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actual placing of cement concrete, it shall be sprinkled with water and it shall be ensured that no pools of water or soft patches are formed on the surface.

Over the prepared sub grade, 75mm thick base layer of cement concrete in 1:4:8 (1 cement :4 fine sand : 8 burnt brick aggregate/ stone aggregate) shall be provided in the area excluding roads, drains, cable trenches as per detailed engineering drawing.

Amendment II SI No 175

For easy drainage of water, the slope of 1:1000 is to be provided from the ridge to the nearest drain. The ridge shall be suitably located at the centre of the area between the nearest drains.

~~The above slope shall be provided at the top of base layer of cement concrete in 24 hours after laying of the cement concrete.~~

The above slope shall be provided at the top of base layer of cement concrete.

The cement concrete shall be laid over a saturated sub-grade to ensure avoiding of leaching of slurry. A layer of cement slurry of mix 1:6 (1 cement: 6 fine sand) shall be laid uniformly over cement concrete layer. The cement consumption for cement slurry shall not be less than 150 kg. Per 100 sq.m.

Amendment II SI No 174

Add:

In case acceptable quality of burnt brick aggregate is not available in any of the locations stone aggregate shall be used without any financial implication to POWERGRID

A final layer of 100mm thickness of uncrushed/crushed/broken stone of 40mm nominal size (ungraded size) shall be spread uniformly over cement concrete layer after curing is complete.

The filter areas shall be finished with Plain Cement Concrete (PCC) of grade 1:3:6 which shall be at least 100mm thick.

8.3.6 SEWAGE SYSTEM

- a) Sewage system (including collection, treatment and disposal) shall be provided for all utility buildings including the converter buildings, the relay building, and other auxiliary buildings.
- b) For treating the effluents the Contractor shall provide septic tank and soak pit system of suitable size within the stations.
- c) The sewage system shall consist of all necessary piping, pumps (if

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required), fittings, manholes, clean-outs, piping connections and all other materials required for a safe and efficient sewage system. Sewer pipes and fittings shall conform to the relevant Indian Standards.

- d) Sewers shall be designed for a minimum self cleansing velocity of 0.75 m/sec and the maximum velocity shall not exceed 2.4 m/sec.
- e) Cement concrete pipes or Cast Iron pipes shall be used below ground level. However, salt glazed stoneware pipes can be used

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in localized areas not subject to any traffic load. However, all vertical pipes from the building shall only be cast iron.

- f) Manholes shall be provided at every 30 m along the length, and at connection points, and at every change of alignment, gradient or diameter of a sewer pipeline.

8.3.7 DRAINAGE

8.3.7.1 SITE DRAINAGE

The Contractor shall provide rain water drainage system within the switchyard fencing. Connection at one or more locations to the outfall points located outside the station boundary wall is in the scope of the Contractor. Invert level of drainage system at outfall points shall be decided in such a way that the water can easily be discharged outside the station boundary wall. In case outfall point is more than 50M away from boundary wall, only 50 metre drain outside the boundary wall is in the scope of Contractor. Outfall points shall be got approved by the Employer before commencement of construction. While designing the drainage system following points shall taken care of:

- i) The surface of the switchyard shall be sloped to prevent accumulation of water.
- ii) Drain shall be constructed on both sides of roads. In the switchyard maximum spacing between two drains shall not be more than 100 meter. It shall be ensured that no area is left undrained.

Amendment I Sl. No 16

- iii) ~~Open surface rectangular brick drains having minimum 400mm width and 300mm depth with plaster on inner face and top of brick walls shall be provided.~~

Open surface rectangular drains shall be provided as per drawing

C/ENGG/STD/DRAIN/01 Rev 0 (copy enclosed)

Amendment II Sl No 176

~~Open surface rectangular brick drains having minimum 400mm width and 300mm depth with plaster on inner face and top of brick walls shall be provided. The base of the brick drain shall be in two layers. A layer of 100 mm thick 1:2:4 of PCC shall be laid over a layer of 40 mm thick 1:4:8 mix laid over well compacted earth.~~

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- iv) ~~Longitudinal slope shall not be less than 1 in 1000.~~

Amendment II SI No 177

Delete

- v) ~~Open surface drains shall be constructed with 100mm thick plain cement concrete 1:2:4 (1cement: 2 coarse sand: 4 stone aggregate 20mm nominal size). PCC 1:2:4 shall be laid over 40mm thick layer of PCC 1:4:8 (1 cement: 4coarse sand: 8 stone aggregate 20mm nominal size.)~~

Amendment III SI No 95

—————iii), iv) & v) The drains shall be as per the drawing

C/Engg/Std/Drain/HVDC which is enclosed as Annexure R.

- vi) The side wall of the drains shall be 25 mm above the gravel level to prevent falling of gravel into drain. Groove of 125 mm width shall be provided at 2000 mm spacing with suitable mild steel grating..

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- vii) The maximum velocity for pipe drains and open drains shall be limited to 2.4m/sec and 1.8m/sec respectively. However, minimum non-silting velocity of 0.6m/sec shall be ensured.
- viii) Pipe drains shall be provided in areas of switchyard where movement of crane shall be necessary in operating phase of the substation.
- ix) For pipe drains, concrete pipe of class NP2 shall be used. However, for road crossings etc. higher strength pipe of class NP3 shall be provided. For rail crossings, RCC pipes of class NP4 shall be provided. For design of RCC pipes for drains and culverts, IS:456 and IS:783 shall be followed.
- x) Two Nos. of portable pumps of 5 hp capacity for drainage of water shall be provided by the Contractor.
- xi) Pipe drains shall be connected through manholes at an interval of maximum 30m.
- xii) If the invert level of outfall point is above the last drain point in the substation boundary, sump of suitable size has to be constructed within the substation boundary.
- xiii) The drainage scheme and associated drawings shall be got approved from the Employer before commencement of construction.

8.3.7.2 RAIN WATER HARVESTING

In addition to drainage of rainwater in accordance with, the Contractor shall make arrangement for rainwater harvesting also. Rainwater harvesting shall not be done if the depth of water table is within 8.0m from finished ground level.

Rainwater harvesting shall be done by providing two numbers recharge structures with bore wells. The recharge structures shall be suitably located within the sub-station. Branch drains from the main drain carrying rainwater from entire switchyard, shall be connected to the recharge structures.

The internal diameter of recharge shafts shall be 4.5 meter with 230mm thick lining of brick work upto a depth of 2.0 meter from ground level and 345mm thick brickwork below 2.0 meter depth. The brickwork shall be constructed with cement mortar 1:6 (1 cement: 6 coarse sand). The overall depth of shaft shall be 5.0 meter below invert level of drain. The shaft shall be covered with RCC slab for a live load of 300 kg. per sq.m. Two openings of size

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0.7 x 0.7 meter shall be provided in the RCC cover slab. An iron cover made of 5mm thick chequered plate with hinges shall be provided on the openings. Galvanized M.S. rungs of 20mm diameter at spacing of 300 mm shall be provided in the wall of shaft below the opening in the RCC slab to facilitate cleaning of shaft.

A 300 mm diameter bore well shall be drilled in the centre of the shaft. The depth of bore well shall be 5.0 meter more than the depth of sub soil water.

A 100 mm dia medium duty MS pipe conforming to IS 1161 shall be lowered in the bore well keeping bail plug towards bottom of bore well. The pipe shall have 1.58mm holes for 4.0 meter length starting from 1.0 meter from bottom of bore well. Holes of 3.0mm dia shall be provided for a length of 2.0 meter starting from the bottom level of coarse sand and down wards. The overall length of pipe shall be equal to total depth of bore well plus depth of shaft.

Gravel of size 3mm to 6mm shall be filled around 100 dia MS pipe in the bore well. The shaft shall be filled with 500 mm thick layers each from the bottom of shaft with boulders of size 50mm to 150mm, gravel of size 5mm to 10mm, coarse sand having particle size 1.5mm to 2.0mm and boulders of size not less than 200mm respectively.

8.3.8 ROADS

- a) All roads shall be concrete road (rigid) pavement.
- b) Adequate turning space for vehicles shall be provided and bend radii shall be set accordingly. Road to the Converter transformer /Reactor shall be as short and straight as possible.
- c) CPWD specification shall be followed for construction of Roads.

Amendment I Sl. No. 17

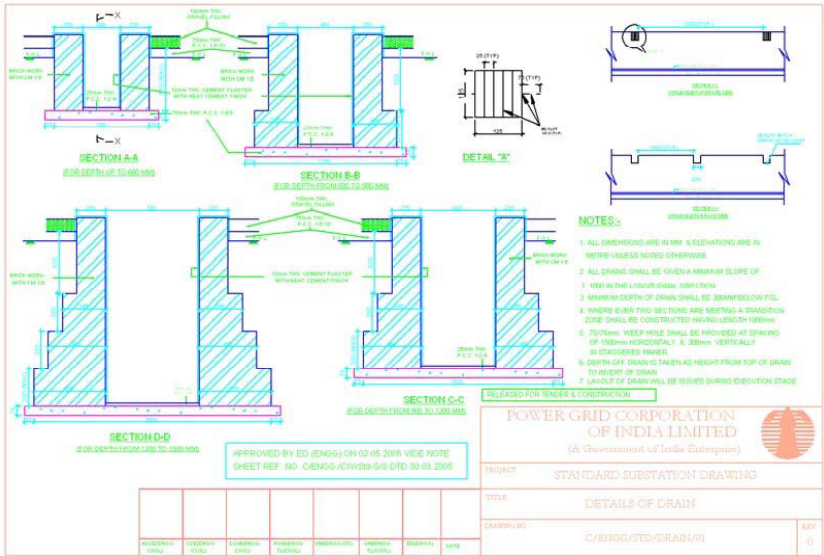
- d) ~~Cross section of the road shall be as per drawings C/ENGG/STD/ROAD/410 & 411 enclosed with the tender documents.~~

The width of the roads around the converter island and the main approach road from station entrance gate shall be at least 7 meters and the roads within the AC & DC switchyards shall be at least 3.75 meters. The rail cum road track provided shall be of 10 meter width. The drawings for the 3.75 road are attached with the specification whereas the cross section of the 7meter road shall be furnished by the contractor for approval by the Employer.

