

**TECHNICAL SPECIFICATION  
FOR  
KALLAM SUBSTATION- FOR IMPLEMENTING OF 1 NO. 400 kV BAY  
AT KALLAM PS  
CIVIL & STRUCTURE**

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## **SECTION: CIVIL WORKS**

### **1.0 GENERAL**

**1.1** All civil works shall be carried out as per design/drawings prepared by the contractor, the design/drawings shall be approved by the employer before execution. In case any item is not covered under specification then the same shall be carried out as per CPWD specification /Latest Standard Specification issued by CEA /applicable BIS Standards and Codes. Any item for which specification is not provided herein and is not covered under CPWD specification/ BIS Standards, the same shall be executed as per manufacturer guidelines with the approval of employer. All materials shall be of best quality conforming to relevant Indian Standards and Codes. In case of any conflict between Standards/ Code and Technical Specification, the order of precedence shall be as under:

**1.1.1** Technical specification

**1.1.2** BIS codes

**1.1.3** CPWD specification.

The decision of engineer in charge in this regard shall be final and binding.

**1.2** Wherever reference to CPWD/BIS Codes is made, it shall be to the latest edition/revision of the same, issued up to 7 days prior to the date of opening of this tender.

**1.3** The Contractor shall arrange all labour, tools, equipment, materials, temporary works, constructional plant & machinery, 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 drawings, specifications, and direction of Employer.

**1.4** All materials including cement, reinforcement steel, structural steel etc. shall be arranged by the Contractor.

**1.5** The Contractor shall execute the work as per the Field Quality Plan (FQP) All testing required shall be arranged by the Contractor at his own cost.

**1.6** The bidder shall fully apprise himself of the prevailing conditions at the proposed site, Climatic conditions including monsoon patterns, local conditions and site-specific parameters, soil parameters, availability of construction material and shall include for all such conditions and contingent measures in the bid, including those which may not have been specifically brought out in the specifications.

**1.7** Unless levelling is in the scope of the bidder, levelled site with single level/terraces with various levels/ gradual slope shall be handed over to the Contractor, in a phased manner. The finished ground level (FGL) with a tolerance of (+/-) 100mm shall be decided by the Employer. 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 provide all assistance 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. In case levelling is in the scope of bidder, FGL shall be decided by the employer.

**1.8** Employer has standardized its technical specification for various items/ works. Specification for items which are covered in the scope and as defined in Section project shall only be referred.

**1.9** The material specification, workmanship and acceptance criteria shall be as per approved standard Field Quality Plan. In case certain item is not covered in FQP, it shall be constructed as per CPWD specification/ relevant BIS.

## **2.0 GEOTECHNICAL INVESTIGATION:**

The Contractor shall perform a detailed soil investigation to arrive at sufficiently accurate conclusion regarding general as well as specific information about the soil profile and the necessary soil parameters of the site, in order to design and construct the foundation of the various structures 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 utilized for the design.

**2.1 SCOPE:** This specification covers all the work required for detailed soil investigation and preparation of a detailed report. The work shall include mobilization 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 starting from 0.5M from existing ground level 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 reduced level of these locations with respect to the benchmark indicated by the Employer.

## **2.2 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 15meter depth into virgin soil or to refusal whichever occurs earlier shall be drilled. Total area of substation plot (including of Switchyard, Township and Future area) shall be considered for arriving at number of bore holes to be drilled. In any case number of boreholes shall not be less than five and shall not exceed twenty. By refusal it shall mean that a standard penetration blow count (N) of 100 is recorded for 30 cm penetration. In case rock is encountered within five meters from existing ground level, 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 0 .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.

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 and transported to the laboratory without any damage or loss.

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.

**2.3 TRIAL PITS:** Trial pits shall be carried out at minimum one location per hectare as directed by the Employer. In case hard rock is encountered in trial pit, test need not be carried out. Total area of substation plot (including of Switchyard, Township and Future area) shall be considered for arriving at number of Trial Pit to be excavated. Minimum number of trial pits shall be five and maximum number shall be ten. 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.

**2.4 ELECTRICAL RESISTIVITY TEST:** The resistivity of earth varies over a wide range depending on its moisture content, temperature, salt content and compactness. Therefore, earth resistivity test shall be conducted preferably during the dry season in order to get conservative results.

#### 2.4.1 TEST LOCATION

In the evaluation of earth resistivity for the substations, at least eight test directions shall be chosen from the centre of the substation to cover the entire area including the future area. The number of test points shall be as per approved drawing.

**2.4.2 PRINCIPLE OF TEST** Wenner's four electrode method shall be used. In this method, four small electrodes shall be buried in four small holes in the earth along a straight line at equal intervals. A test current (I) by earth resistivity tester shall be passed between two outer electrodes and the voltage difference (V) between the two inner electrodes shall be measured. The test current (I) thus flowing into the earth, produces an electric field proportional to its density and to the resistivity of the soil. The voltage (V) measured between the inner electrodes is proportional to the field. Consequently, the resistivity will be proportional to the ratio of the voltage to current. Thus, the resistivity shall be calculated from the following equation.

$$\rho_a = \frac{4\pi AR}{1 + \frac{2a}{\sqrt{a^2 + 4b^2}} - \frac{a}{\sqrt{a^2 + b^2}}}$$

Where,

- $\rho_a$  is the apparent resistivity of the soil in  $\Omega$ -m.
- R is the measured resistance in  $\Omega$
- a is the distance between adjacent electrodes in metres.
- b is the depth of the electrodes in m.

#### 2.4.3 TEST PROCEDURE

In the selected test point and chosen direction, four electrodes with insulated connecting wires shall be driven into the earth along a straight line of equal intervals (a). The depth of the electrodes in the earth shall be of the order of 15 cm to 20 cm. The megger shall be placed on a steady and approximately level base, the link between terminals P1 and C1 shall be opened, and the four electrodes connected to the instrument terminals. An appropriate range on the instrument shall be selected to obtain clear readings avoiding the two ends of the scale as far as possible.

Resistivity shall be calculated by substituting the value of R in the above equation. The test shall be repeated in a chosen direction with a number of different electrode spacing, increasing from 2m to 50m preferably in the steps of 2, 5, 10, 15, 25 and 50m. When the spacing is increased gradually from low values, at a stage, it may be found that the resistivity reading is constant irrespective of the

increase in the electrode spacing. The resistivity for this spacing is noted and taken as the resistivity for that direction. In a similar manner, resistivity for at least eight equally spaced directions from the centre of the test points shall be measured. These measurements shall be repeated for all test points.

NOTES: -

- i. Soil resistivity points shall preferably be one number in each 100mx100m grid and number of test points shall be such that the entire substation including the future area is covered.
- ii. Average resistivity value of all eight directions shall be considered for design of earthing system.
- iii. Soil resistivity measurement may be done in dry season. Small amount of water may be applied at electrodes for making proper contact between the electrodes and soil.

## **2.5 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. Plate load test shall be conducted at two locations to be decided during detailed engineering at the proposed foundation depth below finished ground level for determining the bearing capacity.

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

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 v/s 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.

## **2.6 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.

## **2.7 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.

## **2.8 LABORATORY TEST**

**2.8.1.** 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.

**2.8.2.** 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 down in the relevant I.S. Codes.

The following laboratory tests shall be carried out.

- i) Visual and Engineering Classification
- ii) Liquid limit, plastic limit, and shrinkage limit for C- $\phi$  soils.
- iii) Natural moisture content, bulk density, and specific gravity.
- iv) Grain size distribution.
- v) Swell pressure and free swell index determination.
- vi) California bearing ratio.
- vii) Consolidated drained test with pore pressure measurement.
- viii) 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.
- ix) In case of rock samples following tests shall also be conducted:
  - Rock quality designation (RQD), RMR.
  - UCC test.
  - Point load index test.

## **2.9 TEST RESULTS AND REPORTS**

**2.9.1** 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 site test data shall bear the signatures of the Investigation Agency, Vendor and also site representative of Employer.

**2.9.2** The report shall include, but not limited to the following: -

**2.9.2.1** A plan showing the locations of the exploration work i.e., bore holes, trial pits, Plate load test etc.

**2.9.2.2** 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 stratum.

**2.9.2.3** Test results of field and laboratory tests shall be summarized strata wise as well as in combined tabular form. All relevant graphs, charts tables, diagrams, and photographs, if any, shall be submitted along with report. Sample illustrative reference calculations for settlement, bearing capacity, pile capacity shall be enclosed.



**2.9.2.4** 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 2.5.
- iv) Recommendation regarding liquefaction potential/characteristics of soil during ground shaking and possible remedies shall be provided.
- v) Recommendations regarding slope of excavations and dewatering schemes, if required.
- vi) 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.
- vii) 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, equipment's to be deployed etc. shall be furnished. Illustrative diagram of a symbolic foundation showing details shall be furnished.
- viii) Recommendations for additional investigations beyond the scope of the present work, if considered such investigation as necessary.
- ix) In case of foundation in rocky strata, type of foundation and recommendation regarding rock anchoring etc. should also be given based on RMR value.

**2.9.2.5** All Geotechnical investigation reports must be signed and stamped by qualified Geotechnical engineer/ consultant even if they have been prepared by NABL accredited test labs.

### **3.0 DESIGN/ DRAWINGS:**

- i) Contractor needs to do detailed engineering based on existing scheme and in special case designs/ drawings can be modified based on client approval.
- ii) All tender drawings shall be read in conjunction with this specification. Discrepancy if any shall be brought to the notice of Employer prior to quote.
- iii) Contractor shall develop the drawing/related design documents with project details as per existing scheme and shall submit for Employers approval.
- iv) Items/ components of buildings not explicitly covered in the specification but required for completion of the project shall be deemed to be included in the scope.

### **3.1 ROADS, ROAD CULVERTS, AND RAIL CUM ROAD:**

**3.1.1** Dismantling and diversion of internal roads if required as per electrical layout shall be in the scope of contractor. The Type/Width of the road shall match with existing scheme. The layout of roads shall be as per approved general arrangement drawing. Types of the roads in the scope of contract shall be RCC. If soil conditions are not good, contractor needs to do detailed engineering.

**3.1.2** The width of the road shall be either 5.5m wide or 3.75m. In case of rebuilding the road by dismantling old then dimensions of the road cross-section will match with As Built.

**3.1.3** The type & location of culverts i.e., the number and diameter of Hume pipes shall be as decided during detailed engineering. The invert level of Hume pipes of culverts shall match with the invert level of drain meeting the culvert.

