SECTION-IVD

CONTRACTOR DESIGN FOUNDATIONS

(Applicable for Transmission Lines wherein Foundation Design is in Contractor's scope)

TECHNICAL SPECIFICATIONS

SECTION-IV D

CONTRACTOR DESIGN FOUNDATIONS

Revision History

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TECHNICAL SPECIFICATIONS

SECTION-IV D

CONTRACTOR DESIGN FOUNDATIONS

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TECHNICAL SPECIFICATIONS

SECTION- IV D

CONTRACTOR DESIGN FOUNDATIONS

1.1 Foundations

Foundation includes supply of all labour, tools & machineries, materials such as cement, sand, coarse aggregates and reinforcement steel and all associated activities, such as, excavation, concreting and back filling etc.

1.2 Type of Foundations

The foundation shall generally be of open cast type Reinforced Cement Concrete footing shall be used for all type of normal towers. The Bidder shall offer open type of foundation (i.e., slab and chimney) with maximum depth of foundation up to 3.5 meters for above classification of foundations depending on economy and feasibility of construction at site. However , Bidder may offer foundation depth up to 4.0 m in case of Dry type of foundation depending on economy and feasibility of construction at site with compatible stub. Further, for tower type DN/DDN/QDN (as mentioned in clause section 1.2.2 IVA)/special river crossing/anchor tower, the Bidder shall offer open type of foundation (i.e., slab and chimney) with maximum depth of foundation up to 5.0 meters (while taking proper safety precaution during excavation in line with IS 3764) for above classification of foundations, depending on economy and feasibility of construction at site with compatible stub. For Hard Rock type and also where specific site conditions/ properties demand foundation of different depths (lower or higher), the same shall be adopted. Minimum reinforcement as 0.12% of cross section area shall be provided in raft/ block of hard rock foundation. The raft/ block shall also satisfy the design criteria as per IS 456.

Bidder has to furnish along with the bid one sample calculation for assessment of present design capability of the Bidder.

1.3 Classifications of Foundations:

The foundation designs shall depend upon the type of soil, sub soil water level and the presence of surface water which have been classified as follows (except pile foundations which is described in relevant section of this specification).

1.3.1 Normal Dry

To be used for locations where normal dry cohesive or non-cohesive soils are met. Foundations in areas where surface water encountered from rain runoff shall also be classified as normal dry.

1.3.2 **Sandy Dry Soil**

To be used for locations where cohesion less pure sand or sand with clay content less than 10% met in dry condition. If the clay content is more than 10 % met in dry condition, the foundation shall be classified as Normal Dry.

1.3.3 **Wet**

To be used for locations where sub-soil water table is met between 1.5 meters from ground level and the depth of foundation below the ground level.

1.3.4 **Wet Cultivated**

To be used for locations where there is no sub-soil water within the foundation depth but which are in surface water for long period with water penetration not exceeding one meter below the ground level e.g. paddy fields/ cultivated field. However, if water penetration due to surface water is more than one meter below ground level, the adoption of suitable foundation shall be decided by site In-charge in consultation with Corporate engineering Department.

1.3.5 **Partially Submerged**

To be used at locations where sub-soil water table is met between 0.75 meter and 1.5 meter below the ground level.

1.3.6 **Fully Submerged**

To be used at locations where sub-soil water table is met at less than 0.75 meter below the ground level.

1.3.7 **Black Cotton Soil**

To be used at locations where soil is clayey type, not necessarily black in colour, which shrinks when dry and swells when wet, resulting in differential movement. For designing foundations, for such locations, the soil is considered submerged in nature.

1.3.8 **Fissured Rock**

To be used at locations where decomposed or fissured rock, hard gravel, kankar, limestone, laterite or any other soil of similar nature is met. Under cut type foundation is to be used for fissured rock locations.

In case of fissured rock locations, where water table is met at 1.5M or more below ground level, wet fissured rock foundations shall be adopted. Where fissured rock is encountered with subsoil water table less than 1.5 meter below ground level, submerged fissured rock foundations shall be adopted. In case of dry locations dry fissured rock foundations shall be adopted.

1.3.9 **Hard Rock**

The locations where chiseling, drilling and blasting is required for excavation for monolithic rock for a particular leg/tower, Hard rock type foundations are to be used. For these locations rock anchoring is to be provided to resist uplift forces.

For quoting prices of Hard Rock foundations, Rock level shall be assumed at 1.5 meters below the ground level. Due to change in Rock level, no extra payment shall be payable on account of increase in concrete volume, excavation volume and weight of reinforcement. Also, no recovery shall be made if the actual volume of concrete, excavation and weight of reinforcement are less than that quoted in Schedule of prices. However, for design purpose, Rock level shall be considered at ground level and no over burden soil weight shall be considered for resisting the uplift.