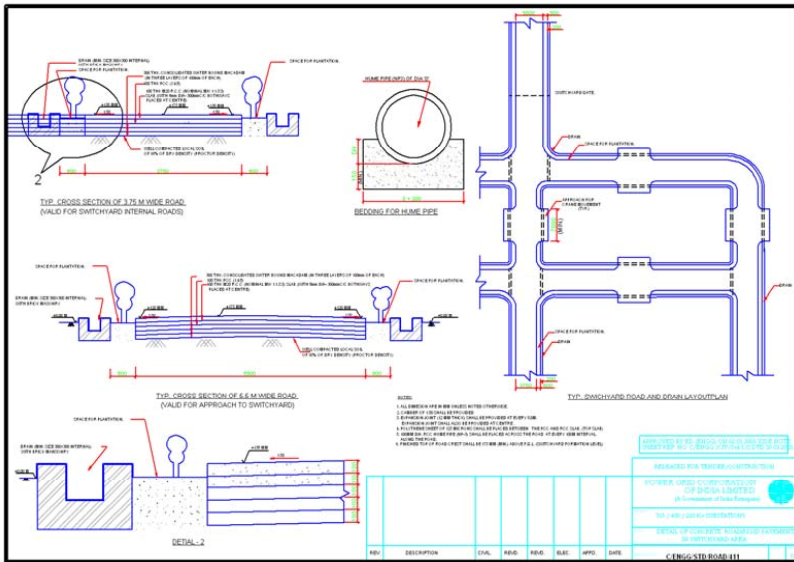
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- e) All the culverts and allied structures (required for road/rail, drain, trench crossings etc.) shall be designed for class AA loading as per IRC standard / IS code and should be checked for transformer loading.

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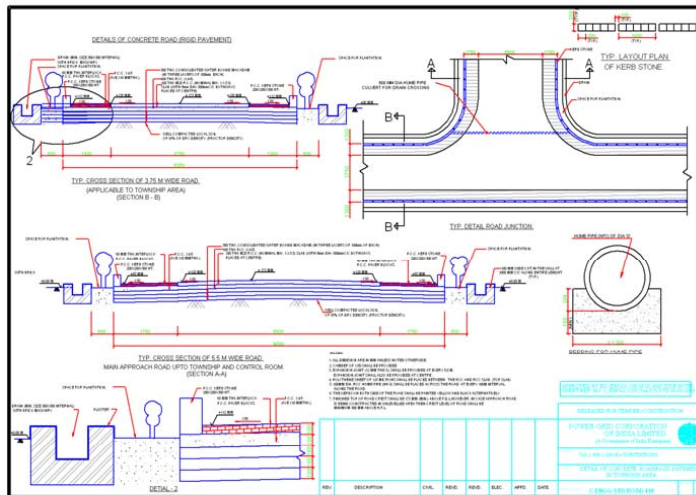


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8.4 FOUNDATIONS AND OTHER RCC CONSTRUCTIONS

8.4.1 GENERAL

Amendment III SI No 96 (Add)

- .1 Work covered under this Clause comprises the design, supply and construction of foundations and other RCC constructions for switchyard structures, equipment supports, trenches, drains, jacking pad, pulling block, fencing, boundary wall, control cubicles, bus supports, transformers, reactors, marshalling kiosks, auxiliary equipments & systems, buildings, tanks, rail tracks or for any other equipment or service and any other foundation/RCC construction required to complete the work. This clause is as well applicable to the other RCC constructions.

PPC (ordinary Portland cement) shall not be used for RCC works

Amendment II SI No 178

- .2 ~~Concrete shall conform to the requirements mentioned in CPWD specification and all the tests shall be conducted as mentioned in Standard field quality plan appended with the specification.~~

~~A minimum grade of M20 concrete shall be used for all structural/load bearing members. Nominal mix by volume 1:1.5:3 (1cement: 1.5 coarse sand: 3stone aggregate 20mm nominal size) shall be used for all RCC works. Higher grades of concrete can be allowed if Contractor carries out mix design and installs a batching plant or arranges the concrete from a approved ready mix concrete supplier.~~

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Reinforced Concrete shall conform to the requirements mentioned in IS 456 (latest version).

A minimum grade of M 25 concrete shall be used for all structural/load bearing members for all RCC works in the terminal stations. Only weigh batching shall be allowed for design mix concretes.

ADD:

All the tests shall be conducted as mentioned in the IS 456 for design mix concretes and will supersede the relevant sections of Standard field quality plan appended with the specification. In case of repeater stations where the concrete volume is very small nominal mix conforming to CPWD specification may be used.

Amendment II SI No 179

- ~~.3 Where the site is inclined, the foundation height shall be adjusted to maintain the exact level of the top of structures to compensate such slopes.~~

Amendment II SI No 180

- ~~.4 The switchyard foundations plinth and building plinth shall be minimum 300 mm and 500 mm above finished ground level respectively.~~

The switchyard foundations plinth and building plinth shall be minimum 300 mm and 750 mm above finished ground level respectively

- .5 Minimum 75 mm thick lean concrete 1:4:8 (1 cement : 4 coarse sand : 8 stone aggregate 40mm nominal size) shall be provided below all underground structures, foundations, trenches etc. to provide a base for construction.

Amendment II SI No 181

- ~~.6 Concrete made with ordinary Portland cement shall be carefully cured and special importance shall be given during the placing of concrete and removal of shuttering. Portland pozzolone / slag cement can be used, however 53 grade cement shall be used with specific approval of Employer.~~

Concrete made with Portland Pozzolana or slag cements cement shall be carefully cured and special importance shall be given during the placing of concrete and removal of shuttering. In case of encountering of aggressive soils and sub soil water OPC/PPC Sulphate resisting cement shall be used for foundations as per the provisions of IS 456

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8.4.2 DESIGN

- .1 All the foundations shall be of reinforced cement concrete. The design and construction of RCC structures shall be carried out as per IS-456.
- .2 The design and construction of steel-concrete composite beam shall be carried out as per IS-11384.
Amendment II SI No 182
- .3 For detailing of reinforcement IS-5525 and SP:34 shall be followed. Cold twisted deformed bars ($F_y=415 \text{ N/mm}^2$) conforming to IS-1786 or Thermo – mechanically treated bars of equal grade shall be used as reinforcement. *In line with provisions of IS 13920 high strength deformed steel bars, produced by thermo-mechanical treatment process, of grades Fe 500 & Fe 550, having elongation more than 14.5% and conforming to other requirements of IS 1786:1985 may also be used for the reinforcement.* However, in specific areas, mild steel (Grade I) conforming to IS-432 can also be used with specific approval of the Employer. Two layers of reinforcement (on inner and outer face) shall be provided for wall & slab sections having thickness of 150 mm and above. Clear cover to reinforcement shall be as per IS: 456 (latest).
- .4 RCC water retaining structures like storage tanks, cooling water basin etc. shall be designed as un-cracked section in accordance with IS-3370 (Part I to IV) by working stress method. However, water channels and substructure of pump house shall be designed as cracked section with limited steel stresses as per IS-3370 (Part I to IV) by working stress method.
- .5 The procedure used for the design of the foundations shall be the most critical loading combination of the steel structure and/or equipment and/or superstructure, and other conditions,

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which produces the maximum stresses in the foundation or the foundation component and as per relevant IS codes.

- .6 The design and detailing of foundations shall be done based on the approved soil data and sub-soil conditions as well as for all possible critical loads and the combinations thereof. The spread footings foundation or pile foundation as may be required based on soil/sub-soil conditions and superimposed loads shall be provided.
- .7 When pile foundations are adopted, the same shall be cast-in-situ/driven/bored or pre-cast type as per relevant IS. Only RCC piles shall be provided. Suitability of the adopted pile foundations shall be justified by way of full design calculations. Detailed design calculations shall be submitted by the Contractor showing complete details of piles/pile groups proposed to be used. Necessary initial load test shall also be carried out by the Contractor at their entire cost, to establish the piles design capacity. Only after the design capacity of piles has become established, the Contractor shall take up the job of piling. All the work (design & testing) shall be planned in such a way that these shall not cause any delay in project completion.

Amendment II SI No 183

- .8 ~~All foundations shall rest below virgin ground level and the minimum depth of foundation below the virgin ground level shall be at least 1000 mm. For small equipments & minor foundations like marshalling kiosks, pylon supports, cable trenches, drains, etc., this may be reduced to 500 mm with specific approval of the Employer.~~

~~—All foundations shall extend to a depth of atleast 500 mm below virgin ground level as stipulated in IS 1904. For small structures like minor foundations of marshalling kiosks, fire fighting pipe line pylon supports, fencing posts, cable trenches, drains, etc., coming in filled up soil this stipulation shall not be applicable. In such cases a layer of 200 mm thickness of stone ballast filled with local sand shall be provided on compacted soil layer (minimum 95% compaction) before laying PCC~~

All R.C.C. piles (including short piles) shall be suitably anchored into hard virgin strata. The friction resistance of back fill earth shall be neglected for calculation of pile capacity for design purposes, however negative friction due to earth fill, if any, has to be duly considered for deciding pile capacity.

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- .9 Design shall consider any sub-soil water pressure that may be encountered following relevant standard strictly.
- .10 Necessary insulation shall be provided in reinforcement steel to avoid closed loops, wherever required e.g. reactor foundations.
- .11 Necessary protection to the foundation work, if required, shall be provided to take care of any special requirements for aggressive alkaline soil, black cotton soil or any other type of soil which is detrimental/ harmful to the concrete foundations.
- .12 RCC columns shall be provided with rigid connection at the base.
- .13 All building sub-structures including pump houses shall be checked for sliding and overturning stability during both construction and operating conditions for various combinations of loads. Factors of safety for these cases shall be taken as mentioned in relevant IS Codes or as stipulated elsewhere in the Specifications.
- .14 Earth pressure for all underground structures shall be calculated using coefficients of earth pressure at rest; co-efficient of active or passive earth pressure (whichever is applicable). However, for the design of substructure of any underground enclosures, earth pressure at rest shall be considered.
- .15 In addition to earth pressure and ground water pressure etc., a surcharge load of minimum 2 T/sq.m shall also be considered for the design of all underground structures including channels, sumps, tanks, trenches, substructure of any underground hollow enclosure etc., to account for the vehicular traffic in the vicinity of the structure.
- .16 Following conditions shall be considered for the design of substructure of pump house, channels, sumps, tanks, trenches and other underground structures :-
 - a) Full water pressure from inside and no earth pressure & ground water pressure & surcharge pressure from outside (applicable only to structures which are liable to the filled up with water or any other liquid).
 - b) Full earth pressure, surcharge pressure and ground water pressure from outside and no water pressure from inside.
 - c) Design shall also be checked against buoyancy due to the ground water during construction and maintenance stages. Minimum factor of safety of 1.5 against buoyancy shall be ensured ignoring the superimposed loadings.
- .17 Base slab of the any underground enclosure/tank shall also be

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designed for its empty condition during construction and maintenance stages with maximum ground water table (GWT). Minimum factor of safety of 1.5 against buoyancy shall be ensured ignoring the super-imposed loadings.

- .18 Base slab of any underground enclosure like water storage tank shall also be designed for the condition of different combination of pump sumps being empty during maintenance stages with

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maximum GWT. Intermediate dividing piers of such enclosure shall be designed considering water in one pump sump only and the other pump sump being empty e.g. for maintenance.

- .19 The foundations shall be proportioned so that the estimated total and differential movements of the foundations are not greater than the movements that the structure or equipment is designed to accommodate. Foundation settlements shall, in no case, exceed the permissible limits specified in relevant Indian Standard Specification.
- .20 All machine foundations shall be designed in accordance with the provisions of the relevant parts of IS-2974, IS-456 and IS-2911. The provisions of DIN-4024 (latest) shall also be followed.