**3.1.4** 100mm diameter RCC Hume pipe (NP-3) shall be provided across the road at every 100M interval along the road. In case NP3 pipe is not available, vendor may provide 100 dia UPVC pipe encased with 75 mm thk. concrete 1:2:4 around without any financial implication to INDIGRID.

**3.1.5** Road within the switchyard area should have shoulder of 600mm wide on either sides of road. Shoulder shall be smooth finished with well compacted 75mm thick PCC 1:4:8. The road leading to control room building and the roads outside switchyard fence area shall be provided with kerb stone and interlocking tiles on shoulder. Width of shoulder shall be 1.75m in case of 5.5m wide road and 1.3m in case of 3.75m wide road.

**3.1.6** The shoulder of the road in case of substation extension shall match with the shoulder of the existing road in all respect.

**3.1.7** Road leading towards the area of Autotransformer/Reactor shall be as short as possible. Road layouts shall be prepared with adequate turning radius, so that easy movement of vehicles is possible. Roads which are to be used for carrying transformers / reactors shall be provided with turning radius preferably 19.5M or more but not less than 16.5M. Turning radius of other roads may be decided at site depending on layout constraints.

**3.1.8** Contractor may use WMM instead of WBM with prior approval of employer without any additional financial implication to INDIGRID. Guidelines of IRC: 109-1997 shall be followed for Wet Mix Macadam (WMM) only. However, measurement of road shall be done as specified elsewhere in this specification.

**3.1.9** In rigid pavements, RCC shall be laid and finished with screed board, vibration, vacuum dewatering process etc.

### **3.2 DRAINS:**

**3.2.1** The construction drawing for the section of drain is enclosed with the tender documents.

**3.2.2** The Contractor shall propose an overall drainage layout for the new sub-station or extension of substation during detailed engineering considering the site conditions which is to be approved by INDIGRID before execution. The type of drains used shall be of the sections standardized and indicated in the drawings enclosed with the tender documents.

### **3.3 CHAIN LINK FENCING AND SWITCHYARD GATE:**

**3.3.1** Dismantling of Existing Fencing / Gate and construction of new fence/Gate if required as per electrical layout shall be in the scope of contractor. Contractor shall submit design/drawings for employer approval before execution. Contractor shall adhere the dimension and material specification as per As-built for extension portion.

**3.3.4** The whole assembly of tubular post and frame of panels shall be hot dip galvanized. The zinc coating shall be minimum 610 gram per square meter. In case the substation is located within 30km from seacoast, the zinc coating shall be 900gm per square meter. The purity of zinc shall be 99.95% as per IS: 209.

**3.3.5** The gate shall be made of medium duty M.S. pipe of grade YST210 and conform to IS: 1161 with welded joints. The main frame (outer frame) of the gate shall be made of 40mm nominal bore pipe and vertical pipes of 15mm nominal bore @ 125mm spacing (maximum) shall be welded with the main frame. Gate shall be painted with one coat of approved steel primer and two or more coats of synthetic enamel paint to give an even shade.

#### **3.3.6 CABLE TRENCHES:**

**3.3.6.1** The construction drawings of cable trenches, cable trench crossing road and sump are enclosed with tender documents. The construction of cable trenches shall be cast in situ type or pre-cast RCC as per drawings and meeting the technical specification. The Contractor shall propose an overall cable trench layout for the substation during detailed engineering which is to be approved by INDIGRID before execution.

**3.3.6.2** The layout should show type of cable trench, longitudinal slope and invert level calculated considering future extensions also. The types of cable trench shall be of the section indicated in the drawings enclosed with the tender documents.

#### **3.4 MISCELLANEOUS**

The work to be performed under this specification shall include providing all labour, supervision, materials, storages, inventories, all enabling works like scaffolding, watch and ward for the works, power, fuel, construction equipment, water, tools and plants, transportation, all taxes and duties, all labour welfare and safety measures, complete and all other incidental items not shown or specified, but reasonably implied or necessary for successful completion of the work including Contractor's supervision and in strict accordance with the drawings and specifications, inspection and testing standards and field quality control and testing as given in the tender documents and the complete execution of the works.

Any technical clarifications required regarding the drawings/specifications during the progress of works shall be obtained from the Engineer-in-Charge of INDIGRID.

Employer reserves the right to inspect all the material before dispatch.

**3.4.1** All structural steel angle for supporting barbed wire/concertina coil shall be painted with epoxy paint of approved brand and colour shade.

#### **4.0 STONE SPREADING AND ANTI-WEED TREATMENT**

**4.1** The layout of the area, where anti-weed treatment and stone spreading is to be done, shall be developed by the Contractor during detailed engineering and the same shall be submitted to the employer for approval. The Contractor shall arrange all labour, equipment and materials required for complete performance of the work in accordance with the drawings, specification, and direction of the Employer. The thickness of stone layer will solely depend on Earth-mat design and any variation in the Thickness of gravel will be in the account of Contractor.

**4.2** 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.

**4.3** The material to be used for stone filling/site surfacing shall be stone aggregate 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:

- |    |                                   |                        |
|----|-----------------------------------|------------------------|
| i) | Sieve Analysis limits (Gradation) | (IS : 383 – Table – 2) |
|    | Sieve Size                        | % passing by weight.   |
|    | 63mm                              | 100                    |
|    | 40mm                              | 85-100                 |
|    | 20mm                              | 0-20                   |
|    | 10mm                              | 0-5                    |
- ii) Hardness: Abrasion value (IS:2386 Part-IV) – not more than 40% Impact value (IS: 2386 Part-IV) – not more than 30%.
- iii) Flakiness Index: As per IS: 2386 Part – I maximum value is 25%
- iv) Frequency of test shall be conducted for sieve analysis, Hardness & Flakiness index as per latest SFQP.

**4.4** After all the structures/equipment's are erected, antiweed treatment shall be applied in the switchyard wherever 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 wherever feasible while choosing the type of chemical to be used.

**4.5** The antiweed 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 (appx) and shall be sprinkled with water at least once in the afternoon every day 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.

**4.6** Engineer-in-charge shall decide final formation level 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.

**4.7** After antiweed 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/surface vibrator 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.

**4.8** 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 equipment's, the material shall be compacted by hand rammer, if necessary. Due care shall be exercised so as not to damage any foundation structures or equipment during rolling / compaction.

4.9 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 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.

4.10 Over the prepared sub grade, 75mm thick base layer of cement concrete in 1:5:10 (1 cement: 5 fine aggregates: 10 burnt brick aggregate 40mm nominal size) shall be provided in the area excluding roads, drains, cable trenches as per detailed engineering drawing. The Contractor shall have option to use graded stone aggregate 40mm nominal size in place of brick aggregate without any extra cost to employer. For easy drainage of water, the slope of 1:1000 is to be provided from the ridge to the nearest drain.

4.11 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 1:5:10. A layer of cement slurry of mix 1:6 (1cement: 6 fine aggregate) shall be laid uniformly over cement concrete layer. The cement consumption for cement slurry shall not be less than 150 kg for every 100 sq.m.

4.12 A final layer of 100mm thickness of stone aggregate of 40mm nominal size shall be spread uniformly over cement concrete layer after curing is complete. However, if gravel layer thickness required to be increased, the same shall be decided during detailed engineering as per earthing calculation.

## **5.0 EXCAVATION AND BACKFILL OF FOUNDATIONS:**

Excavation for foundations shall be in accordance with CPWD Specification/ the relevant BIS code. Excavation shall include removal of all materials of whatever nature at all depth and whether wet or dry necessary for the construction of foundations. The bottom of excavation shall be levelled both longitudinally and transversely unless otherwise mentioned in the drawings or as directed by Engineer-in-charge. Excavation shall be measured as classified under: -

- a) Excavation in all kinds of soil including soft/ disintegrated rock, PCC, WBM, Brickwork/ stone masonry etc (excluding hard rock).
- b) Excavation in hard rock (required blasting)

5.1 If required the sides of excavations should be supported in such a way as is necessary to secure these from falling in, and the shoring, if required, shall be provided, and maintained in position as long as necessary. No extra payment shall be made for shoring.

5.2 Whenever water table is met during the excavation, it shall be dewatered and water table shall be maintained below the bottom of the excavation level during excavation, the excavation shall be kept free from water: -

- When concrete and/or masonry works are in progress and till they come above the natural water level.
- Till the Employer considers that the concrete/ mortar is sufficiently set.

No extra payment shall be made for dewatering.

5.3 Material unsuitable for foundations shall be removed and replaced by suitable fill material as per specification and to be approved by the Employer.

5.4 Backfill material around foundations or other works shall be suitable for the purpose for which it is used and compacted. Requirements regarding density / tests of backfilled earth shall be as specified

in Field Quality Plan. The sub-grade for the roads and embankment filling shall be compacted to minimum 95% of the Standard Proctor's density at OMC (Optimum moisture content). Cohesion less material sub-grade shall be compacted to 70% relative density (minimum).

5.5 If, excavated material is not suitable or not required for backfill, it shall be disposed of in areas as directed by Employer up to a maximum lead of 2 km from the substation boundary.

#### **5.6 DISMANTLING & DEMOLISHING WORKS**

a. The scope of work includes dismantling of existing R.C.C. works at all levels (in foundations or super structures) either manually or by mechanical means including disposal of steel bars and unserviceable material as per direction of Engineer – in charge. The work of dismantling of RCC works shall be measured in cu. m. Dismantling work must be carried out very carefully under strict close supervision to ensure structural stability of the remaining and/or adjoining/ abutting structure.

b. The scope of work includes Demolishing/dismantling of existing chain link fencing either manually or by mechanical means including disposal of unserviceable material as per direction of Engineer – in-charge. The work of dismantling/demolishing of existing chain link fencing shall be measured in running meter.

#### **5.7 REQUIREMENT FOR FILL MATERIAL UNDER FOUNDATION:**

5.7.1 The thickness of fill material under the foundations shall be such that the maximum pressure from the footing, transferred through the fill material and distributed onto the original undisturbed soil will not exceed the allowable soil bearing pressure of the original undisturbed soil.

5.7.2 The filling shall be done in accordance with clause 4.10 of IS: 1080. For expansive soils the fill materials and other protections etc. to be used under the foundation is to be go approved by the Employer.

5.7.3 Cohesive Non-Swelling (CNS) soil, if required, for filling under / around the foundations, cable trenches, drains, roads etc shall conform to IS: 9451: 1994 reaffirmed 2004.

#### **6.0 CEMENT:**

6.1 The type of cements which can be used are Portland Pozzolana cement (conforming to IS:1489), Ordinary Portland cement (conforming to IS:269 or IS:8112 or IS:12269), and Portland Slag cement. (Conforming to IS: 455). Cement shall be arranged by contractor.