1.3.10 The sub-soil water table is not constant and its level changes during different seasons due to various factors. In case during soil investigation/ trial pit or during excavation, if wet soil/ fissures rock is encountered within the foundation depth, it is to be considered that water table has been encountered (considering that water table had reached that level sometime in past) and accordingly type of foundation shall be classified.

1.3.11 Where soil is of composite in nature, classification of foundation shall be according to the type of soil predominant in the foundation pit**.**

1.3.12 The foundation classification at any particular location shall be based on the type of soil (clay/ sandy/ silt/ fissured rock etc.) and water table, presence of surface water, etc. at the location. However, in case of locations which are in vicinity of rivers, depending upon case to case, type of foundation is to be decided considering other aspects also e.g. in case RL (reduced level) of a location in comparison to the HFL is lower and there is possibility of submergence at the time of floods due to absence of river bunds/ protection etc., FS type foundation with suitable raised chimney is to be adopted. Further in case there is a possibility of change in river course, considering the nature and turbulence of probable water flow and subsequent scouring of soil, pile type or special foundation may be considered for these locations.

1.3.13 In addition to above, if required, depending on the site conditions, special type foundations shall also be provided by the Contractor suitable for intermediate conditions under the above classifications to affect more economy for following reasons:

(a) Shallow Depth or Raised Chimney foundations are necessarily required to suit the site condition or

(b) Soil properties as per the soil report at particular location are found inferior/ superior to the properties specified in the bid documents and considered for normal foundation design.

1.3.14 The proposal for special foundations shall be submitted by the Contractor based on the detailed soil investigation report/ to suit site conditions and approval for the same shall be obtained from the Employer. Decision of the Employer shall be final and binding with respect to requirement of special foundation. In case of Special foundations, payment for installation of stub shall be made on pro-rata basis of installation rate of approved stub weight of normal tower up to +9m extension.

1.3.15 During execution of the Line, if foundation for other types of towers/ structures viz Gantry, single circuit/ Multi circuit towers in Double circuit line, Double circuit/ Multi-circuit towers in a Single circuit line, Single circuit/ Double circuit towers in a Multi circuit line, Narrow base towers, Towers of higher extensions (viz. +43m/ +55 m for 765kV D/C lines wherever applicable), Towers of different configuration, etc. are required, for which design is not in the scope of Contractor**,** supply & all works associated for installation of these shall be carried out by the contractor as per Employer supplied design/ drawings.

If Employer designed towers are not covered in the BPS, Payment for these, shall be made on mutually agreed rates to be derived on the basis of rates available in the Contract during execution stage.

1.3.16 Design and Casting of Foundations for Contractor design towers including Raised Chimney foundations, which are not specified in the Final BPS of the Contract Agreement, but required during execution of the project and authorised by the Employer, shall have to be carried out by the Contractor. No additional payment on account of Design charges shall be payable. Payment for execution of such foundations shall be made on mutually agreed rates to be derived on the basis of rates available in the Contract during execution stage.

1.4 Soil Investigation

The contractor may be required to undertake soil investigation as per *clause 4.0 of Section-3* at tower locations as required by the Employer. The bearing capacity of soil is to be derived from both shear and settlement criteria. The total permissible settlement of soil may be considered as 50 mm in case of suspension towers and 40 mm in case of tension towers for determining bearing capacity of soil from settlement criteria. The provisional number of soil testing locations is furnished in Schedule of Prices. However, contractor shall take reference to the soil investigations wherever already carried out by the Employer.

1.5 Design of Foundations

Design of foundations as classified under *Clause 1.3* for all towers and towers with extensions shall be developed by the Contractor based on the standard soil properties of the concerned state and shall be submitted for approval of Employer, irrespective of the actual site requirement. However, delay in submission/approval of foundation designs/drawings which are not required for project execution, shall not be considered for Liquidated damages (LD) calculation. Charges for the same are deemed to be included in the quoted prices.

The indicative shape of foundation is enclosed in this specification. In case of normal foundation, minimum clearance between chimney concrete level and ground level shall be 225 mm. Based on specific site condition to avoid rusting of stubs, foundation with 500 mm clearance between concrete level and ground level may be used on case to case basis as may decide by Site In-charge.

1.5.1 **Loads on Foundations**

1.5.1.1 The foundations shall be designed to withstand the specific loads of the superstructure and for the full footing reactions obtained from the structural stress analysis in conformity with the relevant factors of safety.