For the foundations of rotating machines, detailed static and dynamic analysis shall be done. A fatigue factor of at least 2.0 shall be considered for dynamic forces. Minimum reinforcement shall be governed by IS-2974 as well as IS-456. RCC design shall be done by working stress method.

For the foundations supporting minor equipments weighing less than one ton or if the mass of the rotating parts is less than one-hundredth of the mass of the foundation, dynamic analysis is not must. However, if such minor equipment is to be supported on building structures, floors etc. suitable vibration isolation shall be provided by means of springs, neoprene pads etc. and such vibration isolation system shall be designed suitably.
- .21 All other foundations shall be designed in accordance with the provisions of the relevant parts IS-2911 and IS-456.
- .22 The gantry/tower foundations shall be designed for factor of safety of 2.2 for normal and broken wire condition and 1.65 for combined short circuit and broken wire condition.
- .23 Minimum two piles shall be provided in any pile group.

Amendment II SI No 184

Add

- 24. Equipment foundations shall be designed for a factor of safety of 2.2 for normal and 1.65 for short circuit condition

8.4.3 ADMIXTURES & ADDITIVES

- .1 Only approved admixtures shall be used in the concrete for the Works. When more than one admixture is to be used, each admixture shall be batched in its own batch and added to the mixing water separately before discharging into the mixer.

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Admixtures shall be delivered in suitably labelled containers to enable identification.

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- .2 Admixtures in concrete shall conform to IS-9103. The water proofing cement additives shall conform to IS-2645. Concrete Admixtures/Additives shall be approved by the Employer.
- .3 The Contractor shall use an approved neutralized vinsol resin or air-entraining agent in concrete. The Air-entraining agent shall be supplied and batched as a solution with a solid content not exceeding 15% by weight with suitable, stable and consistent pH. Air- entraining requirements shall be in accordance with CP 100 Part I.
- .4 The Contractor can propose and the Employer, at his discretion, may approve the use of a water-reducing set retarding admixture in some of the concrete. The use of such an admixture shall not be approved to overcome problems associated with inadequate concrete plant capacity or improperly planned placing operations and shall only be approved as an aid overcoming unusual circumstances and placing conditions.
- .5 The water-reducing set-retarding admixture shall be an approved brand of ligno-sulphonate type admixture.
- .6 The water proofing cement additives shall be used only after approval of the Employer.

8.4.4 HOT WEATHER REQUIREMENTS

- .1 During hot weather all necessary precautions, as per relevant Codes, shall be taken to avoid premature stiffening of the fresh mix and to reduce water absorption and evaporation losses and when the temperature of the surrounding air is higher than 30°C. The following shall apply unless otherwise approved by the Employer:
 - a) The formwork shall be continuously sprayed with cold water in advance of concreting and excess water shall be removed from inside the forms immediately prior to placement of concrete.
 - b) The reinforcement and the formwork (if metal forms are used), shall be protected from the effects of hot winds and direct sunlight.
 - c) Suitable barriers shall be provided to protect the freshly placed concrete from wind until the concrete is sufficiently hard to allow it to be covered according to (e) below.

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- d) The concrete when placed shall be maintained at a temperature of less than 30 degree C by the use of chilled mixing water or by spraying the aggregate with cold water.
 - e) The concrete shall be mixed, transported, placed and consolidated, as rapidly as possible and shall then be covered with an impervious membrane or wet Hessian until moist curing beings.
- .2 Curing compounds shall not be used as an alternative to the requirements of Clause 8.4.3.
- .3 During hot weather (atmospheric temperature above 40 deg C) or cold weather (atmospheric temperature at & below 5 deg C) the concreting shall be done as per the procedure set out in IS-7861 (Part I & II).

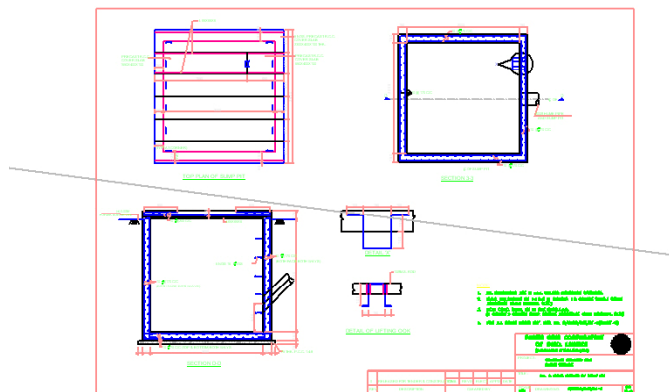
8.5 CABLE & PIPE TRENCHES

Amendment II SI No 185 (Add)

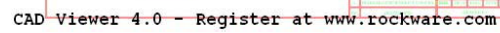
- .1 RCC trenches and pre-cast removable concrete covers (with lifting arrangement) shall be designed to withstand *surcharge* loads of 1000 kg/m² from maintenance trucks and a concentrated load of 200 kg at mid span of cover. Cable trenches shall also be designed with water pressure along with earth pressure.

Amendment II SI No 186

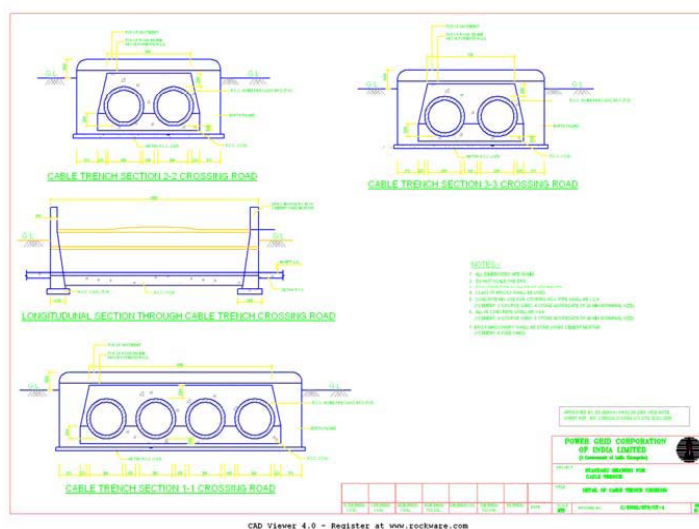
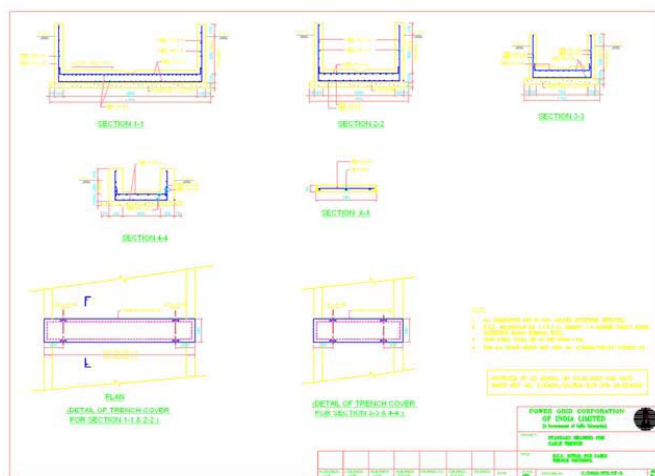
- .2 Trenches shall be of reinforced cement concrete, having minimum ~~M-20~~ grade M-25 grade of concrete. The standard / typical trench drawing is indicated below:



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CAD Viewer 4.0 - Register at www.eockbase.com

(Typical drawing of cable trench)

- .3 Trenches shall be drained. Necessary sumps and sump pumps shall be supplied, as required. Cable trenches shall not be used as storm water drains.
- .4 The top of trenches shall be kept at least 150 mm above the final gravel level and be constructed such that the surface rain water do not enter the trench.
- .5 All metal parts inside the trench shall be connected to the grounding system.
- .6 Cables from trench to equipment shall run in hard conduits that are heavy duty PVC or GI pipe.
- .7 Trench wall shall not foul with the foundation. Suitable clear gap shall be provided.
- .8 A clear (vertical) space of at least 300 mm shall be available for each tier in cable trench. From trench bed to lowest tier, a minimum clearance of 200 mm shall be available for one tier trench & 300 mm for trench having tiers more than one.

At least the following tray to opposite wall (and between trays for multi row trench) clear clearance shall be available:

For trenches having	minimum
---------------------	---------

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depth	clearance
< 500 mm	200 mm
501 - 1000 mm	400 mm
> 1000 mm	500 mm

Instead of cable trays, the Contractor may use steel brackets as per section 6.16 of this specification.

- .9 The trench bed shall have a slope of 1/1000 along the run & 1/250 perpendicular to the run.
- .10 All construction joints of cable trenches i.e. between base slab to base slab and the junction of vertical wall to base slab as well as from vertical wall to wall shall be provided with approved quality PVC water stops of approx. 230 mm x 5 mm size for those cable trenches where the ground water table is expected to be above the junction of base slab and vertical wall of cable trenches.

Suitable expansion joints with PVC water stops and bitumen impregnated board sealing shall be provided at an approximate interval of 30 m for all sections of cable trenches.

8.6 CONVERTER TRANSFORMER / REACTOR FOUNDATION, RAIL TRACK / ROAD CUM RAIL TRACK

Amendment-I Sl. No. 19 & 20

The Contractor shall provide a RCC Rail cum road system integrated with the transformer foundation to enable installation and the removal of any failed unit. The transfer track system shall be suitable to permit the movement of any failed unit fully assembled (including OLTC, bushings) with oil. ~~The rail cum road track shall be provided all along the length of the transformer area covering both Pole I and Pole II so that any failed unit can be moved from its foundation to the nearest road.~~

The rail cum road track with a width of 10 meters shall be provided all along the length of the transformer area covering all the poles so that any failed unit can be moved from its foundation to the nearest road.

If trench/drain crossings are required then suitable R.C.C. culverts shall be provided in accordance with I.R.C. standard / relevant IS. The permanent transfer track system shall have RCC raft type foundation integrated with the converter transformer foundations. The road cum rail track shall be of RCC construction and the surface shall be rendered smooth and suitable drainage system

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shall be provided.

The Contractor shall provide a pylon support system for supporting the fire fighting system.

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Each converter transformer, auto transformer and smoothing reactor (if oil filled) including oil conservator tank and cooler banks etc. shall be placed in a self-sufficient pit surrounded by retaining walls (Pit walls). The clear distance of the retaining wall of the pit from the converter transformer shall be 20% of the transformer height or 0.8m whichever is more. The oil collection pit thus formed shall have a void volume equal to minimum 20% volume of total oil in the converter transformer. The oil collection pits below the converter transformers shall be suitably connected through RCC pipes on pole basis. ~~The pipes shall be placed in such a way so that oil can flow from one pit to the main collection sump pit. Only one main collection sump pit per station shall be made.~~

The pipes shall be placed in such a way so that oil can flow from one pit to the main collection sump pit. One main collection sump pit per station shall be provided at Biswanath Chariali and Siliguri (New) converter stations whereas two pits shall be provided at Agra.