6.2 Generally PPC type shall be used for concrete work. However, depending on availability, OPC may also be used without any additional financial implication to INDIGRID.

6.3 Extra care for curing shall be taken for concrete made with OPC 53 grade & PPC.

6.4 Extra care for removing form work shall be taken, when PPC is used.

6.5 Portland Slag Cement has low heat of hydration and is relatively better resistant to soils. and water containing excessive amount of sulphates of alkali metals, alumina, and iron, as well as to acidic waters. Hence it can be specifically allowed for above conditions with prior approval of EIC.

#### **7.0 CHEMICAL ADMIXTURES & ADDITIVES**

7.1 Use of chemical admixtures shall be permitted in accordance, with the provisions of IS 456 and IS 9103.

7.2 It shall be the responsibility of the producer to establish compatibility and suitability of any admixture with the other ingredients of the mix and to determine the dosage required to give the desired effect. The amount of admixture added to mix shall be recorded in the production record by the producer.

7.3 Admixtures should be stored in a manner that prevents degradation of the product and consumed within the time period indicated by the admixture supplier. Any vessel containing an admixture in the plant or taken to site by the producer shall be clearly marked as to its content.

7.4 When offering or delivering a mix to a purchaser it should be indicated if such a mix contains an admixture or combination of admixtures or not. The admixtures may be identified generically and should be declared on the delivery ticket.

## **8.0 REINFORCED CONCRETE CEMENT (RCC):**

All RCC work including material properties, proportioning, batching, mixing, transporting, pouring, compacting, finishing, curing, sampling, testing, acceptance criterion etc. shall be as per IS: 456-2000 (or latest).

### **8.1 DESIGN MIX CONCRETE**

8.1.1 For new substations and extensions except minor works, Reinforced cement concrete shall be M-25 design mix conforming to IS: 456. IS: 10262 shall be followed for mix proportioning. The minor work may be defined as any work involving less than 3.0 cum of concrete in a single day of concreting at one particular construction site.

8.1.2 Design mix concrete may be procured from approved RMC plant as per latest IS: 4926 or may be prepared by using a portable/mini/compact weigh batch plant conforming to latest IS: 4925

8.1.3 As per provisions of IS: 456, fly ash conforming to grade I of IS: 3812 (part 1) may be used as part replacement of cement, when OPC cement is used for concrete works. Uniform blending with cement is to be ensured.

### **8.2 VOLUMETRIC MIX CONCRETE**

8.2.1 Use of volumetric mix concrete shall be restricted to minor works only (as per clause 8.1.1) s1with approval of engineer in charge. In such cases reinforced cement concrete shall be of volumetric mix 1:1.5:3 (1 cement: 1.5 coarse sand: 3 well graded stone aggregate 20mm nominal size) conforming to CPWD specifications. Volumetric mix 1:1.5:3 shall be considered equivalent to M-20.

8.2.2 In case of volumetric mixes, Standard measuring boxes of 35cmX40cmX25cm (35 litres capacity as per CPWD) shall be used for measuring fine and coarse aggregates.

8.2.3 However, full 50 kg of OPC/PPC/Slag cement shall be directly unloaded into the mixer hopper to ensure that cement consumption is 400kg per cum of 1:1.5:3 concrete irrespective of different types of cements with different densities.



8.2.4 The cement consumption shall be as per (CPWD) for other grades of concretes provided as volumetric concrete in the BPS.

8.2.5 For volumetric mix concretes, the cement used may be generally PPC type, however concrete may be prepared with OPC also, without any financial implication to INDIGRID.

#### **9.0 REINFORCEMENT STEEL:**

Reinforcement steel shall be thermo mechanically treated (TMT) or HYSD reinforcement bars of grade Fe 500D conforming to IS: 1786. Reinforcement shall be arranged by contractor.

#### **10.0 DRAWINGS AND DESIGN TO BE DEVELOPED BY CONTRACTOR / EMPLOYER DURING DETAILED ENGINEERING:**

The following clauses are applicable for the design and drawings which are to be developed during detailed engineering by contractor/ vendor as per section project.

##### **10.1 DESIGN LOADS:**

The following loads shall be considered in design, in addition to the equipment manufacturer's requirements if any. However, all the loads, which are required for design, are subjected to employer's approval.

##### **10.1.1 DEAD LOADS**

Dead loads shall include the self-weight of all structures complete with finishes, fixtures, and partitions.

##### **10.1.2 IMPOSED LOADS**

Super-imposed loads in different areas shall include live loads, minor equipment loads, cable trays, small pipe racks/hangers and erection, operation, and maintenance loads wherever these loads are expected. Equipment loads shall constitute, if applicable, all load of equipment's to be supported on the building frame.

Floors/slabs shall be designed to carry loads imposed by equipment, cables and other loads associated with building. Cable load shall also be considered additionally for floors where these loads are expected. The floor loads shall be subject to Employer's approval. Floors shall be designed for live loads as per relevant IS 875 part 2 (latest), however, for Buildings, the following loads may be considered.

Roof	1.5 kN/m <sup>2</sup> for accessible roofs and 0.75 kN/m <sup>2</sup> for in-accessible roofs
RCC-Floor	i) 5 kN/m <sup>2</sup> for offices ii) 10 kN/m <sup>2</sup> (min.) for equipment floors or actual requirement, if higher than 10kN/m <sup>2</sup> on equipment component and layout plans
Stairs & balconies	5 kN/m <sup>2</sup>
Toilets	2 kN/m <sup>2</sup>
Chequered plate floor	4 kN/m <sup>2</sup>
Walkways	3 kN/m <sup>2</sup>



For crane loads an impact factor of 30% and lateral crane surge of 10% (lifted weight + trolley) shall be considered in the analysis of frame according to provisions of IS:875. The horizontal surge shall be 5% of the static wheel load. Crane load shall be applied as per the requirement of building.

#### **10.1.3 WIND LOAD –**

Wind speed to be considered as per Wind map in National Building Code – 2016 (Volume-I) for all built-up structures in substation.

- i) The wind loads shall be computed as per IS 875 part 3 (latest), the class of structure for design,  $k_1$  factor, shall be considered under the category as 'important buildings and structures like hospitals, communication buildings/towers, power plant structures' for Control Room building, GIS hall, Towers, Gentries, equipment structure. For other buildings/structures wind loads shall be computed as per IS 875 part 3 (latest).
- ii) Wind and Seismic forces shall not be considered to act simultaneously.

#### **10.1.4 SEISMIC LOAD**

- i) Seismic Coefficient method/Response Spectrum method shall be used for the seismic analysis as per IS: 1893: Part 1 with importance factor 1.5.
- ii) Wind and Seismic forces shall not be considered to act simultaneously.

#### **10.1.5 SNOW LOAD**

- i) Snow load shall be computed as per IS:875 part 4 (latest) for snow Prone areas only.
- ii) When snow load is present in roofs, replace imposed load by snow load in respective load combinations.

#### **10.1.6 LOAD COMBINATIONS**

- i) The critical load combinations for design of RCC structures shall be computed or generated by using IS: 875 Part-5 (latest), IS: 456 (latest), IS: 1893- part 1 (latest).
- ii) The critical load combinations for design of Steel structures shall be computed or generated by using IS: 875 Part-5 (latest), IS: 800, IS: 1893- part 1 (latest).

### **10.2 DESIGN OF FOUNDATIONS FOR SWITCH YARD STRUCTURES:**

**10.2.1** All foundation shall be of reinforced cement concrete. The design and construction of RCC structures shall be carried out as per IS: 456. Minimum 75mm thick lean concrete (1:4:8) shall be provided below all underground structures, foundations, trenches etc. to provide a base for construction.

**10.2.2** The switchyard foundation's plinths shall be as per the existing structures. If the site is sloping, the foundation height will be adjusted to maintain the exact level of the top of structures to compensate such slopes.

**10.2.3** The tower and equipment foundations shall be checked for a partial factor of safety of 2.2 for normal condition and 1.65 for short circuit condition.

**10.2.4** 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 Isolated/ Combined/ Strip footings / Raft or pile foundation as may be required based on soil/sub-soil conditions and superimposed loads shall be provided.

**10.2.5** 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 which produces the maximum stresses in the foundation or the foundation component and as per the relevant BIS Codes of foundation design. Detailed design calculations shall be submitted by the bidder showing complete details.

**10.2.6** 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.

**10.2.7** If pile foundations are adopted, the same shall be cast-in-situ bored or pre-cast or under reamed type as per relevant parts of IS: 2911. Only RCC piles shall be provided. Necessary initial load test shall be carried out by the Contractor to establish the pile design capacity. Only after the design capacity of pile has been established, the Contractor shall take up the job of piling. Routine tests for the pile shall also be conducted as per IS: 2911/IS :10262. All the testing work shall be planned in such a way that these shall not cause any delay in project completion. RCC for pile works shall be Design Mix of minimum grade M-25 and minimum cement content shall be 400Kg/ cum as per IS:2911 (Latest revision). In case extra cement is required to meet the provisions of IS: 2911, it will be paid extra.

**10.2.8** 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.

### **10.3 DESIGN OF TRANSFORMER AND REACTOR FOUNDATION:**

**10.3.1** The foundations of Transformer & Reactor shall be of block type foundation. Minimum reinforcement shall be governed by IS: 2974 and IS: 456.

**10.3.2** The Contractor shall provide a RCC Rail cum road system integrated with the Autotransformer / Reactor foundation to enable installation and the replacement 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.

**10.3.3** This system shall enable the removal of any failed unit 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.

**10.3.4** The Contractor shall provide a pylon support system for supporting the firefighting system.

**10.3.5** An oil soak pit should be provided below each transformer/reactor to accommodate 1/3rd of total quantity of oil contained in the transformer/reactor and minimum 300 mm thick layer of gravels/pebbles of approximately 40 mm size (spread over a steel iron grating/trans rack) providing free space below the grating provided a common remote oil collecting pit of capacity at least equal to oil quantity in the largest size transformer/reactor is provided for a group of transformers/reactors.

Bottom of the soak pit below the transformer/reactor should be connected to the common oil collecting pit with drainpipe (two or more Hume/concrete pipes) of minimum 150 mm diameter with

a slope not less than 1/96 for fast draining of oil and water through gravity from soak pit to the burnt oil collecting pit, which is generally located away from transformers/reactors.

Every soak pit below a transformer/reactor should be suitably designed to contain oil dropping from any part of the transformer/reactor.

The common remote oil collecting pit and soak pit (when remote oil collecting pit is not provided) should be provided with suitable automatic pumping facility, to always keep the pit empty and available for an emergency.