1.5.1.2 The reactions on the footings shall be composed of the following type of loads for which these shall be required to be checked:

a) Maximum Tension or uplift along the leg slope.

b) Maximum Compression or down-thrust along the leg slope.

c) Maximum Horizontal shear or side thrust.

1.5.2 **Stability Analysis**

1.5.2.1 In addition to the strength design, stability analysis of the foundation shall be done to check the possibility of failure by over-turning, uprooting, sliding and tilting of the foundation.

1.5.2.2 The following primary types of soil resistance shall be assumed to act in resisting the loads imposed on the footing in earth:

A) Resistance Against Uplift

The uplift loads will be assumed to be resisted by the weight of earth in an inverted frustum of a conical pyramid of earth of this Section on the footing pad whose sides make an angle equal to the angle of repose of the earth with the vertical, in average soil. The weight of concrete embedded in earth and that above the ground will also be considered for resisting the uplift. In case where the frustum of earth pyramids of two adjoining legs super-impose each other, the earth frustum will be assumed truncated by a

vertical plane passing through the centre line of the tower base. In case of foundation with undercut, resistance provided by weight of earth in an inverted frustum of a conical pyramid shall be increased by 25 %. This shall also be applicable for stability analysis check for over turning in case of foundation with undercut.

B) Resistance Against Down Thrust

The down-thrust loads combined with the additional weight of concrete above earth will be resisted by bearing strength of the soil assumed to be acting on the total area of the bottom of the footings.

C) Resistance Against Side-Thrust

The lateral load capacity of a chimney foundation shall be based on chimney acting as a cantilever aided by passive earth resistance developed 500 mm below the ground level.

The chimney shaft shall be reinforced for the combined action of axial force, tension and compression and the associated maximum bending moment. In these calculations, the tensile strength of concrete shall be ignored. The contribution of stub for chimney design may be considered as per latest CBIP Manual. However, if the contribution of stub is considered, the yield stress of stub shall be restricted to 250 N/mm2.

The increase in vertical toe pressure due to maximum bending moment at the bottom of the slab shall be taken into account and the base itself shall be designed for structural adequacy. In this case, the allowable vertical toe pressure may be increased by 25%. The unit weight of reinforced concrete is stipulated in ***Table 2-2***.

1.6 Design Criteria

1.6.1 As per IS 456: 2002 Partial safety factor shall be considered 1.5 for concrete and 1.15 for steel.

1.6.2 The overload factors for open type foundations shall be as 1.1 i.e. all the reactions (compression, tension and side thrust) on foundations shall be increased by 10 percent for development of foundation design.

1.6.3 The physical properties of soil under various conditions are furnished in ***Table 2.1*** to be considered for the design of foundations. These types of foundations correspond to list of foundations furnished in Schedule of prices.

1.6.4 The composite rate shall be paid to the contractor for above foundations irrespective of approved design volumes except for Gantry, Single circuit & Multi circuit towers, not specified in BPS, for which payment shall be made on mutually

agreed rates to be derived on the basis of rates available in the Contract during execution stage. Further, once the foundations are classified based on the preponderant soil, extra claim is not admissible for excavation in different kinds of soil encountered inside the pit.

It may be noted that the soil properties furnished in ***Table 2.1*** are standard for respective states. However, after soil investigations, if it is found that the foundations listed in Schedule of Prices Vol. III cannot be used at that location; new foundation design shall be developed by the Contractor based on properties furnished in soil report. No additional payment on account of Design charges shall be payable.

Any such foundations required during execution of the project and authorised by the Employer, shall have to be carried out by the Contractor for which payment shall be made on mutually agreed rates to be derived on the basis of rates available in the Contract during execution stage.

1.6.5 The foundation shall be designed such as to satisfy the following conditions:

1.6.5.1 The thickness of concrete in the chimney portion of the tower footing shall be provided with minimum cover of not less than 100 mm from any part of the stub angle to the nearest outer surface of the concrete in respect of all dry locations limiting the minimum section of chimney to 300 mm square. In respect of all wet locations, the chimney should have all around clearance of 150 mm from any part of stub angle limiting the minimum section of chimney to 450 mm square.

1.6.5.2 The chimney top or muffing must be at least 225 mm above ground level and also the coping shall be extended up to lower most joint level between the bottom lattices and the main corner legs of the tower. Effective length of 1.5 times the unsupported length shall be considered for evaluating the slenderness ratio of chimney.