The volume of main oil collection pit shall be 220 % of the largest transformer oil volume. (for example large transformer oil volume is 100 kL, then the main collection pit oil volume shall be 220 kL). Similarly separate pipe connection shall be made from individual pole to the main collection sump pit. The minimum height of the retaining walls shall be 15 cm above the finished level of the ground to avoid outside water pouring inside the pit. The bottom of the pit shall have a uniform slope towards a main collection sump pit. While designing the oil collection sump pit, the movement of the transformer must be taken into account.

The pits shall be covered with a grating made of MS flat of minimum size 40mmx 5mm placed at 30mm centre to centre and 25mmx5mm MS flat at spacing of 100mm at right angle to each other. Maximum length of grating shall be 2000mm and width shall not be more than 500mm. The gratings at intermediate location shall be supported on ISMB 150mm, shall be placed at the formation level and shall be covered with 100mm thick layer of broken/crushed/non-crushed stone having size 40mm to 60mm which acts as an extinguisher for flaming oil.

Each oil collection pit shall be drained towards a sump pit within the collection pit whose role is to drain water and oil within the collection pit so that collection pit remains dry.

Complete foundation shall be made of reinforced cement concrete.

A pump of suitable rating with auto start and auto stop features shall be supplied and installed in main collection sump pit by the Contractor to drain out the fire fighting & rain water and oil if any

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from the sump pit in to the nearest drain.

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8.7 FIRE PROTECTION WALLS

8.7.1 GENERAL

Fire protection walls shall be provided, if required, in accordance with Tariff Advisory Committee (TAC) recommendations.

A fire wall shall be erected between each phase of the converter transformers (in the case of single phase equipment) to protect each one from the effects of fire on another.

Also, if the free distance between the converter building and the converter transformers is less than 10 m, a fire wall shall be erected between the building and the equipment, or otherwise the building walls shall be fire resistant.

8.7.2 FIRE RESISTANCE

Amendment II SI No 187

The firewall shall have a minimum fire resistance of 3 hours. The partitions, which are made to reduce the noise level, shall have the same fire resistance. The walls of the building, which are used as firewalls, shall also have a minimum fire resistance of 3 hours. *However, the firewalls around transformers shall have a minimum fire resistance of 4 hours as per IE rules.*

The firewall shall be designed to protect against the effect of radiant heat and flying debris from an adjacent fire.

8.7.3 DIMENSIONS

Amendment II SI No 188

The firewall shall extend 600 mm on each side of the Converter transformer and 600 mm above the conservator tank or safety vent.

These dimensions might be reduced in special cases, as per the approval of Employer where there is lack of space. A minimum of 2.0 meter clearance shall be provided between the equipments e.g. Converter transformer and firewalls.

~~The firewall shall be made of reinforced concrete (M-20 grade), as per the system requirements.~~

The firewall shall be made of reinforced concrete (M-25 grade), as per the system requirements

8.8 STEEL STRUCTURES

8.8.1 GENERAL

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The scope of specification covers design (except design of those tower structures of AC switchyard which are enclosed with the specification), fabrication, proto-assembly, supply and erection of galvanised steel structures for towers, girders, lightning masts and equipment support structures. The scope shall include supply and erection of all types of structures including bolts, nuts, washers, hangers, shackles, clamps anti-climbing devices, bird guards, step bolts, inserts in concrete, gusset plates, equipment mounting bolts, structure earthing bolts, foundation bolts, spring washers, fixing plates and any other items as required to complete the job.

The connection of all structures to their foundations shall be by base plates and embedded anchor/foundation bolts. All steel structures and anchor/foundation bolts shall be fully galvanized. The weight of the zinc coating shall be at least 0.610 kg/m² for anchor bolts / foundation bolts and for structural members. One additional nut shall be provided below the base plate which may be used for the purpose of levelling.

For filter equipment and valve cooling towers etc anchor fasteners (e.g. Hilti etc) may be used.

Amendment III SI No. 97 (Add)

Standard drawings for 400 KV AC switch yard steel structures for wind zone V (50 m/sec) have been attached as Annexure U.

8.8.2 REQUIREMENTS

For design of steel structures loads such as dead loads, live loads, wind loads etc. shall be based on IS:875, Parts I to V. For materials and permissible stresses IS: 802, Part-I, Section-2 shall be followed in general. However, additional requirements given in following paragraphs shall be also considered.

.1 The minimum thickness of members shall be as follows:

	Open Section	Closed Section
Leg members	6 mm	4 mm
Bracing members	5 mm	4 mm
Redundant members	4 mm	4 mm

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- .2 The maximum slenderness ratios for leg members, other stressed members and redundant members for compression force shall be as per IS-802.
- .3 The minimum distance from hole centre to edge shall be $1.5 \times$ bolt diameter and the minimum distance between centre to centre shall be $3.0 \times$ bolt diameter.
- .4 The minimum bolt diameter shall be 16 mm.
- .5 In order to facilitate inspection and maintenance, the structures shall be provided with climbing devices.
- .6 Following design criteria shall be adopted for design of switchyard structures:
 - a) All structures shall be designed for the worst combination of dead loads, live loads, wind loads as per IS-875, seismic forces as per IS-1893, loads due to deviation of conductor, load due to unbalanced tension in conductor, torsional load due to unbalanced vertical and horizontal forces, erection loads, short circuit forces including "snatch" in the case of bundled conductors etc. Short circuit forces shall be calculated in accordance of IEC-865 considering a fault level of 40.0 kA.
 - b) Switchyard gantry structures shall be designed for the condition of all the three wires on one side being broken. The design of all structures shall be based on the condition where stringing is done only on one side i.e. all the three (phase) conductors broken on the other side.

A factor of safety of at least 2.0 under normal as well as broken wire conditions and 1.5 under combined short circuit & broken wire conditions shall be considered for the design of switchyard structures.
 - c) For purpose of design, static tension pull & transverse reaction on the gantries as calculated for each individual span shall be considered. Vertical load of half the span of conductors/string and the earth wires on either side of the beam shall be considered. Weight of man with tools shall be considered at least 150 kgs for the design of structures.
 - d) Terminal/line take off gantries shall be designed for a minimum conductor tension of 4 MT per phase or as per above requirement, whichever is more for 400 kV switchyard. The design of the terminal gantries shall also be checked considering ± 30 degrees deviation of conductor in both

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vertical and horizontal planes.

- .7 The girders shall be connected with lattice columns by bolted joints.
- .8 All equipment supports shall be designed for the worst combination of dead loads, erection load, wind load/seismic forces, short circuit forces and operating forces acting on the equipment and associated bus bars as per IS- 806.
- .9 The design of steel structures for buildings shall be done by working stress method based on IS: 800.

Amendment II SI No 189

(Add)

- 10 *Soft copies of designs and drawings shall be submitted for approval along with hard copies for all structures. Single user package of licensed soft ware shall be provided for checking the drawings and designs*

8.8.3 BOLTING

- i) Every bolt shall be provided with a washer under the nut so that no part of the threaded portion of the bolt is within the thickness of the parts bolted together.
- ii) All steel items, bolts, nuts and washers shall be hot dip galvanised.
- iii) 2% extra nuts and bolts shall be supplied for erection.

8.8.4 WELDING

The work shall be done as per approved fabrication drawings which clearly indicate various details of joints to be welded, type of weld, length and size of weld, whether shop or site weld etc. Symbols for welding on erection and shop drawings shall be according to IS:813. Efforts shall be made to reduce site welding so as to avoid improper joints due to constructional difficulties.

8.8.5 FOUNDATION BOLTS

Foundation bolts for the towers and equipment supporting structures and elsewhere shall be embedded in first stage concrete while the foundation is cast. The Contractor shall ensure the proper alignment of these bolts to match the holes in the base plate.

The Contractor shall be responsible for the correct alignment and levelling of all steel work on site to ensure that the towers/structures are plumb.

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All foundation bolts for lattice structure, pipe structure are to be supplied by the Contractor.

All foundation bolts shall be fully galvanised so as to achieve 0.61 kg. per m² of Zinc Coating as per specifications.

All foundation bolts shall conform to IS:5624 but the material however shall be MS conforming to IS:2062.

8.8.6 STABILITY OF STRUCTURE

The Supplier shall be responsible for the stability of the structure at all stages of its erection at site and shall take all necessary measures by the additions of temporary bracings and guying to ensure adequate resistance to wind and also to loads due to erection equipment and their operations.

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8.8.7 GROUTING

The method of grouting the column bases shall be subject to approval of Purchaser and shall be such as to ensure a complete uniformity of contact over the whole area of the steel base. The Contractor shall be fully responsible for the grouting operations.

8.8.8 GALVANISING

All structural steel works and pipe supports shall be galvanised after fabrication. Zinc required for galvanising shall have to be arranged by the manufacturer. Purity of zinc to be used shall be 99.95% as per IS: 209.

The Contractor shall be required to make arrangement for frequent inspection by the Purchaser as well as continuous inspection by a resident representative of the Purchaser, if so desired for fabrication work.

8.8.9 TOUCH-UP PAINTING

The touch up primers and paints shall consist of Red Oxide / Zinc chromate conforming to the requirements of IS: 2074 with a pigment to be specified by the Employer.

8.9 CHAINLINK FENCING AND GATE

8.9.1 AREAS REQUIRING FENCING

Fencing shall be provided for the complete converter stations. Fencing shall also be provided for equipments mounted on ground or at a height lower than 2.5m. Necessary gates shall be provided for each area so fenced.

8.9.2 MATERIALS

The minimum requirements are as follows:

Amendment II SI No. 190

a) ~~Chain link fence fabric (without galvanization) in accordance to IS:2721.~~

Galvanised Chain link fence fabric in accordance to IS:2721:2003

1. Size of mesh: 75mm
2. Nominal wire size: 3.15mm dia meter

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3. Width of chain 1500mm
link:

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4. Painting: Two or more coats of approved standard make synthetic enamel paint over a coat of standard steel primer.

b) Posts

The posts shall be of medium M.S. tubes of 50mm diameter conforming to grade Yst-22 (Kg/mm²). The tubes shall also conform to IS: 1161/IS 806. The length of tubular post shall be 2600 mm.

An M.S. base plate of size 160 X 160 X 6mm thick shall be welded with the tubular post. The post shall be provided on the top with M S plate.

The tubular post shall be welded with 8 number of M S flat of size 50 x 6mm – 75mm long. Two number of 13.5 mm diameter holes on each cleats shall be provided to bolt the fence fabric panel. The cleats shall be welded at equal spacing in such a way that 4 numbers of cleats are on one side and remaining 4 cleats are on the opposite side of the post. The cleats on the corner posts shall be welded in such a way that it suits the site requirement.