The disposal of transformer oil should be carried out in an environmentally friendly manner.

**10.3.6** The minimum height of the retaining walls of pit shall be 20 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 the sump pit. While designing the oil collection pit, the movement of the autotransformer / reactor must be considered.

**10.3.7** The grating shall be made of MS flat of size 30mm x 5mm placed at 30mm centre to centre and 6mm dia MS bar at spacing of 150mm at right angle to each other. Maximum length of grating shall be 2000mm and width shall not be more than 500mm. The gratings, supported on ISMB 150 mm, shall be placed at the formation level, and will be covered with 100mm thick layer of stone aggregate having size 40mm to 60mm. All steel work used for grating and supports shall be painted with epoxy-based zinc phosphate primer (two packs) confirming to IS: 13238- 1991, thereafter with two or more coat of bituminous paint of approved quality shall be applied. Contractor shall have option to provide factory made electro forged MS grating made of specified size MS flat and round bars without any extra cost to employer.

**10.3.8** Each oil collection pit shall be drained towards a sump pit of size 1000X750mm and 500mm deep below the floor level within the collection pit whose role is to drain water and oil due to leakage within the collection pit so that collection pit remains dry.

**10.3.9** Under Ground Oil Storage Tank Each transformer unit shall be provided with an underground oil storage tank. The oil storage tank shall have non-Corrosive, waterproof, epoxy coated (from Inside) mild steel (minimum thickness 5 mm) to store drained out oil on operation of NIFPS. The tank shall be painted from outside as per **table below**:

Painting	Surface preparation	Primer coat	Intermediate undercoat	Finish coat	Total dry film thickness (DFT)	Colour shade
Oil Storage Tank	Shot Blast cleaning Sa 2 ½*	Epoxy base Zinc primer (30-40µm)	Epoxy high build Micaceous iron oxide (HB MIO) (75µm)	Aliphatic polyurethane (PU) (Minimum 50µm)	Minimum 155µm	RAL 7035

The total capacity of storage tank shall be at least 10% of transformer tank oil to avoid overflowing of oil considering that drained oil volume shall be around 10% of transformer tank oil. Necessary arrangement shall be made on underground storage tank so as to take out the drained oil from the tank for further processing and use. All the pipe and physical connection from transformer to oil pit shall be in the scope of contractor. This storage tank shall be placed in the pit made of brick walls with

PCC (1:2:4) flooring with suitable cover plates to avoid ingress of rainwater. The design of tank and pit shall be finalised during detailed engineering.

#### **10.4 DESIGN OF FIRE PROTECTION WALLS:**

**10.4.1** The construction of fire walls shall be cast in situ type or pre-cast RCC as per drawings and meeting the technical specification.

**10.4.2** The firewall shall have a minimum fire resistance of 4 hours. The walls of the building, which are to be used as firewalls, shall have also a minimum fire resistance of 4 hours. The firewall shall be designed to protect against the effect of radiant heat and flying debris from an adjacent fire.

**10.4.3** The firewall shall extend 600 mm on each side of the Autotransformer or Reactors and 600 mm above the conservator tank or safety vent. A minimum of 2-meter clearance shall be provided between the equipment's e.g., Autotransformer or Reactors and firewalls. In case of space constraints, these dimensions can be reduced as per the approval of Employer.

**10.4.4** The building walls, which act as firewalls, shall extend at least 1 m above the roof or 600 mm above the conservator tank or safety vent, whichever is maximum, in order to protect it.

**10.4.5** The firewall will be made of reinforced cement concrete with smooth surfaces devoid of honeycomb, undulations etc. and shall be finished with water proofing cement paint of approved colour.

#### **10.5 DESIGN OF CHANNELS, TRENCHES, AND OTHER UNDER-GROUND STRUCTURES:**

**10.5.1** RCC Oil pits/ liquid retaining structures etc. shall be designed as un-cracked section in accordance with IS: 3370 (Part I to IV) by working stress method. In case of water channels, shall be designed as cracked section with limited steel stresses as per IS: 3370 (Part I to IV) by working stress method.

**10.5.2** All sub-structures 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 BIS Codes or as stipulated elsewhere in the Specifications. For checking against overturning, weight of soil vertically above footing shall be taken and inverted frustum of pyramid of earth on the foundation should not be considered.

**10.5.3** Earth pressure for all underground RCC structures like cable trenches, Oil collection pits, Septic tanks, basements etc. shall be calculated using co-efficient of earth pressure at rest, co-efficient of active or passive earth pressure (whichever is applicable). However, for the design of substructures of any underground enclosures, earth pressure at rest shall be considered.

**10.5.4** In addition to earth pressure and ground water pressure etc., a surcharge load of 2T/Sq.m shall also be considered for the design of all underground structures for the vehicular traffic in the vicinity of the structure.

**10.5.5** Underground tanks shall be checked for full water pressure from inside and no earth pressure & ground water pressure & surcharge pressure from outside (application only to structures which are liable to be filled up with water or any other liquid). They shall also be checked for full earth pressure, surcharge pressure and ground water pressure from outside and no water pressure from inside.

**10.5.6** 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. Base slab of any underground enclosure shall also be designed for 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.

**10.5.7** Base slab of any underground enclosure like liquid storage tank shall also be designed for the condition of different combination of pump sumps being empty during maintenance stages with maximum GWT. Intermediate dividing piers of such enclosures shall be designed considering water in one pump sump only and the other pumps sump being empty for maintenance.

#### **11.0 SUBMISSION:**

The following information shall be submitted for review and approval to the Employer:

**11.1** Editable Soft as well as hard copies of structural design calculations and structural drawings (including construction/fabrication) of all items designed and developed by contractor shall be submitted during approval process as well as during As-Built stage (Auto cad Drawing & Staad-pro files shall also be submitted).

**11.2** Fully, dimensioned concept plan including floor plans, cross sections, longitudinal sections, elevations, and perspective view of each building. These drawings shall identify the major building components. Staad Pro Files & Auto cad drawings shall also be submitted.

**11.3** Fully dimensioned drawings showing details and sections drawn to scales of sufficient size to clearly show sizes and configuration of the building components and the relationship between them.

**11.4** Product information of building components and materials, including walls partition flooring ceiling, roofing, door, and windows and building finishes to be submitted to EIC.

**11.5** A door & window schedule showing door types and locations, door lock sets and latch sets and other door hardware. Approval of the above information shall be obtained before ordering materials or starting fabrication or construction as applicable.

#### **12.0 MISCELLANEOUS REQUIREMENTS:**

**12.1** All joints including construction and expansion joints for the liquid retaining structures shall be made watertight by using PVC ribbed water stops with central bulb. The minimum thickness of PVC water stops shall be 5 mm and minimum width shall be 230 mm.

**12.2** Angles 50x50x6 mm (minimum) with lugs shall be provided for edge protection all round cut outs/openings in floor slab.

**12.3** The material specification, workmanship and acceptance criteria shall be as per approved Field Quality Plan. In case certain item is not covered in FQP, it shall be constructed as per CPWD specification.

**12.4** Items/ components of buildings not explicitly covered in the specification but required for completion of the project shall be deemed to be included in the scope.

## **12.5 FIELD QUALITY PLAN**

All tests as required in accordance to IS codes or equivalent international standards must be carried out. The contractor shall prepare field quality plan for civil works as per relevant IS codes/equivalent International Standards during detailed engineering stage and submit to Employer for approval within ONE month after award of work.

## **13.0 INTERFACING:**

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, Crane girder alignment, Connection between old and new PEB 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.

## **14.0 STATUTORY RULES:**

**14.1** Contractor shall comply with all the applicable statutory rules pertaining to factories act (as applicable for the State), Fire Safety Rules of Tariff Advisory Committee, Water Act for pollution control etc.

**14.2** Statutory clearance and norms of State Pollution Control Board shall be followed as per Water Act for effluent quality from plant.

**14.3** All building/construction materials shall conform to the best quality specified in CPWD specifications if not otherwise mentioned in this specification.

**14.4** All tests as required in the field quality plan must be carried out without any financial implication to employer.

## **15.0 SPECIFICATION FOR SITE LEVELLING WORK**

### **15.1 SCOPE OF WORK AND GENERAL CONDITION**

This specification shall apply to site levelling works as are required to be executed under the Contract or otherwise directed by the Engineer-in-Charge from INDIGRID.

Site levelling work shall consist of clearance of site, excavation in all kinds of soils, soft/disintegrated rock, hard rock, dewatering, transporting of excavated earth, filling, consolidation of earth, levelling benching, giving slopes and making formations, levelling operations, removal and satisfactory disposal of unsuitable materials necessary for achieving desired formation level, if required, in accordance with the requirements of the specifications and the lines, grades and cross-sections shown in the drawings or indicated by the Engineer-in-Charge. The work shall include the hauling and stacking of or the hauling to levelling site, of suitable materials as required, as also the disposal of unsuitable materials in specified manner; and the trimming and finishing of works.

This work also includes cutting of diversion channel to prevent the area from flooding and construction of kuccha surface drains for drainage of the area.

The quality of work and materials shall comply with the requirements set forth in the succeeding sections. Where the drawings and Specifications describe a portion of the work only in general terms, and not in complete details, it shall be understood that only the best general practice is to prevail, materials and workmanship of the best quality are to be employed and the instructions of the Engineer-in-Charge are to be fully complied with.

The work to be performed under this specifications consists of providing all labour, supervision, materials, planking and strutting, power, fuel, construction equipment's, tools and plants, supplies, transportation, blasting materials if required, storage, insurance, royalty and all incidental items not shown or specified by reasonably implied or necessary for successful completion of work including contractor's supervision and in strict accordance with drawing and specifications.

The scope may however vary based on the specific requirement of various works/site, which shall be specified by the Owner / Employer.

The work shall be executed according to "Released for Construction", drawings with additions, alterations and modifications made from time to time as required or approved by the Engineer-in-Charge from INDIGRID.

Construction traffic shall not use the levelled area without prior permission of the Engineer-in-Charge from INDIGRID. Any damage arising out of such use shall be made good by the Contractor at his own expense.

The words like Contract, Contractor, Project Manager, Drawings, Owner / Employer, works, site used in this Specifications shall be considered to have the meaning as understood from the definition of these terms included in the General Conditions of Contract (GCC).

#### **15.2 PRESERVATION OF PROPERTY/AMENITY:**

The Contractor shall undertake all reasonable precautions for the protection and preservation of Trees, shrubs, any other plants, pole lines, fences, signs, monuments, buildings, pipelines, sewers or other subsurface drains, pipes, conduits, and any other structures under or above ground, which may be affected by construction operations and which in the opinion of the Project Manager shall be continued in use without any change. The Contractor shall provide and install at his own expenses, suitable safeguards approved by the Project Manager for this purpose. However, if any of these objects is damaged by reason of the Contractor's negligence, it shall be replaced or restored to the original condition without any financial implication to INDIGRID.