The whole assembly of tubular post shall be hot dip galvanized. The zinc coating shall be minimum 610 gram per sq. meter. The purity of zinc shall be 99.95% as per IS:209.

c) Fence Fabric Panel

Chain link fencing shall be fabricated in the form of panel 1300 X 2928 mm. An M.S. flat of at least 50x6 mm size shall be welded all-round fence fabric to form a panel. Four pairs of 13.5mm diameter holes on the vertical M S flat matching the spacing of holes in cleats fixed with pipe as shown in the drawing shall be provided to fix the fence panel with the tubular posts. A washer shall also be provided below each nut. The Contractor, for fixing the panels, shall supply the 12mm diameter bolts including nuts and washers. All nuts, bolts and washers shall be hot dip galvanized.

The fence panel shall be provided with two or more coats of approved standard synthetic enamel paint over approved standard steel primer.

d) Installation

- i) Fence shall be installed as shown in the approved drawings.
- ii) All posts shall be 3.0m apart measured parallel to ground

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surface.

- iii) Posts shall be set in 1:2:4 Plain Cement Concrete block of minimum 0.40x0.40x1.2m depth. 75mm thick plain cement concrete 1:4:8 shall be provided below concrete blocks. Posts shall be braced and held in plumb position and true alignment and elevation until concrete has set.
- iv) Fence fabric shall not be installed until concrete has been cured for a minimum of 7 days.

—Amendment II SI No 191

- v) ~~Fence fabric panel shall be fixed to the post by 4 nos. MS flat each of 50x6, 75 long through 2 nos. of bolts (12 diameters) on each flat.~~

Fence fabric panel shall be fixed to the post by 4 nos. GI flat each of 50x6, 75 long through 2 nos. of bolts (12 diameters) on each flat.

Amendment II SI No 192

- vi) ~~The painting pattern of fence panels shall be decided by Engineer in charge.~~

e) Gate

- i) The gate shall be made of medium duty M.S. pipe conforming to relevant I.S. with welded joints. The main frame (outer frame) of the gate shall be made of 40mm dia pipe and vertical pipes of 15mm dia @ 125mm spacing (maximum) shall be welded with the main frame. Other details shall be as shown in the drawing.
- ii) The gates shall be fabricated with welded joints to achieve rigid connections. The gate frames shall be painted with one coat of approved steel primer and two coats of synthetic enamel paint.
- iii) The gates shall be provided with suitable locking arrangement.
- iv) The main gate shall be 5.0m wide and shall be of double leaf type (as shown in the drawing). Next to the main gate, a man gate (1.25m wide single leaf) shall also be provided.
- v) The main gate shall be motorised .
- vi) Gate shall be installed in location as shown in approved G.A. drawing.

SECTION 8: CIVIL WORKS

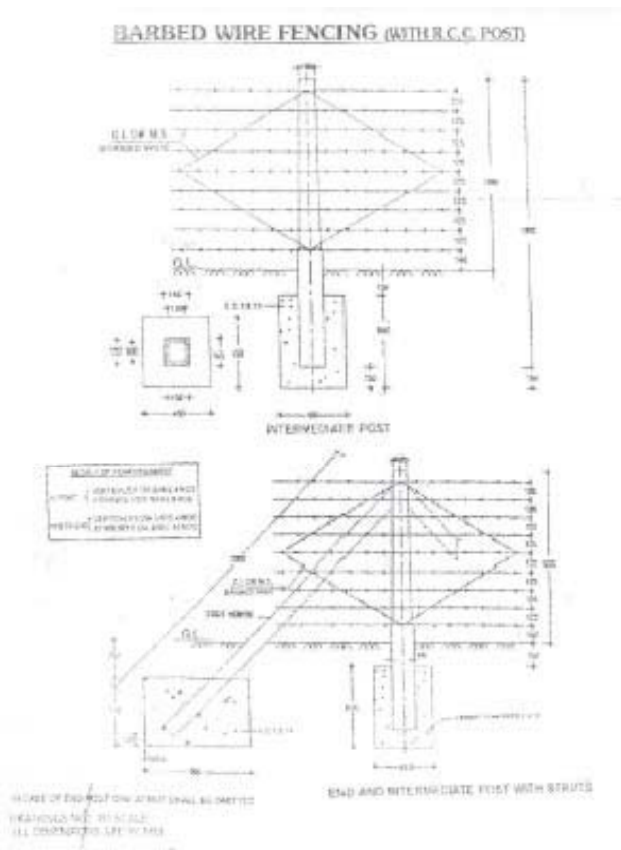
f) Electrode station fencing:

Amendment II SI No 193

The fence shall be 1.2 m high comprising of 1.8 m RCC standard posts, with wooden plugs or 6 mm bar nibs, placed every 3 m apart embedded in cement concrete blocks. Every 15th post, last but one end post and corner post shall be struttled on both sides and end post on one side only. ~~There shall be nine parallel horizontal lines of barbed wire~~

There shall be nine parallel horizontal lines of galvanized barbed wire

9.38 kg per 100 metres (minimum) between the two posts fitted and fixed with GI staples on wooden plugs or GI binding wire tied to 6 mm bar nibs. In addition to horizontal lines, two diagonals shall also be provided between the posts. The RCC posts and fencing shall be provided as per the enclosed drawing.



SECTION 8: CIVIL WORKS

8.10.6 BUILDING STORM WATER DRAINAGE

The building design shall provide for the collection of storm water from the roofs. This water shall be drained to the main drainage system of the station.

Cast Iron rain water down comers conforming to IS-1230 with water tight lead joints or medium class galvanized mild steel pipes conforming to IS-1239/IS-3589 shall be provided to drain off the rain water from the roof. These shall be suitable concealed with masonry work of cement concrete or cladding material. The number and size of down comers shall be governed by IS-1742 and IS-2527.

All drains inside the buildings shall have minimum 40 mm thick grating covers and in areas where heavy equipment loads would be coming, pre-cast RCC covers shall be provided in place of steel grating.

For all buildings, suitable arrangement for draining out water collected from equipment blow downs, leakages, floor washings, fire fighting etc. shall be provided for each floor.

8.11 MISCELLANEOUS GENERAL REQUIREMENTS

Amendment II SI No 202

1. ~~Dense concrete with controlled water cement ratio preferably 0.45 shall be used~~
Dense concrete with controlled water cement ratio preferably 0.45 (As per IS 456) shall be used for all underground concrete structures such as pump-house, tanks, water retaining structures, cable and pipe trenches etc. for achieving water-tightness.

Amendment II SI No 203

~~For all civil works covered under this specification, nominal mix by volume batching as per CPWD specification is intended.~~

For all civil works covered under this specification design mix concrete is intended in conformity to IS 456. However, in case of repeater station work where, nominal mix by volume batching as per CPWD specification is intended. The relationship of grade of concrete and ratio of ingredients shall be as below:

SECTION 8: CIVIL WORKS

S.No.	Mix	Cement	Sand	Coarse Aggregate (As per IS 383)
1.	M10	1	3	6
2.	M15	1	2	4
3.	M20	1	1.5	3

Amendment II SI No 204

~~The material specification, workmanship and acceptance criteria shall be as per relevant clauses of CPWD specification and approved Field Quality Plan.~~

The material specification, workmanship and acceptance criteria shall be as per the provisions of IS 456:2000 In case of nominal mixes relevant clauses of CPWD specifications shall be adopted. Approved Field Quality Plan shall be followed for adherence to quality norms.

SECTION 8: CIVIL WORKS

2. All joints including construction and expansion joints for the water retaining structures shall be made water tight by using PVC ribbed water stops with central bulb. However, kicker type (externally placed) PVC water stops shall be used for the base slab and in other areas where it is required to facilitate concreting. The minimum thickness of PVC water stops shall be 6 mm and minimum width shall be 230 mm.

In case the Contractor can demonstrate for adopting a suitable construction technique to avoid seepage of ground water, then the PVC water stops need not be used as specified above.

3. All steel sections and fabricated structures which are required to be transported on sea shall be provided with anti-corrosive paint to take care of sea worthiness.
4. All mild steel parts used in the water retaining structure shall be hot double dip galvanized. The minimum coating of the zinc shall be 750 gm/sq.m. for galvanized structures and shall comply with IS-2629 and IS-2633. Galvanizing shall be checked and tested in accordance with IS-2629. The galvanizing shall be followed by the application of an etching primer and dipping in black bitumen in accordance with BS-3416.
5. A screed of concrete layers not less than 100 mm thick and of grade not weaker than M10 shall be provided below all water retaining structures. A sliding layer of bitumen paper or craft paper shall be provided over the screed layer to destroy the bond between the screed and the base slab concrete of the water retaining structures.
6. Bricks having minimum 75 kg/m² compressive strength can only be used for masonry work.
7. Monorails, monorail girders and fixtures shall be provided, wherever required.
8. Doors and windows on external walls of buildings (other than areas provided with insulated metal cladding) shall be provided with RCC sun-shade over the openings with 300 mm projection. Projection of sunshade from the wall shall be minimum 450 mm over window openings and 750 mm over door openings.
9. All stairs shall have a maximum riser height of 150 mm and a minimum tread width of 250 mm. Minimum clear width of stairs shall be 1500 mm.

SECTION 8: CIVIL WORKS

10. Angles with lugs shall be provided for edge protection all round cut outs/openings in floor slab, edges of drains supporting grating covers, edges of RCC cable/pipe trenches supporting covers, edges of manholes supporting covers, supporting edges of pre-cast covers including cable trench covers and any other place where breakage of corners of concrete is expected.
11. Anti- termite treatment shall be done as per CPWD specification.
12. Hand railing minimum 1200 mm high shall be provided around all floor/roof openings, projections/balconies, walkways, platforms, steel stairs etc. All handrails and ladder pipes shall be 32 mm nominal bore MS pipes (medium class) and shall be galvanized (medium-class as per IS-277). All rungs for ladder shall also be galvanized as per IS-277 medium class.

Stairs within the service building shall be provided with 50mm dia stainless steel hand rail and, 20 mm dia stainless steel balustrades with suitable flats.

Amendment III SI No. 101

13. ~~All shuttering material used shall be of wood only.~~
All centering and shuttering materials used shall be of steel only. However, for sides of footings, beams and columns, densified wood may be used.
14. The proper coordination & execution of all interfacing civil works activities like fixing of conduits in roofs/walls/floors, fixing of foundation bolts, fixing of lighting fixtures, fixing of supports/embedment, provision of cut-outs etc. shall be the sole responsibility of the Contractor. He shall plan all such activities in advance and execute in such a manner that interfacing activities do not become bottlenecks and dismantling, breakage etc. is reduced to minimum.

8.12 STATUTORY RULES

1. The Contractor shall comply with all the applicable statutory rules pertaining to Factories Act, Fire Safety Rules of Tariff Advisory Committee, and Water Act for pollution control etc.
2. Provisions for fire proof doors, number of staircases, fire separation wall, lath plastering on structural members (in fire prone areas) etc. shall be made according to the recommendations of Tariff Advisory Committee.
3. Statutory clearance and norms of State Pollution Control Board

SECTION 8: CIVIL WORKS

shall be followed as per Water Act for effluent quality from plant.