#### **15.3 DISPOSAL OF MATERIALS:**

All materials arising from jungle clearing, grubbing operation, all type of excavation etc. shall be the property of INDIGRID and shall be disposed of by the Contractor as hereinafter provided or directed by the Project Manager within a lead of 2000 m beyond the periphery of substation area. Also, boulders, stones, and other materials usable shall be neatly stacked.

All products of clearing and grubbing which in the opinion of the Project Manager cannot be used or auctioned shall be cleared away to waste areas and burnt, if so desired, at locations away to a lead mentioned above in a manner as directed. Care shall be taken to see that unsuitable waste materials are disposed of in such a manner that there is no likelihood of these getting mixed up with the materials meant for filling.



Where the excavated material is directed to be used in the filling area, it shall be directly deposited at the required location complying with the total requirements. All disposed material other than hard material shall be spread in layers at the places within specified leads.

All hard materials, such as hard moorum, rubble, etc., not intended for use in the filling, shall be stacked neatly on INDIGRID land as directed by the Project Manager, for future use. Unsuitable and surplus materials not intended for use in any part of the works shall be disposed of.

#### **15.4 SITE CLEARANCE**

The work shall consist of numbering of trees, removing and disposing of all materials such as trees, bushes, woods, shrubs, grass, stumps, rubbish, rank vegetation, roots, foreign materials, etc., which in the opinion of the Project Manager are unsuitable for incorporation in the works, from within the limits and areas as may be specified by the Project Manager.

All trees up to a girth (perimeter) of 30 cm measured at one metre above the ground level shall also be cut and useful portion of the trees so cut shall be stacked at a suitable place as directed by the Project Manager and shall be considered incidental to clearing and grubbing operations.

The roots of trees shall be dug up to 60 cm below the ground level or 15 cm below formation level whichever is deeper and after removal of all vegetable and organic matter from the holes so formed by removal of the roots, holes and hollows shall be filled with good earth in layer of 20 cm, well rammed, consolidated and levelled.

The serviceable and unserviceable materials obtained from the site clearance shall be removed from the area and disposed of to a place as per the directions of the Engineer-in- Charge. All unserviceable and serviceable materials obtained from the site clearance shall be the property of INDIGRID.

Clearing and grubbing item is not payable and the same shall be deemed to be included in the earth work in excavation and filling.

Trees having girth above 30 cm are not in the scope of Contractor.

#### **15.5 CLASSIFICATION OF EXCAVATED MATERIALS:**

All materials involved in excavation shall be classified in the following groups:

##### **15.5.1 ALL KIND OF SOILS AND SOFT/DISINTEGRATED ROCK**

The material which can be quarried/excavated with pick, shovels, jumpers, scarifiers, crowbars etc. and other mechanical implements. All materials involved under this classification are as below:

All kind of soils includes several types of soils, plain concrete, shingle, and river or nallah bed boulders, soling of road, paths and hard core, macadam surface of any description, stone masonry below the ground level, soft conglomerate and laterite stone which can be detached from the matrix with picks and shovel.

Soft/disintegrated Rock (Not requiring blasting): Rock and boulders which may be quarried and split with crow bars and other mechanical implements etc. It includes limestone, sandstone, hard conglomerate.



### **15.5.2 HARD ROCK:**

All kind of rocks which can be excavated by machines and requires blasting chiselling in edging or in another agreed method. This can be classified under the following categories:

a) Hard Rock (Requiring Blasting)-This shall comprise:

- i) Any rock for the excavation of which the use of mechanical plant or blasting is required.
- ii) Reinforced cement concrete (reinforcement cut through but not separated from the concrete) below ground; and
- iii) Boulder requiring blasting.

b) Hard Rock (Blasting Prohibited)

Hard rock requiring blasting as described under (a) above but where blasting is prohibited for any reason and excavation must be carried out by chiselling, wedging or any other agreed method.

### **15.5.3 AUTHORITY FOR CLASSIFICATION EXCAVATION:**

The classification of excavation shall be decided by the Project Manager and his decision shall be final and binding on the Contractor. Merely the use of explosives in excavation will not be considered as a reason for higher classification unless blasting is clearly necessary in the opinion of the Project Manager. All the excavated material shall be the property of the INDIGRID.

## **15.6 SITE LEVELLING OPERATIONS:**

### **15.6.1 SETTING OUT AND MARKING PROFILES**

After the site has been cleared, the limits of site levelling shall be set out true to lines, curves, slopes, grades, and sections as shown on the drawings or as directed by the Engineer-in-charge. The Contractor shall provide all labour, survey instruments and materials such as strings, pegs, nails, bamboos, stones, lime, mortar, concrete, etc., required in connection with the setting out of works and establishment of benchmarks. A grid system of co-ordinates shall be established by the Contractor at the site. The Contractor shall be responsible for the maintenance of permanent reference pillars, benchmarks and other marks and stakes as long as in the opinion of the Project Manager they are required for the work. All such marks/pillars shall be removed by the Contractor at his own cost as soon as the purpose is over.

Masonry pillars shall be erected at suitable places in the area to serve as benchmarks for the execution of the work. These benchmarks shall be connected with G.T.S. of any other permanent benchmark approved by the Project Manager. Necessary profiles with pegs, bamboos and strings or "Burgeis" shall be made to show the correct formation levels before the work is started and the same shall be approved by the Project Manager. The contractor shall supply all labour, tools, equipment, materials, safeguards, and incidentals necessary for setting out and making profiles and burgeis & pillars for the work at his own cost. The profiles and burgeis shall be maintained during the execution of the work.

Marks/pillars shall invariably be diagonal unless otherwise directed and should be such that their average height is representative of average depths. Payments will be made on the basis of volume measurement after with-holding the amount corresponding to 5% of the volume of earth work on account of non-removal of marks/pillars.

The Contractor shall have to remove the marks/pillars and utilise the earth spoils as per the directions of the Project Manager. The withheld amount as stated in the above paragraph may be paid after

certification of the Project Manager; regarding his full satisfaction and to the effect that the mark/pillars, etc. have been removed and soils/earth thereof has been utilised as directed by him. If the contractor fails to remove, partly or fully the marks/pillars in the manner and within the period as aforesaid double the amount spent by the Owner / Employer for removal of marks/pillars will be recovered from dues payable to the contractor.

#### **15.6.2 EXCAVATION AND FILLING**

All excavations shall be carried out in conformity with the directions laid herein under and in a manner approved by the Project Manager. The work shall be so done that the suitable materials available from excavation are satisfactorily utilised as decided upon before disposal.

While planning or executing excavation, the Contractor shall take all adequate precautions against soil erosion, water pollution, air pollution etc.

The excavations shall conform to the lines, grades, side slopes and levels shown on the drawings or directed with a negative tolerance of 100mm. The Contractor shall not excavate outside the slopes or below the established grade or loosen any material outside the limits of excavation. Subject to the permitted tolerances, any excess depth excavated below the specified levels shall be made good at the cost of the Contractor with suitable material of similar characteristics and compacted to the required density and to the satisfaction of the Project Manager.

All debris and loose material on the slopes of cuttings shall be removed.

Cutting shall be done from top to bottom. Under no circumstances undermining or undercutting shall be allowed. Final surface shall be neatly dressed. The earth from cutting shall be directly used for filling and no extra claim for double handling of earth shall be admissible to the contractor.

If cutting be taken deeper, it shall be brought to the required level as per the instructions, by filling it with the earth and duly consolidating at the Contractor's cost. Filling shall be done in regular horizontal layers not exceeding 20 cm. in depth. The earth shall be free from all roots, grass, rubbish and humps and clods exceeding 80mm in any direction shall be broken. Each layer shall be consolidated by breaking clods and compacting each layer with wooden /steel rammer or movement of dozers, trucks or 8/10 tonne power road rollers, sheep foot roller and vibratory compactors etc. so that compaction of 95% of the maximum dry density is achieved at optimum moisture content. The surface finished shall be neatly dressed to the required formation levels with tolerance of ( $\pm$ ) 100 mm.

Tests for Compaction are to be performed as per the procedures laid down in the relevant I.S. Codes of practice and approved Field Quality Plan. In cases of compaction below the stipulated percentage, the contractor shall adopt proper techniques as directed by the Engineer in-Charge and to his satisfaction to ensure the specified degree of compaction. The cost of tests to be performed shall be borne by the Contractor. During the execution of work, the contractor shall maintain natural drainage of the area.

#### **15.6.3 HARD ROCK EXCAVATION**

Hard Rock, when encountered during excavation, shall be removed up to the finished ground level or as indicated on the drawings. In all cases, the excavation operations shall be so carried out that at no point on cut formation the rock protrudes above the specified levels, provided, however, that a negative tolerance of 150 mm shall be permissible.

Slopes in rock cutting shall be finished to uniform lines corresponding to slope lines shown on the drawings or as directed by the Project Manager. Notwithstanding the foregoing, all loose pieces of rock on excavated slope surface which move when prised by a crowbar shall be removed.

Blasting shall be carried out as per relevant clause mentioned elsewhere in this specification and all precautions indicated therein to be observed.

#### **15.6.4 DEWATERING**

If water is met with in the excavation due to stream flows, springs, seepage, rain or other causes, it shall be removed by suitable diversions, pumping or bailing out and other excavation kept dry whenever so required or directed by the Project Manager, Care shall be taken to so discharge the drained water as not to cause damage to the works, crops or any other property. No extra payment shall be admissible to the contractor on this account.

#### **15.6.5 FINISHING OPERATIONS**

Finishing operations shall include the work of properly shaping and dressing all excavated surfaces. When completed, no point on the slopes shall vary from the designated slopes by more than 150 mm measured at right angles to the slope, except where excavation is in rock where no point shall vary more than 600 mm from the designated slope. In no case shall any portion of the slope encroach on the roadway.

#### **15.7 EARTH FILL MATERIAL:**

##### **15.7.1 SUITABLE MATERIAL**

The borrowed earth used in filling shall be free from all roots, grass, shrubs, rank vegetation, brush wood, tree sapling and rubbish.

##### **15.7.2 UNSUITABLE MATERIAL**

Unsuitable material shall mean materials unsuitable for placing as fill in the works and shall comprise:

- a) Material from swamps, marshes, and bogs.
- b) Peat, logs, stumps, and perishable materials.
- c) Material susceptible to spontaneous combustion.
- d) Any natural material or industrial and domestic produce which will adversely affect other materials in the work.
- e) Clay with liquid limit exceeding 80% and/or plasticity index exceeding 55%.

##### **15.7.3 SPREADING AND COMPACTION OF FILLING**

For the earth works contractor shall satisfy the Project Manager that the entire specified requirement regarding compaction can be achieved. Testing shall be carried out as per field quality plan.

The Final formation shall be correct in level and profile after compaction. In the case of earth work consolidated under optimum moisture conditions, each layer of earth shall be carefully moistened to give field moisture content of about + 1% to - 2% of the optimum moisture content (OMC). The OMC shall be determined according to IS: 2720 (Pt. VII & VIII) Methods of Tests for Soils.

Each layer shall then be compacted by rolling with wooden/ steel rammer or movement of dozers, trucks, 8/10 tonnes power road roller, sheep foot roller and vibratory compactors/roller. The required amount of water shall be added during consolidation to keep the moisture content of the soil at the optimum as per test. The density to be achieved for each layer of the material shall not be less than 95% of the density obtained in the laboratory (Proctor Method).

Control on compaction in the field shall be exercised through frequent moisture content and density determinations. A systematic record of these shall be maintained. At all times during construction the top of the embankment shall be maintained at such cross fall as will shed water and prevent pounding.

## **15.8 BLASTING OPERATIONS.**

### **15.8.1 GENERAL**

Blasting shall be carried out only with the written permission of the Project Manager. All the statutory laws, regulations, rules, Indian Standards, etc., pertaining to the acquisition, transport, storage, handling, and use of explosives shall be strictly followed. The Contractor may adopt any method or methods of blasting consistent with the safety and job requirements, after approval from the Project Manager and shall muffle the blasting adequately to the satisfaction of the Project Manager. Blasting should be carried out as far as possible with the help of Ammonium Nitrate mixed with proper proportions of fuel oil which is a safer method. However, in the event of its nonavailability the convenient practice of using gelatine with detonators can be resorted to. The magazine for the storage of explosives shall be built to the designs and specifications of the Explosives Department concerned and located at the approved site. No unauthorised person shall be admitted into the magazine which when not in use shall be kept securely locked. No matches or inflammable material shall be allowed in the magazine. The magazine shall have an effective lightning conductor. The following shall be hung in the lobby of the magazine.

- a) A copy of the relevant rules regarding safe storage both in English and in the language with which the workers concerned are familiar,
- b) A statement of up-to-date stock in the magazine,
- c) A certificate showing the last date of testing of the lightning conductor,
- d) A notice that smoking is strictly prohibited.

In addition to these, the Contractor shall also observe the instructions in following clauses and any further additional instructions which may be given by the Project Manager and shall be responsible for damage to property and any accident which may occur to workers or the public or the materials on account of any operations and blasting. The Project Manager shall frequently check the Contractor's compliance with these precautions.

### **15.8.2 MATERIALS, TOOLS, AND EQUIPMENT**

All the materials, tools and equipment used for blasting operations shall be of approved type and shall be arranged by the contractor from any authorised dealer of such approved material. Necessary assistance in the form of approval for procurement of the material shall be given by the Corporation. The contractor shall be fully responsible for entering into the agreement with any authorised magazine contractor in respect of rates, regularity of supply, etc. the Project Manager may specify the type of explosives to be allowed in special cases. The fuse to be used in wet locations shall be sufficiently water-resistant as to be unaffected when immersed in water for 30 minutes. The rate of burning of the fuse shall be uniform and definitely known to permit such a safe length being cut as will permit sufficient time to the firer to reach safety before explosion takes place. Detonators shall be capable of

giving effective blasting of the explosives. The blasting powder, explosives, detonators fuses, etc., shall be fresh and not damaged due to damp, moisture, or any other cause. They shall be inspected before use and damaged articles shall be discarded totally and removed immediately.

#### **15.8.3 PERSONNEL**

The blasting operation shall remain in the charge of competent and experienced supervisor and workers who are thoroughly acquainted with the details of handling explosives and blasting operations.

#### **15.8.4 BLASTING OPERATIONS.**

The blasting shall be carried out during fixed hours of the day preferably during the midday lunch hour or at the close of the work as ordered in writing by the Project Manager. The hours shall be made known to the people in the vicinity. All the charges shall be prepared by the man in charge only. Proper precautions for safety of persons and property shall be taken.

Red danger flags shall be displayed prominently in all directions during the blasting operations. People, except those who actually light the fuse shall be prohibited from entering this area. The flags shall be planted 200 metres from the blasting site in all directions and all persons including workers shall be excluded from the flagged area at least 10 minutes before the firing, a warning whistle being sounded for the purpose. The charge holes shall be drilled to required depths and in suitable places. Blasting should be as light as possible consistent with thorough breakage of the material necessary for economic loading and hauling. Any method of blasting which leads to overshooting shall be discontinued.

When blasting is done with powder, the fuse cut to the required length shall be inserted into the hole and the powder dropped in. The powder shall be gently tamped with copper rods with rounded ends. The explosive powder shall then be covered with tamping material which shall be tamped lightly but firmly.

At a time, not more than 10 such charges will be prepared and fired. The man in charge shall blow a whistle in a recognised manner for cautioning the people. All the people shall then be required to move to safe distances. The charges shall be lighted by the man in charge only. The man in charge shall count the number of explosions. He shall satisfy himself that all the charges have been exploded before allowing the workers to go back to the work site.

When blasting is to be carried out in the proximity of other existing structures, sand/earth bags, etc. shall be used on the top of the blast holes to prevent the rock fragment from causing damage to the structures.

However, when blasting is prohibited for any reasons, the excavation shall be carried out by chiselling, wedging or any other agreed method.

#### **15.8.5 MISFIRE**

In case of misfire, the following procedure shall be observed:

- i) Sufficient time shall be allowed to account for the delayed blast. The man in charge shall inspect all the charges and determine the missed charges.
- ii) If it is the blasting powder charge it shall be completely flooded with water. A new hole shall be drilled at about 45 cm. from the old hole and fired. This should blast the old charge. Should it not blast the old, the procedure shall be repeated till the old charge is blasted.

- iii) If a misfire has been found to be due to defective detonator, the whole quantity in the box from which defective article was taken must be sent to the authority directed by the Project Manager for inspection to ascertain whether all the remaining materials in the box are also defective.

#### **15.8.6 ACCOUNT.**

A careful and day to day account of the explosives shall be maintained by the Contractor in an approved register and manner which shall be open to inspection by the Engineer-in- Charge at all times.

#### **15.9 RECORDING OF MEASUREMENTS**

The ground levels shall be taken at every 5 metres distance and at closer distances where pits, undulations, etc. are met with. The ground level shall be recorded in field book, plotted on plans, and shall be signed by contractor and the Project Manager before the earth work is started.

The levels of the area after excavation shall be recorded in the field book duly signed by the Project Manager and contractor. The labour, materials, tools, equipment, safeguards, and incidentals required for taking levels shall be supplied by the contractor at his own cost.

All measurements shall be made in the metric system. Different items of work shall be measured in accordance with the procedures set forth in the relevant sections.

All measurements and computations, unless otherwise indicated, shall be carried nearest to the following limits:

- a) Length and breadth -- 10 mm
- b) Height, depth, or thickness of work -- 5 mm
- c) Area -- two places of decimal
- d) Cubical qty. -- two places of decimal

#### **16.0 MODE OF MEASUREMENT**

Mode of measurement for different items is given below, however, in case of any ambiguity relevant part of IS: 1200 (latest) shall be referred.

#### **16.1 EARTHWORK**

This shall include excavation in all kinds of soil including rock, all leads and lifts including back filling, compacting, dewatering (if required) and disposal of surplus earth/ rock to a suitable location within a lead up to two km. Excavation or dismantling of lean concrete shall be measured under this item. The quantity of excavation for foundations of towers, equipment structures, all transformers, firewall, cable trenches, water tank, reactors, buildings, marshalling kiosks, underground water tanks and covered car parking shall only be measured. The quantity of excavation for roads, rail cum road, drains, culverts, rainwater harvesting, septic tank, soak pit, external water supply system, site surfacing, chain link fencing (including gate) shall not be measured separately and shall be deemed to be included in the composite rates quoted by the bidder for the respective works. All other excavation required for the completion of the work including fixing of lamp posts/ electric poles, plinth protection, flooring, sewerage system, manholes, pipes, earth mat, pipe support etc. shall also not be paid for. The measurement of excavation for all concrete works shall be made considering dimension of the pit keeping 150mm gap around the base pad (lean concrete) or excavated pit, whichever is less. For hard rock excavation, the volume of hard rock shall be computed based on stacks of excavated rubble after making 50% deduction for voids. The unit of measurement shall be in cubic meter. The unit rate shall

include stacking, disposal of excavated material for leads up to 2000 meters beyond the levelling boundary.

The quantity shall be measured in cubic meters as per following details:

- a) Excavation in all kinds of soil including soft/ disintegrated rock, PCC, WBM, Brickwork/ stone masonry etc (excluding hard rock).
- b) Excavation in hard rock (required blasting)

#### **16.2 PLAIN CEMENT CONCRETE (PCC)**

Providing and laying Plain Cement Concrete of all types and at all locations including all leads and lifts. The quantity shall be measured in cubic meters as per lines and levels indicated in the drawings.

**16.2.1** PCC 1:2:4 (1 cement: 2 fine aggregate: 4 coarse aggregate 20 mm nominal size) shall be measured in flooring of buildings, plinth protection, fencing, transformer foundation, reactor foundation, rail track, drain, culverts, septic tank, chain link fencing, gate etc. as indicated in the drawings.

**16.2.2** PCC 1:3:6 (1 cement: 3 fine aggregate: 6 stone aggregate, 40mm nominal size) shall be measured below all foundations including buildings, underground water tanks, covered car parking cable trench, roads, under flooring, rail-cum-road, transformer foundation, reactor foundation, drain, water tank, culverts, gate, tower/equipment etc. as indicated in the drawings.

**16.2.3** PCC 1:4:8 (1 cement: 4 fine aggregate: 8 stone aggregate, 40mm nominal size) shall be measured below all foundations including buildings, underground water tanks, covered car parking cable trench, roads, under flooring, rail-cum-road, transformer foundation, reactor foundation, drain, water tank, culverts, gate, tower/equipment etc. as indicated in the drawings.

**16.2.4** PCC 1:5:10 (1 cement: 5 fine aggregate: 10 brick aggregate/ stone aggregate 40mm nominal size) shall be provided for site surfacing in switchyard. This shall include providing and laying cement slurry in case of site surfacing in switchyard.