4. Requirement of sulphate resistant cement (SRC) for sub-structural works shall be decided in accordance with the Indian

SECTION 8: CIVIL WORKS

Standards based on the findings of the detailed soil investigation to be carried out by the Bidder/ Contractor.

5. Foundation system adopted by the Contractor shall ensure that relative settlement shall be as per provisions in IS-1904 and other Indian Standards.
6. All water retaining structures designed as un-cracked section shall also be tested for water tightness at full water level as per clause no. 10 of IS-3370 (Part-I).
7. Construction joints at the following locations shall be provided
 - a) At the meeting points of the columns and the raft.
 - b) At the points of contra flexure in the columns.

Additional reinforcements and shear keys shall be provided at the construction joints.

8. All underground concrete structures like pump houses, water retaining structures etc. shall have plasticizer cum water proofing cement additive conforming to IS-9103. In addition, limit on permeability as given in IS-2645 shall also be met with. The concrete surface of these structures in contact with earth shall also be provided with two coats of bituminous painting for water/damp proofing.

In case of water leakage in the above structures, Injection grouting shall be applied for repairing the leakage.

PGCIL Field Quality Plan

(Pages 1 to 20)

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STANDARD FIELD QUALITY PLAN FOR SWITCHYARD CIVIL WORKS

Section : FOUNDATION MATERIALS

Sl. No.	Component/Operation & Description of Test	Sampling Plan with basis	Ref. Document & acceptance norm	Testing Agency	Remarks	Check
1.	CHECKING OF FOUNDATION MATERIALS					
A)	CEMENT					
i)	Fineness	One sample per lot of 100 MT or part thereof from each source for MTCs and one sample per lot of 200 MT or part thereof from each source for site testing	IS:456, IS:269	Manufacturer/ POWERGRID approved lab	Review of manufacturers test certificates (MTCs) and laboratory test results by POWERGRID	B
ii)	Compressive Strength		IS:8112, IS:12269			
iii)	Initial & final setting time		IS:1489 & POWERGRID specification			
iv)	Soundness					
v)	Heat of Hydration for low heat cement (Not applicable for OPC & PPC)					
vi)	Chemical Composition of Cement	One sample per lot of 100 MT or part thereof from each source for MTCs	IS:456, IS:269 IS:8112, IS:12269 IS:1489 & POWERGRID specification	Manufacturer	Review of manufacturers test certificates by POWERGRID	B
B)	COARSE AGGREGATES					
i)	Determination of Partical size (Sieve Analysis)	One sample per lot of 100 cubic meter or part thereof from each source for each size	IS:383, IS:2386 and POWERGRID specification	POWERGRID approved lab. However, Moisture content test for design mix concrete shall be done on all days of concreting at site.	Each source to be approved by POWERGRID Review and acceptance of test result by POWERGRID.	B
ii)	Flakiness Index					
iii)	Crushing Value					
iv)	Specific Gravity*					
v)	Bulk Density*					
vi)	Absorption Value*					
vii)	Moisture Content*					
viii)	Soundness of Aggregate**					
ix)	Presence of deleterious materials					
	* Applicable Design concretes only	** Applicable to concrete work subject to frost action				

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C)	FINE AGGREGATE					
i)	Gradation/Determination of Particle size (Sieve Analysis)	One sample per lot of 100 cubic meter or part thereof from each source	IS:383,IS:2386,IS:456 and POWERGRID specification	POWERGRID approved lab. However Moisture content test for design mix concrete shall be done on all days of concreting at site.	Each source to be approved by POWERGRID Review and acceptance of test result by POWERGRID.	B
ii)	Specific Gravity and density					
iii)	Moisture content					
iv)	Absorption Value					
v)	Bulking					
vi)	Silt Content Test					
vii)	Presence of deleterious materials					
D)	BRICKS					
i)	Dimensional tolerance	As per enclosed Annexure-II	CPWD & POWERGRID specification	POWERGRID approved Lab.	Approved by POWERGRID	B
ii)	Compressible Strength					
iii)	Water Absorption					
iv)	Efflorescence					
E)	WATER					
i)	Cleanliness (Visual Check)	Random	IS:456, IS:3025 and POWERGRID specification. The water used for mixing concrete shall be fresh, clean and free from oil, acids and alkalies, organic materials, or other deleterious materials	Contractor	Each source to be approved by POWERGRID	B
ii)	Chemical and physical properties of water for checking its suitability for construction purposes	One sample per source	IS:456, IS:3025 and POWERGRID specification	Contractor/ POWERGRID Approved Lab	Approved by POWERGRID	B
	*Applicable to design mix concretes only					

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Sl. No.	Component/Operation & Description of Test	Sampling Plan with basis	Ref. Document & acceptance norm	Testing Agency	Remarks	Check
1.	REINFORCEMENT STEEL					
i)	Identification & size	Random	IS:432, IS:1139, IS:1786 & POWER GRID specification	Contractor	Approved by POWERGRID	B
ii)	Chemical Analysis Test	One sample per heat	IS:432, IS:1139, IS:1786 POWERGRID specification	Manufacturer	Review of manufacturers test certificates by POWERGRID	B
iii) iv) v)	Tensile Test Yield stress/proof stress Percentage Elongation	One sample per lot of 40 MT or part thereof for each size of steel conforming to IS: 1139 and 5 MT or part thereof for HDS wire for each size of steel as per IS: 432. For steel as per IS:1786 under 10mm 1 sample for each 25 MT or part thereof. 20 mm-16 mm 1 sample for each 35 MT or part thereof. Over 16mm 1 sample for each 45 MT or part thereof	IS:432, IS:1139, IS:1786 POWER GRID specification	Manufacturers/ POWERGRID approved lab	Review of manufacturers test certificates as well as lab test results by POWERGRID	B
vi)	Bend/Rebend Test	One sample per lot of 20 MT or part thereof for each size of steel as per IS:432, IS:1139. For steel as per IS:1786 under 10mm-16mm 1 sample for each 25MT or part thereof 10 mm-16mm 1 sample for each 45 MT or part thereof.	IS:432, IS:1139, IS:1786 POWER GRID specification	Manufacturers/ POWERGRID	Review of manufacturers test certificates as well as lab test results by POWERGRID	B
vii)	Reverse Bend Test for HDS wire	One sample per lot of 5 MT or part thereof for each size	IS:432 POWER GRID specification	Manufacturer/ POWERGRID approved lab	Review of manufacturers test certificates as well as lab test result by POWERGRID	B

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Section : FOUNDATION

Sl. No.	Component/Operation & Description of Test	Sampling Plan with basis	Ref. Document & acceptance norm	Testing Agency	Remarks	Check
C.	STRUCTURAL STEEL USED IN CABLE TRENCHES & FOUNDATIONS					
i)	Dimensional Check	Random	POWERGRID Specification & approved drawing	Contractor	Checklist to be prepared and signed jointly	B
ii)	Visual Check for damages, rusting, Pitting etc.	100%	POWERGRID Specification & approved drawing	Contractor	Checklist to be prepared and signed jointly	C
iii)	Visual Check for welding, defects, primer, coating and painting/galvanizing as applicable	Random	POWERGRID specification & approved drawings	Contractor	Checklist to be prepared and signed jointly	C
iv)	Physical properties of structural steel	1 sample per lot of 40 MT or part thereof for tensile tests and 1 sample per lot of 20 MT or part thereof for bend test for each size.	IS:2062, POWERGRID specification & approved drawings	Manufacturer/ POWER GRID Approved lab	Review of Mfgs. Test certificates as well as lab test results by POWERGRID	B

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Sl. No.	Component/Operation & Description of Test	Sampling Plan with basis	Ref. Document & acceptance norm	Testing Agency	Remarks	Check
2.	GANTRY/EQUIPMENT FOUNDATION/ CABLE TRENCH					
A.	BEFORE EXCAVATION					
i)	Checking of pegs condition as per line and alignment	100% on each location	IS:4091, IS:3764 & POWERGRID approved drawings/specification	Contractor	Approval by POWERGRID	C
ii)	Checking of pit making as per drawing & RL	100% on each location	IS:4091, IS:3764 & POWERGRID approved drawings/specification	Contractor	Approval by POWERGRID	C
B.	EXCAVATION					
i)	Dimensional conformity	Each location	IS:4091, IS:3764 & POWERGRID approved drawings/specification	Contractor	Approval by POWERGRID (JMC/MB)	B
ii)	Verticality/slopes & Squareness of each pit	Each location	IS:4091, IS:3764 & POWERGRID approved drawings/specification	Contractor	Checklist to be prepared and signed jointly	B
iii)	Verification of classification of foundation wherever applicable	Each location	IS:4091, IS:3764 & POWERGRID approved drawings/specification	Joint inspection by POWER GRID and contractor	Approval by POWERGRID	B
C.	FOUNDATION BOLTS/METALLIC INSERTS					
i)	Check for proper	100%	POWERGRID	Contractor	Checklist to be	C

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	identification foundation bolts w.r.t type of foundation		specification & approved drgs.		prepared and signed jointly	
ii)	Visual check for mechanical damage and galvanising/ painting if applicable for metallic insert	100%	POWERGRID specification & approved drgs.	Contractor	Checklist to be prepared and signed jointly	C
iii)	Alignment & Level	100%	POWERGRID specification & approved drgs.	Contractor	Checklist to be prepared and signed jointly	B
iv)	Grouting/Underpinning of foundation base plate	100%	POWERGRID specification & approved drgs.	Contractor	Checklist to be prepared and signed jointly	C
D.	P.C.C. Padding	For all locations	IS:456 and POWERGRID approved foundation drawings & specification	Joint inspection by POWER GRID and contractor	Approval by POWERGRID	B
E.	SHUTTERING(Form work)					
i)	Check for materials, breakage or damage	100%	IS:456, POWERGRID specification/ approved drawings	Joint inspection by POWER GRID and contractor	Approval by POWERGRID	C
ii)	Check for plumb, alignment parallelism, squareness and equidistance from stub	100% casting	IS:456, POWERGRID specification/ approved drawings	Joint inspection by POWER GRID and contractor	Approval by POWERGRID	B
iii)	Dimensional check	100% before casting	IS:456, POWERGRID specification/ approved drawings	Joint inspection by POWER GRID and contractor	Approval by POWERGRID	B
iv)	Check for level & height	100% before casting	POWERGRID specification/ approved drawings	Joint inspection by POWER GRID and contractor	Approval by POWERGRID	B
v)	Check for rigidity of	100%	POWERGRID	Joint	Approval by	B