All other PCC required for the completion of the work including hold fasts of doors/windows/rolling shutters, fixing of plumbing pipes, bedding concrete for sewer lines, embedment of electrical conduits, water proofing of roof etc. shall not be measured and deemed to be included in the composite rates quoted by the bidder for respective works. Water proofing compound wherever specified shall be added without any extra cost.

#### **16.3 RCC**

Measurement of reinforced cement concrete at all locations shall be made and shall include all leads, lifts, formwork, grouting of pockets and underpinning. This shall also include pre-cast RCC work, and addition of water proofing compound & admixtures wherever required for which no additional payment shall be made. The quantity shall be measured in cubic meters as per lines and levels indicated in the drawings. No deduction shall be made for volume occupied by reinforcement/inserts/sleeves and for openings having cross-sectional area up to 0.1 sq.m.

#### **16.4 REINFORCEMENT STEEL**

Reinforcement shall be measured in length (actual or theoretical as per drawing whichever is less) including hooks, if any, separately for different diameters as actually used in work, excluding overlaps. From the length so measured, the weight of reinforcement shall be calculated in tons on the basis of sectional weights as adopted by Indian Standards. Wastage, overlaps, couplings, welded joints, spacer



bars, chairs, stays, hangers and annealed steel wire or other methods for binding and placing shall not be measured and cost of these items shall be deemed to be included in the rates for reinforcement.

#### **16.5 STONE FILLING**

Measurement of stone (40-60mm size) for transformer/ reactor foundations shall be made as per theoretical volume of the space to be filled in the transformer foundation as per drawings. This shall be measured in cum. no voids shall be deducted.

#### **16.6 MISCELLANEOUS STRUCTURAL STEEL**

Measurement for Supply, fabrication, transportation, and erection of all miscellaneous structural steel work for monorails (RS joists), rails for transformers/ reactors, trusses, framework, purlins, gratings including factory made electro forged gratings, steel tubes, built up sections along with all other steel fittings and fixtures, inserts and embedment in concrete shall be made as per drawings. The unit rate for this item shall be inclusive of cutting, grinding, drilling, bolting, welding, pre- heating of the welded joints, applying a priming coat of steel primer / anti corrosive bitumastic paint/ synthetic enamel paint etc. wherever specified (For gratings and its supports epoxy zinc phosphate primer shall be used) setting of all types of embedment in concrete, etc. Steel required for foundation bolts & fasteners (other than towers and equipment support structures), doors, windows, ventilators, louvers, rolling shutters, chain link fencing, gratings in drains, soil pipes, plumbing pipes, floor traps, embedment's required for rainwater harvesting, septic tank, soak pit, roof truss and purlins required for fire water tank, steel structures of PEB buildings, etc. shall not be considered for payment and measurements. Quantity shall be measured in MT.

#### **16.7 ROADS**

**19.7.1** The measurement for the concrete road shall be made on the basis of area in square meter ( $M^2$ ) of top concrete completed surface of the road and shall be deemed to include all items such as earth work (excavation, disposal etc.), compaction, rolling, watering, WBM, Kerb stone, grating, shoulder, 100mm dia RCC Hume pipe to be provided at every 100M etc where ever indicated complete as per drawing. Concreting all type and reinforcement shall be measured and paid separately under relevant items mentioned elsewhere in this specification. Usage of WMM in place of WBM shall be done with approval of employer without any additional financial implication.

**16.7.2** Interlocking concrete tiles required to be provided on the shoulders of the road shall be measured in square meter ( $M^2$ ) and paid separately under relevant item.

#### **16.8 ANTIWEED TREATMENT**

The measurement shall be done for the actual area in square metres of antiweed treatment which will include supplying required chemicals and doing the treatment complete in all respect as per the specification for the specified area.

#### **16.9 STONE SPREADING IN SWITCHYARD**

The measurement shall be done for the actual area in square meters of stone spreading in the switchyard which will include supplying and laying of stone aggregate as per specification for the specified area. The thickness of stone layer will solely depend on Earth-mat design and any variation in the Thickness of gravel will be in the account of Contractor.

#### **16.10 CABLE TRENCH CROSSING AND ROAD CULVERTS THROUGH HUME PIPES**



Cable trench crossings and road culverts shall be measured by length (in running meters) of individual Hume pipe which will be laid as per the drawings. The item shall be inclusive of earth work (excavation, backfilling, disposal etc.), laying, back filling, jointing, brickwork, plastering etc complete in all respect but excluding concrete (all type) which will be measured and paid separately under respective items.

#### **16.11 RAIL CUM ROAD**

The measurement for the rail cum road shall be made in square metres of top concrete completed surface of the rail cum road and shall include all items such as earth work (excavation, backfilling, disposal etc.), compaction, rolling, watering, WBM etc. complete as per drawing but excluding concrete (all type), reinforcement, structural steel, and rails. Usage of WMM in place of WBM shall be done with approval of employer without any additional financial implication.

#### **16.12 CABLE TRENCHES:**

Various items like earth work (excavation, backfilling, disposal etc.), concrete (all type), reinforcement steel and miscellaneous steel required for construction of cable trenches shall be measured and paid under respective clauses mentioned above.

#### **16.13 DRAINS:**

The item Concrete (all type) & Reinforcement for drains shall be measured under relevant clauses as mentioned above. All other items required for completion of drains shall be seemed to be included in the rate of items quoted for the drain. The quantity for each type of drain section shall be measured in meters along the centre line of drain.

#### **16.14 SOIL TREATMENT:**

CNS or sand filling or boulder packing with interstices filled with sand under or sides of the foundations, roads, cable trenches, drains etc shall be measured in cubic meters.

#### **16.15 PILE FOUNDATION:**

**16.15.1** For payment purpose pile of different diameter shall be measured separately in length (running meter) from bottom of pile cap to the lowest point of pile. The rate shall include boring, providing and installation including temporary casing as applicable etc. complete in all respect except for concrete and reinforcement steel which will be paid separately under relevant items of BPS. Initial and routine test for vertical load and lateral load shall be payable under respective items of BPS.

**16.15.2** In case pile foundation is not envisaged originally in the LOA then concrete and reinforcement steel shall be measured and paid as per items mentioned under relevant clauses as mentioned above. Boring installation including temporary casing, bentonite treatment, initial and routine tests etc of pile will be paid as an extra item. In case extra quantity of cement is required to meet the provisions of IS: 2911, it will be paid as an extra item.

#### **16.16 CONTRACTOR DESIGNED FOUNDATIONS:**

Contractor designed foundations shall be measured {quantity of earth work (excavation, backfilling, disposal etc.), PCC, RCC, reinforcement} and paid as per relevant clauses as mentioned above, unless otherwise specified.

**16.17** Civil works for Pipe supports and deluge valve housing for firefighting shall be deemed to be included in the items for firefighting and shall not be paid under civil works.

**16.18 SITE LEVELLING:**

**16.18.1 EARTH WORK IN EXCAVATION AND FILLING**

The quantity of excavation in all types of soil and soft/disintegrated rock shall be worked out by using initial and final levels. No void deduction shall be made to calculate net quantity of earth work. Only Excavation/cutting will be measured for payment purpose. The unit of measurement shall be in cubic metre.

In case hard rock is encountered during excavation, the level of rock surface before start and completion of rock excavation shall be recorded for calculating the quantity of excavation of hard rock. The volume of hard rock shall be computed on the basis of stacks of excavated rubble after making 50 % deduction for voids. The item of excavation in hard rock shall be payable separately.

The quantity of earth work in excavation in all kinds of soil & soft/disintegrated rock shall be arrived by reducing quantity of hard rock from the gross excavated quantity.

The unit rate shall include all lifts and all leads within levelling boundary. It also includes disposal of surplus earth and stacking of unusable material up the lead of 2000 meters beyond the levelling boundary. Rate of item shall include all operations specified in the respective clause of technical specification.

**16.18.2 EARTH WORKS IN EXCAVATION IN ALL TYPES OF SOILS AND SOFT /DISINTEGRATED ROCKS, HARD ROCKS, AND DISPOSAL.**

Quantity of excavation in all type of soils and soft/disintegrated rocks shall be worked out based on initial level before start of excavation and final levels after excavation. No void deduction shall be made to calculate net quantity of earth work in excavation. The excavated soil and soft/disintegrated rock shall be used for filling in lower areas of the substation. The unit rate shall include disposal of excavated material for leads up to 1000 meters beyond the levelling boundary. For hard rock excavation, the volume of hard rock shall be computed based on stacks of excavated rubble after making 50% deduction for voids. The unit of measurement shall be in cubic meter. The unit rate shall include stacking, disposal of excavated material for leads up to 2000 meters beyond the levelling boundary. Where soil, soft/disintegrated rock and hard rock are mixed, the quantity of earth work in excavation in all kinds of soil & soft/disintegrated rock shall be arrived by reducing quantity of hard rock from the gross excavated quantity. Rate of item shall include all operations specified in the respective clause of technical specification.

**16.18.3 FILLING USING EARTH BORROWED FROM OUTSIDE THE SUBSTATION LAND**

For borrowed earth, the measurement shall be based on levels of area under filling only. The quantity of earth shall be worked out based on initial and final levels of levelling area. No void deduction shall be made to calculate net quantity of earth work. The unit of measurement shall be in cubic meter. The rate shall include arrangement of borrow area, payment of royalty, transportation, laying compaction, all leads and lifts etc. Rate of item shall include all operations specified in the respective clause of technical specification.

## **SECTION: STRUCTURE**

### **1.0 GENERAL**

The scope of specification covers design, fabrication, proto assembly, supply, and erection of galvanized steel structures for towers, girders, lightning masts, and equipment support structures. Structures shall be lattice or Pipe type structure fabricated from structural steel conforming to relevant Indian standard Codes (IS Codes).

Contractor shall design and develop design/drawings for Towers, girders, Lightning mast, equipment support structures for 400/220kV structures and get approved by Employer. The bidder shall mention in their bid for the type of proposed structure i.e., Pipe or lattice type structure. The fabrication drawings, proto corrected drawings along with Bill of Material (BOM) for all the structures (Both Gantry and Equipment support structures) shall be prepared by the contractor during detailed engineering for submission to Employer for their approval. Support structure for circuit breaker shall also be designed by the Contractor. Contractor is expected to design the equipment support structures with the provision of stool. Stools shall be provided by the Contractor between the equipment and its support structure to match the bus bar height. The top of stool shall be connected to the equipment and the bottom of the stool shall be connected to the Base support structure.