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	frame/tightness		specification/ approved drawings	inspection by POWER GRID and contractor	POWERGRID	
vi)	Cleaning and oiling	100%	POWERGRID specification/ approved drawings	Joint inspection by POWER GRID and contractor	Approval by POWERGRID	B
vii)	Diagonal bracing if required as per drawings/site conditions	100%	POWERGRID specification/ approved drawings	Joint inspection by POWER GRID and contractor	Approval by POWERGRID	C
viii)	Checking of joints to avoid undue loss of cement slurry	100%	POWERGRID specification/ approved drawings	Joint inspection by POWER GRID and contractor	Approval by POWERGRID	C
E.	PLACEMENT OF REINFORCEMENT STEEL					
i)	Check the steel bars for rust, cracks, surface flaws, laminates etc. (Visual check)	100%	IS:456 and POWERGRID specification/ approved drawings	Joint inspection by POWER GRID and contractor	Approval by POWERGRID	C
ii)	Check as per the bar bending schedule before placement of concrete	For all locations	IS:456,IS:2502 and POWERGRID specification/ approved drawings	Joint inspection by POWER GRID and contractor	Approval by POWERGRID (Pour Card)	B
iii)	Check cutting tolerance for bars as per check list/drawings. Check whether all the bent bars and lap lengths are as per approved bar bending schedule	For all locations	IS:456,IS:2502 and POWERGRID specification/ approved drawings	Joint inspection by POWER GRID and contractor	Approval by POWERGRID (Pour Card)	B
iv)	Check whether all joints & crossing of bars are tied properly	100%	IS:456 and POWERGRID specification/	Joint inspection by POWER	Approval by POWERGRID	C

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	with right guage & annealed wire as per specification		approved drawings	GRID and contractor		
v)	Check for proper cover distance spacing of bars, spacers, & chairs after the reinforcement cage has been put inside the formwork	100%	IS:456 and POWERGRID specification/ approved drawings	Joint inspection by POWER GRID and contractor	Approval by POWERGRID	C
vi)	Check whether lapping of bars are tied properly with right gauge and annealed wire as per specification	100%	IS:456 and POWERGRID specification/ approved drawings	Joint inspection by POWER GRID and contractor	Approval by POWERGRID	B
G.	PILE FOUNDATION (Additional Tests)					
i)	Check of centre line of pile group	Each pile group	IS:2911 & POWERGRID approved pile foundation drawings/specification	Joint inspection by POWER GRID and contractor	Checklist to be prepared and signed jointly	B
ii)	Check pile location	Each pile	IS:2911 & POWERGRID approved pile foundation drawings/specification	Joint inspection by POWER GRID and contractor	Checklist to be prepared and signed jointly	B
iii)	Temporary casing tube & permanent liner also check thickness of liner material (if applicable)	Each pile	IS:2911 & POWERGRID approved pile foundation drawings/specification	Joint inspection by POWER GRID and contractor	Verticality of the tube to be checked	B
iv)	Bentonite slurry (if applicable)	Each pile	IS:2911 & POWERGRID approved pile foundation drawings/specification	Joint inspection by POWER GRID and contractor	Records to be kept by POWERGRID for specific gravity of slurry	B
v)	Pile depth, level, size	Each pile	IS:2911 &	Joint	Approved by	B

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	and alignment		POWERGRID approved pile foundation drawings/specification	inspection by POWER GRID and contractor	POWERGRID	
vi)	Chipping of pile head	Each pile	IS:2911 & POWERGRID approved pile foundation drawings/specification	Joint inspection by POWER GRID and contractor	Before concreting pile cap, pile head to be chipped off for concreting	B
vii)	Standard Penetrator Test	As per Powergrid BOQ/Specification	IS:2911 & POWERGRID approved pile foundation drawings/specification	Joint inspection by POWER GRID and contractor	Records to be kept by POWERGRID	B
viii)	Pile load testing	As per Powergrid BOQ/Specification IS:2911	IS:2911 & POWERGRID approved pile foundation drawings/specification	Joint inspection by POWER GRID and contractor	Records to be kept by POWERGRID Approval by POWERGRID	B
ix)	Anchor bolts if applicable					
a)	Level, centre to centre distance of bolts	100% on each location	POWERGRID approved pile foundation drawings/specification	Joint inspection by POWER GRID and contractor	Checklist to be prepared and signed jointly	B
b)	Visual check for galvanising	100% on each location	POWERGRID approved pile foundation drawings/specification	Joint inspection by POWER GRID and contractor	Checklist to be prepared and signed jointly	B
3.	CONCRETING					
A)	APPROVAL OF MIX DESIGN	Each Mix.	IS:456 & POWERGRID approved drawings and specifications	POWER GRID Approved by lab	Approval by POWERGRID	A
B)	BATCHING,MIX-	100%	IS:456 &	Joint	Approval by	B

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	ING & PLACING OF CONCRETE AND COMPACTING		POWERGRID approved drawings and specifications	inspection by POWER GRID and contractor	POWERGRID	
C)	FIXING OF CHIMNEY COLUMN Check for Width/length squareness, parallelism & equidistance from stub	100%	IS:456 & POWERGRID approved drawings and specifications	Joint inspection by POWER GRID and contractor	Approval by POWERGRID	C
D)	PLACING CONCRETE, AND COMPACTING	100%	IS:456 & POWERGRID approved drawings and specifications	Joint inspection by POWER GRID and contractor	Min. gap between boxes and reinforcement bars should be maintained Approval by POWERGRID	B
E)	CONCRETE TESTING					
i)	Slump test	One sample per foundation	IS:456,IS:516, IS:1199 and POWERGRID Specification	Contractor	Approval by POWERGRID	B
ii)	Check for quantities for cement, fine aggregate, coarse aggregate and water while batching	100% on all locations	IS:456,IS:516, IS:1199 and POWERGRID Specification	Contractor	Checklist to be prepared and signed jointly	B

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Sl. No.	Component/Operation & Description of Test	Sampling Plan with basis	Ref. Document & acceptance norm	Testing Agency	Remarks	Check
F)	CONCRETE CUBE TESTING					
i)	Compressive Strength	One sample for every 20 Cum of concreting or part thereof for each days concreting (one sample consists of min. 3 test cubes for 28 days strength).	IS:1199,IS:456, IS:516 and POWERGRID Specification	POWERGRID Approved lab	Approval by POWERGRID Cubes must be tested within a week after 28 days curing period and test results should be approved.	A
G)	CHECK FINISING, DIMENSIONAL CONFORMITY AND WORKMANSHIP BEFORE & AFTER BOX REMOVAL	100%	IS:456,IS:516, IS:1199 and POWERGRID Specification	Contractor	Approval by POWERGRID	B
4.	BACKFILLING					
i)	Check for thickness of Layer & watering	100%	POWERGRID Specification and approved drawings	Contractor	Approval by POWERGRID	C
ii)	Visual check for correction/ramming	100%	POWERGRID Specification and approved drawings	Contractor	Approval by POWERGRID	C
iii)	Compaction test (Percentage of max. dry density)	Gantry Foundation-2 samples for each pit. Equipment	POWERGRID specification	POWERGRID approved lab	Review of lab test results by POWERGRID Elevation for testing to be	B

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		and other foundation-20% at random			decided by POWERGRID	
5.	BRICK-WORK					
i)	Mortar mix/proportion	Random	IS:2250, POWERGRID Specification & CPWD Specification	Contractor	Approval by POWERGRID	B
ii)	Plumb & Alignment	Random	POWERGRID Specification & CPWD Specification	Contractor	Approval by POWERGRID	B
iii)	Joints	Random	POWERGRID Specification & CPWD Specification	Contractor	Approval by POWERGRID	B
6.	PLASTERING					
i)	Plastering thickness and evenness	Random	POWERGRID Specification & CPWD Specification	Contractor	Approval by POWERGRID	B
ii)	Mortar mix proportion	Random	POWERGRID Specification & CPWD Specification	Contractor	Approval by POWERGRID	B
7.	CURING FOR CONCRETE, MASONRY, PLASTERING ETC.	100% on all location	IS:5613 & POWERGRID Specification	Contractor	Approval by POWERGRID	C
8.	SWITCH YARD EARTHING					
i)	Check for dimension of earth mat rod	Random	POWERGRID Specification & drawings	Contractor	Approval by POWERGRID	B
ii)	Depth of excavation	Random	POWERGRID Specification & drawings	Contractor	Approval by POWERGRID	C
iii)	Check for weld joints and anti corrosive treatment	Random	POWERGRID Specification & drawings	Contractor	Approval by POWERGRID	B
iv)	Backfilling	100%	POWERGRID Specification & drawings	Contractor	Approval by POWERGRID	C
9.	SITE SURFACING					
i)	Levelling	100%	POWERGRID Specification and approved drawings	Contractor	Checklist to be prepared and signed jointly	C

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ii) a)	Soil Sterilisation Spraying of chemicals	100%	POWERGRID Specification and Manufacturers recommendations	Con tractor	Checklist to be prepared and signed jointly	B
iii)	Grading of 20/40mm Stone	1 sample per lot of 500 Cubic Metre or part thereof from each source for each size	IS: 383, IS: 2386 and POWERGRID Specification. The grading shall be as per single sized nominal size	Contractor/ POWERGRID Approved lab	Each source to be approved by POWERGRID Review and acceptance of test results by POWERGRID	B
iv)	Compacted thickness of 20/40 mm stone layers as applicable	Random	POWERGRID Specification and specification drawings	Contractor	Checklist to be prepared and signed jointly	B

Section: GENERAL GUIDELINES FOR IMPLEMENTATION

1. Details of categories of check codes A,B & C including accepting and deviation dispositioning authorities are indicated at Annexure-I.
2. POWERGRID specification shall mean POWERGRID technical specification, approved drawings data sheets and LOA provisions applicable for the specific contract.
3. Acceptance criteria and permissible limits for certain tests are indicated at Annexure-II. For balance tests, site to verify the same with respect to POWERGRID specification, relevant Indian Standards and/or prevalent code of practice.
4. It is clarified that the tests indicated at column 2 of this FQP i.e. against column “Component operation & Description of Test”, are only generally required to be conducted. However, POWERGRID reserves the right to carry-out any additional tests at any stage if the situation so warrants.
5. POWERGRID site representative shall witness all the tests conducted by the contractor as mentioned in the FQP. However, in case of tests conducted in the POWERGRID approved lab, it is preferred to witness the tests in the lab itself, if possible.
6. Head of GHQ shall approve testing laboratory before accepting the test results from the lab.
7. Head of GHQ shall approve the sources for cement , coarse aggregate, fine aggregate & water before actual utilization.
8. All the testing & measuring equipments used by the contractor for testing are required to be calibrated. A copy of valid calibration report shall be retained by POWERGRID as records.
9. Classification of foundations shall be approved by POWERGRID based on the Joint Inspection Report & soil investigation reports.
10. Curing of concrete work should be continued for minimum period of 10 days.

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11. ZONE-IV FINE AGGREGATE

11.1 Zone-IV fine aggregate shall be used for nominal mix. Reinforced cement concreting work.

11.2 Zone-IV fine aggregate shall be avoided for design mix reinforced cement concreting work unless tests have been done to ascertain the suitability of proposed with the prior approval POWERGRID site.

12. Bricks should be free from cracks, flaws and modules of free lime. They should have smooth rectangular faces with sharp corners and should be uniform in colour.

13. CEMENT

13.1 In case of cement is in the scope of the contractor, the same shall be procured from sources approved by POWERGRID site and got tested on sample basis for specified acceptance tests as specified in the FQP at a reputed Third Party Lab approved by POWERGRID site.

13.2 The samples of cement for site testing shall be taken within three weeks of the delivery and all the tests shall be commenced within one week of sampling. If the cement remains in store for a period of more than six months. All the site tests are required to be repeated before usage.

14. REINFORCEMENT STEEL & STRUCTURAL STEEL USED IN CABLE TRENCHES & FOUNDATIONS

14.1 In case supply of steel is in the scope of the contractor, the same shall be procured from the main producers i.e. SAIL, TISCO, IISCO or Rashtriya Ispat Nigam or the rerollers approved by main producers. The steel shall be got tested at site on sample basis for specified acceptance tests as specified in this FQP at a reputed Third Party Lab approved by POWERGRID site.

14.2 The results of the testing of cement and reinforcement steel referred in 13.1 and 14.1 above shall be got approved from POWERGRID site before cement and reinforcement steel are put to use. However, in exceptional cases due to exigencies of work. POWERGRID site may authorize the contractor to use Cement and Reinforcement Steel even before the test results are received. However, in all such cases, if the test results subsequently received are found to be not complying with the specified acceptance criteria, the contractor shall have to dismantle and recast all such foundations cast with such non-conforming materials at his own cost. Confirmation to this effect shall be obtained from the contractor by the Project authorities beforehand in all such cases.

15. The contractor shall submit welding procedure specification (WPS) including the type of electrode used for approval of POWERGRID site before starting the welding work.

16. Approval/acceptance of individual test results by POWERGRID in the course of execution of contract will not relieve the contractor of his contractual obligations and responsibilities, nor does it limit the Owner's right under the contract.

17. In case, requirement of special items like Super Sulphated Cement, Corrosive Resistant Reinforcement Steel (CRRS) etc. arise due to site conditions, the specific approval of POWERGRID may be obtained before using the same and all the tests as per relevant standards shall be carried out.

18. All the materials shall be stored by the contractor in a manner affording convenient access for identifications and inspection at all times. Storage of material shall be in accordance with IS: 4032 (Latest Edition).

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ANNEXURE-I

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ACCEPTING AND DEVIATION DISPOSITIONG AUTHORITIES FOR DIFFERENT CATEGORIES OF CHECKS AS ENVISAGED IN FIELD QUALITY PLANT

CATE GORY	TYPE OF CHECK	100% CHECKING/WITNESSING BY	COUNTER CHECK/SURVEI LLANCE CHECK BY	ACCEPTING AUTHORITY, IF TEST RESULTS ARE WITHIN PERMISSIBLE LIMITS	DEVIATION DISPOSITIONING AUTHORITY
'A'	CRITI- CAL	EXECUTING DEPTT. PLUS FQA REPRES-ENTATIVE GHQ	FQA REPRES- ENTATIVE AND RHQ/DHQ REPRES- ENTATIVE	HEAD OF DHQ	HEAD OF RHQ IN CONSULTATION WITH CQA, IF REQUIRED.
'B'	MAJOR	EXECUTING DEPTT.	DHQ- REPRESENTATI VE	HEAD OF GHQ	HEAD OF DHQ
'C'	MINOR	CONTRACTORS REPRESENTATIVE	EXECUTING DEPTT.	MINIMUM E4 LEVEL EXECUTING OF SUB- STATION/TL	HEAD OF GHQ

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ACCEPTANCE CRITERIA AND PERMISSIBLE LIMITS FOR FOUNDATION MATERIALS AND CONCRETE

A) CEMENT

S. No.	Description of the tests	33 Grade OPC as per IS:269	43 Grade cement as per IS:8112	PPC as per IS:1489	Low Heat cement
1.	Fineness (min.)	225 m ² /kg	225 m ² /kg	300 m ² /kg	225 m ² /kg
2.	Compressive strength (min.) 72 ± 1 hours 168 ± 2 hours 672 ± 4 hours	160 kgf/cm ² 220 kgf/cm ² -	23 MPa 33 MPa 43 MPa	16 MPa 22 MPa 33 MPa	100 Kgf/cm ² 160 Kgf/cm ² 350 Kgf/cm ²
3.	Initial setting time (min.)	30 minutes	30 minutes.	30 minutes	30 minutes
4.	Final setting time (max.)	600 minutes	600 minutes	600 minutes.	600 minutes.
5.	Soundness (Le Chatelier Method)	Maximum 10 mm expansion	Maximum 10 mm expansion	Maximum 10 mm expansion	Maximum 10 mm expansion
6.	Heat of Hydration (max.)	-	-	-	Max. 65 cal/gm for 7 days & max. 75 cal./gm for 28 days
7.	Chemical composition	As per IS	As per IS	As per IS	As per IS

B) COARSE AGGREGATE :

(i) Sieve Analysis

IS SIEVE DESIGNATION	PERCENTAGE PASSING FOR GRADED AGGREGATE OF NOMINAL SIZE		PERCENTAGE PASSING FOR SINGLE SIZED AGGREGATE OF NOMINAL SIZE	
	40 mm	20 mm	40 mm	20 mm
63 mm	-	-	100	-
40 mm	95 to 100	100	85 – 100	100
20 mm	30 to 70	95 to 100	0 – 20	85 - 100
10 mm	10 to 35	25 to 55	0 – 5	0 - 20
4.75 mm	0 to 5	0 to 10	-	0 - 5

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- (ii) Flakiness Index Not to exceed 25%
- (iii) Crushing value Not to exceed 45%
- (iv) Soundness of aggregate applicable for concrete works subject to frost action Loss of weight after 5 cycle not to exceed 12% when tested with Sodium sulphate and 18% when tested with magnesium sulphate
- (v) Deleterious material Not to exceed 5% of the weight of aggregate when tested as per IS:2386 Part – II (1963)

(C) FINE AGGREGATE

- (i) Sieve Analysis Shall confirm to Zone-I, Zone-II or Zone-III

IS Sieve designation	Grading Zone-I	Percentage Grading Zone-II	Passing for Grading Zone-III	Grading Zone-IV
10 mm	100	100	100	100
4.75 mm	90 - 100	90 - 100	90 - 100	90 - 100
2.36 mm	60 - 95	75 - 100	85 - 100	95 - 100
1.18 mm	30 - 70	55 - 90	75 - 100	90 - 100
600 Micron	15 - 34	35 - 59	60 - 79	80 - 100
300 Micron	15 - 20	8 - 30	12 - 40	15 - 50
150 Micron	0 - 10	0 - 10	0 - 10	0 - 15

- (ii) For guidance of adjusting sand in mix of concrete, the following table may be used.

Moisture Content %	building % by volume
2	15
3	20
4	25
5	30

- (iii) Silt Content Test: Shall not exceed 8% when tested as per test procedure specified in appendix-D of chapter 3 of 1991-92 CPWD Specification.
- (iv) Deleterious Materials: Total deleterious material shall not be more than 5% by weight.

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(D) REINFORCEMENT STEEL: As per relevant Indian Standards.

(E) CONCRETE CUBE TEST

For nominal (volumetric) concrete mixes, compressive strength for 1:1½:3 (cement : sand : coarse aggregate) concrete shall be 265 kg/cm² for 28 days and for 1:2:4 nominal mix, it shall be 210Kg/cm².

(F) ACCEPTANCE CRITERIA BASED ON 28 DAYS COMPRESSIVE STRENGTH FOR NOMINAL MIX CONCRETE

- (a) The average of the strength of three specimen be accepted as the compressive strength of the concrete, provided the strength of any individual cube shall neither be less than 70% nor higher than 130% of the specified strength.
- (b) If the actual average strength of accepted sample exceeds specified strength by more than 30%, the Engineer-in-charge, if he so desires, may further investigate the matter. However, if the strength of any individual cube exceeds more than 30% of specified strength, it will be restricted to 30% only for computation of strength.
- (c) If the actual average strength of accepted sample is equal to or higher than specified strength upto 30%, then strength of the concrete shall be considered in order and the concrete shall be accepted at full rates.
- (d) If the actual average strength of accepted sample is less than specified strength but not less than 70% of the specified strength, the concrete may be accepted at reduced rate at the discretion of Engineer-in-Charge.
- (e) If the actual average strength of accepted sample is less than 70% of specified strength, the Engineer-in-Charge shall reject the defective portion of work represented by sample and nothing shall be paid for the rejected work. Remedial measures necessary to retain the structure shall be taken at the risk and cost of contract. If, however, the Engineer-in-Charge so desires, he may order additional tests to be carried out to ascertain if the structure can be retained. All the charges in connection with these additional tests shall be borne by the contractor.

(G) ACCEPTANCE CRITERIA FOR DESIGN MIX CONCRETE SHALL BE AS PER IS:456.

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(H) SAMPLING PLAN FOR BRICK WORK

- i) Scale of sampling and permissible number of defectives for visual and dimensional characteristics.

No. of bricks in the lot	For characteristics specified for individual bricks		For dimensional characteristics for group of 20 bricks-No. of bricks to be selected
	No. of bricks to be selected	Permissible no. of defective in the sample	
(1)	(2)	(3)	(4)
2001-10000	20	1	40
10001-35000	32	2	60
35001-50000	50	3	80

Note : In case the lot contains 2000 or less bricks the sampling shall be as per decision of the Engineer-in-Charge.

- ii) Scale of sampling for physical characteristics

Lot size	Sampling size for compressive strength water absorption and efflorescence	Permissible no of defectives for efflorescence
(1)	(2)	(3)
2001-10000	5	0
10001-35000	10	0
35001-50000	15	1

Note: In case the lot contains 2000 or less bricks, the sampling shall be as per decision of Engineer-in-Charge.

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(I) ACCEPTANCE CRITERIA FOR BRICK-WORK

- (i) Dimensional tolerances: The dimensions of modular bricks when tested shall be within the following limits per 20 bricks.

Length 372 to 388 cm (380 ± 8 cm)

Width 176 to 184 cm ($180 \pm$ cm)

Height 176 to 184 cm (180 ± 4 cm) for 90 mm high bricks

- (ii) In case of non-modular bricks, %age tolerance will be +/- 2% for group of 20 numbers of class 10 bricks and +/- 4% for other class of bricks.

- (iii) Compressive strength: The bricks, shall have a minimum average compressive strength as specified in POWERGRID specification. The compressive strength of any individual brick tested shall not fall below the min. average compressive strength specified for the corresponding class of brick by more than 20%. In case compressive strength of any individual brick tested exceeds the upper limit specified for the corresponding class of bricks, the same shall be limited to upper limit of the class as specified for the purpose of calculating the average compressive strength.

- (iv) Water absorption: The average water absorption of bricks shall not be more than 20% by weight.

- (v) Efflorescence: The rating of efflorescence of bricks shall not be more than moderate.