The scope shall include supply and erection of all types of structures including bolts, nuts, washers, step bolts, inserts in concrete, gusset plates, equipment mounting bolts, structure earthing bolts, foundation bolts, spring washers, fixing plates, ground mounted marshalling boxes (AC/DC Marshalling box & equipment control cabinets), structure mounted marshalling boxes and any other items as required to complete the job.

The connection of all structures to their foundations shall be with base plates and embedded anchor/foundation bolts. All steel structures and anchor/foundation bolts, fasteners (Nuts, bolts, washers) shall be fully galvanized as per relevant Indian standard Codes (IS Codes). The weight of the zinc coating shall be at least 610 grams /sq. m 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. Contractor shall provide suitable arrangement on the equipment support structures wherever required to suit fixation of accessories such as marshalling boxes, MOM boxes, Control Cabinets, Junction box, surge counter, etc. in the equipment structure fabrication drawings.

### **2.0 DESIGN REQUIREMENTS FOR STRUCTURES**

2.1 For design of steel structures loads such as dead loads, live loads, wind loads etc. shall be based on relevant Indian standard Codes (IS Codes). Wind speed to be considered as per Wind map in National Building Code – 2016 (Volume-I) for all built-up structures in substation.

2.2 For materials and permissible stresses, relevant Indian standard Codes (IS Codes). Shall be followed in general. However, additional requirements given in following paragraphs shall be also considered.

2.3 Minimum thickness of galvanized lattice structure member shall be as follows:

Members Min Thickness	(mm)
Leg members, Ground wire	5
Peak members/Main members	5
Other members	4
Redundant members	4

2.4 Maximum slenderness ratios for leg members, other stressed members and redundant members for compression force shall be as per relevant Indian standard Codes (IS Codes).

2.5 Minimum distance from hole centre to edge shall be  $1.5 \times$  bolt diameter. Minimum distance between centre to centre of holes shall be  $2.5 \times$  bolt diameter.

2.6 All bolts shall be M16 or higher as per design requirement.

## **2.7 Step Bolts**

To facilitate inspection and maintenance, the tower structures shall be provided with climbing devices. Each tower shall be provided with M16 step bolts 175mm long spaced not more than 450mm apart, staggered on faces on diagonally opposite legs extending from about 0.5 meters above plinth level to the top of the tower. The step bolt shall conform to relevant Indian standard Codes (IS Codes). Ladders along with safety guard shall be provided for the Lightning Mast Tower.

## **2.8 Design Criteria**

- a) All gantry structures shall be designed for the worst combination of dead loads, live loads, wind loads and Seismic forces as per relevant Indian standard Codes (IS Codes). (latest), 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. Relevant Indian standard Codes (IS Codes) may be followed for evaluation of short circuit forces.
- b) Switchyard gantry structures shall be designed for the two conditions i.e., normal condition and short circuit condition. In both conditions the design of all structures shall be based on the assumption that stringing is done only on one side i.e., all the three (phase) conductors broken on the other side. Factor of safety of 2.0 under normal conditions and 1.5 under short circuit condition shall be considered on all external loads for the design of switchyard structures.
- c) Vertical load of half the span of conductors/string and the earth wires on either side of the beam shall be taken into account for the purpose of design. Weight of man with tools shall be considered as 150 kgs. for the design of structures.
- d) The distance between terminal gantry and dead-end tower shall be taken as approximate 200 meters for 400/220kV switch yard. The design of these terminal gantries shall also be checked considering  $\pm 30$  deg deviation of conductor in both vertical and horizontal planes. For other gantries the structural layout requirements shall be adopted in design.
- e) The girders / beams shall be connected with lattice/Tower columns by bolted joints.
- f) All equipment support structures 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 relevant Indian standard Codes (IS Codes).
- g) If luminaries are proposed to be fixed on gantries/towers, then the proper loading for the same shall be considered while designing. Also holes for fixing the brackets for luminaries should be provided wherever required.
- h) Foundation bolts shall be designed for the loads for which the structures are designed.

- i) The height of Lightning Mast shall be as per approved structural layout and designed for diagonal wind condition. The lightning mast shall be provided with platform for mounting of lighting fixtures and a structural steel ladder within its base up to the level of platform. The ladder shall be provided with protection rings the platforms shall also have protection railing. The details of lighting fixtures would be as per approved drawings of electrical fixtures.

### **3.0 DESIGN, DRAWINGS, BILL OF MATETRIALS AND DOCUMENTS**

3.1 The Contractor shall submit design and line diagram of each structure for approval of Employer. Fabrication drawing based on approved line diagram shall be prepared by the contractor for approval of Employer. The BOM (Bill of Material) shall be prepared by the contractor based on approved fabrication drawing. The Line diagram should indicate not only profile, but section, numbers and sizes of bolts and details of typical joints. In case Employer feels that any design or drawings are to be modified even after its approval, Contractor shall modify the designs & drawings and resubmit the same for approval.

3.2 The fabrication drawings shall indicate complete details of fabrication and erection including all erection splicing details and typical fabrication splicing details, lacing details, weld sizes and lengths. Bolt details and all customary details in accordance with standard structural engineering practice. The fabrication drawing and bill of material based on design/line diagram shall be submitted to Employer for approval. Approved bill of materials prepared on the basis of fabrication drawing shall be the basis for payment.

3.3 Such approvals shall, however, not relieve the contractor of his responsibility for safety and durability of the structure and good connection and any loss occurring due to defective fabrication, design or workmanship shall be borne by the contractor.

3.4 The contractor shall submit editable soft copy of all designs preferably in Staad / excel form and drawings in AutoCAD to Employer. The list of Indian standard codes relevant to steel structures have been given in Civil section of technical specification, the list is illustrative but not exhaustive. The contractor shall submit the copy of relevant portion of IS codes referred to Employer for reference if necessary, during detailed engineering stage.

### **4.0 FABRICATION AND ERECTION**

4.1 The fabrication and erection works shall be carried out generally in accordance with relevant Indian standard Codes (IS Codes). All materials shall be completely shop fabricated. and finished with proper connection material and erection marks for ready assembly in the field.

4.2 The component parts shall be assembled in such a manner that they are neither twisted nor otherwise damaged and shall be so prepared that the specified camber, if any, is provided. In order to minimize distortion in member the component parts shall be positioned by using the clamps, clips, dogs, jigs and other suitable means and fasteners (bolts and welds) shall be placed in a balanced pattern. If the individual components are to be bolted, paralleled and tapered drifts shall be used to align the part so that the bolts can be accurately positioned.

4.3 Sample towers, beams and lightning masts and equipment support structures may be proto assembled in the fabrication shop to ensure fitment of various members and to avoid problems during erection. It is the sole responsibility of contractor to ensure the member fitment at site.

4.4 For all structures, BOM along with fabrication drawings in hard and editable soft copies shall be submitted to Employer as document for information. The responsibility of correctness of such fabrication drawing and BOM shall be fully with the contractor.

4.5 Approval of fabrication drawings and BOM shall, however, not relieve the Contractor of his responsibility for the safety and durability of the structure and good connections and any loss or damage occurring due to defective fabrication, design or workmanship shall be borne by the Contractor.

4.6 The Contractor should arrange on his own all plant and equipment, welding set, tools and tackles, scaffolding, trestles equipment's and all other accessories and ancillaries required for carrying out erection without causing any stresses in the members which may cause deformation and permanent damage. Minor modification if any, required during erection shall be done at site with the approval of Employer.

## **5.0 BOLTING**

- a) 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.
- b) In case of fasteners, the galvanizing shall confirm to relevant Indian standard Codes (IS Codes). The spring washer shall be electro galvanized as per relevant Indian standard Codes (IS Codes).

## **6.0 WELDING**

The work shall be done as per approved fabrication drawings which shall clearly indicate various details of joints to be welded, type of weld, length and size of weld, Symbols for welding on erection and shop drawings shall be according to relevant Indian standard Codes (IS Codes). Welding shall be carried out in accordance with relevant Indian standard Codes (IS Codes) /

## **7.0 FOUNDATION BOLTS**

7.1 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.

7.2 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.

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

7.4 All foundation bolts shall be fully galvanised so as to achieve minimum 610 grams Per Sq. m. of Zinc Coating as per relevant Indian standard Codes (IS Codes).

7.5 All foundation bolts and its material shall conform to relevant Indian standard Codes (IS Codes). All foundation bolts shall be provided with two number standard nuts, one check nut, one plain washer and MS plate at the bottom of foundation bolt.

## **8.0 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.

## **9.0 GROUTING**

The method of grouting the column bases shall be subject to approval of Employer and shall be such as to ensure a complete uniformity of contact over the whole area of the steel base. No additional payment for grouting shall be admissible.

## **10.0 GALVANISING**

10.1 All structural steel works (Gantry structures, Equipment support structures) and foundation bolts shall be galvanized after fabrication. The galvanization shall be done as per requirement relevant Indian standard Codes (IS Codes).

10.2 Zinc required for galvanizing shall have to be arranged by the Contractor/manufacturer. Purity of zinc to be used shall be 99.95% as per relevant Indian standard Codes (IS Codes).

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

## **11.0 TOUCH-UP PAINTING**

Minor defects in hot dip galvanized members shall be repaired by applying zinc rich primer and two coats of enamel paint to the satisfaction of Employer before erection.

## **12.0 INSPECTION BEFORE DISPATCH**

Each part of the fabricated steel work shall be inspected as per approved quality plans and certified by Employer or his authorized representative as satisfactory before it is dispatched to the erection site. Such certification shall not relieve the Contractor of his responsibility regarding adequacy and completeness of fabrication.

## **13.0 TEST CERTIFICATE**

Copies of all test certificates relating to material procured by the Contractor for the works shall be submitted to Employer.

## **14.0 MODE OF MEASUREMENT**

The measurement of the structure, fasteners (Nuts, Bolts, and Washers) and foundation bolts including its nuts washers and MS Plate at bottom shall be done as per Bid price schedule (BPS). The weight of all structural members, fasteners, step bolts and foundation bolts (Bolt, Nuts, washer, and MS steel plates welded at bottom of bolt) shall be measured under one head in Metric Tonne.



### **15.0 SAFETY PRECAUTIONS**

The Contractor shall strictly follow all precautions at all stages of fabrication, transportation, and erection of steel structures. The stipulations contained in relevant Indian standard Codes (IS Codes) for Safety during erection of structural steel work shall also be adhered to.

### **16.0 MANUFACTURING QUALITY PLAN**

The material specification shall also be as per relevant Indian standard Codes (IS Codes). The Contractor shall prepare the manufacturing quality plan to accept/check the material, galvanization, and welding as per relevant IS codes within 1 month after award of work and submit the same to Employer for approval.