1.6.5.3 The centroidal axis of slab shall coincide with the axis of the chimney and pass through the center of foundation base. The design of the foundation (base slab and its reinforcement) shall take into account the additional stresses in the foundation resulting from the eccentricity introduced due to non-compliances of this requirement.

1.6.5.4 In case of RCC type foundations, the frustum can be single or multi stepped. The thickness of bottom slab (including slopped slab portion) should not be less than 300 mm. The bottom portion of minimum 100 mm thickness of the slab shall have vertical sides and balance portion shall have 45° slope as indicated in drawing enclosed in the bidding documents.

1.6.5.5 The minimum distance between the lowest edge of the stub angle and the bottom surface of concrete footing shall not be less than 100 mm or more than 150 mm

in case of dry locations and not less than 150 mm or more than 200 mm in case of wet locations.

1.6.5.6 The total depth of open type foundations below the ground level (including lean concrete pad) shall not be less than 1.5 meters and more than 3.5 meters.

1.6.5.7 The portion of the stub in the slab shall be designed to take full down-thrust or uplift loads by the cleats combined with the bond between stub angles and slab concrete. The Contractor shall furnish the calculation for uprooting of stub along with the foundation design. Bolted cleat angles evenly spaced in sets of 4 along all sides of embedded portion of the stub shall be provided to act as shear connector with sufficient number of bolts.

1.6.5.8 In case of R.C.C. foundations having steel reinforcement in base slab, at least 50 mm. thick pad of lean concrete corresponding to 1:3:6 nominal mix shall be provided below the bottom slab.

1.6.5.9 The base slab of the foundation shall be designed for additional moments due to eccentricity of the loads.

1.6.5.10 The additional weight of concrete in the footing below ground level over the earth weight & full weight of concrete above the ground level in the footing and embedded steel parts will also be taken into account adding to the down thrust.

TABLE 2.1: Soil Properties

Sl. No	Properties of Soil	Ultimate Bearing Capacity in KN/M^2 (Kg/M^2)	Angle of Repose (Degree)
1	**For Normal Soil (UP, Uttarakhand, Haryana, Delhi, Bihar, Jharkhand, WB, MP, Chhattisgarh, Kerala, J&K, Ladakh, Assam, Andhra Pradesh, Telangana, Tamil Nadu)**		
	Normal Dry Soil	268 (27350)	30
	Wet Soil Due to Presence of Subsoil/ Surface Water	134 (13675)/ 268(27350)	15
	Black cotton Soil Due to Presence of Subsoil/Surface water and dry condition	134 (13675)	0
	Sandy Soil	268 (27350)	20
2	**For Normal Soil (Rajasthan)**		
	Normal Dry Soil	268 (27350)	25
	Wet Soil Due to Presence of Subsoil/ Surface Water	134 (13675)/ 268(27350)	10
	Black cotton Soil Due to Presence of Subsoil/Surface water and dry condition	134 (13675)	0
	Sandy Soil	268 (27350)	20
3	**For Normal Soil (Maharashtra)**		
	Normal Dry Soil	490(50000)	30

	Wet Soil Due to Presence of Subsoil/ Surface Water	122.5 (12500)/ 490(50000)	10
	Black cotton Soil Due to Presence of Subsoil/ Surface Water and dry condition	122.5 (12500)	0
4	**For Normal Soil (Himachal Pradesh)**		
	Normal Dry Soil	196 (20000)	30
	Wet Soil Due to Presence of Subsoil/ Surface Water	98 (10000)/ 196 (20000)	15
	Black cotton Soil Due to Presence of Subsoil/ Surface Water and dry condition	98 (10000)	0
	Sandy Soil	196 (20000)	20
5	**For Normal Soil (Karnataka)**		
	Normal Dry Soil	214.5 (21870)	30
	Wet Soil Due to Presence of Subsoil/ Surface Water	107.2 (10935)/ 214.5 (21870)	15
	Black cotton Soil Due to Presence of Subsoil/ Surface Water and dry condition	107.2 (10935)	0
	Sandy Soil	214.5 (21870)	20
6	**For Normal Soil (Odisha)**		
	Normal Dry Soil	256.5 (26175)	30
	Wet Soil Due to Presence of Subsoil/ Surface Water	183.8 (18750)/ 256.5 (26175)	15
	Black cotton Soil Due to Presence of Subsoil/ Surface Water and dry condition	183.8 (18750)	0
	Sandy Soil	256.5 (26175)	20
7	**For Normal Soil (Punjab)**		
	Normal Dry Soil	264.6 (27000)	30
	Wet Soil Due to Presence of Subsoil/ Surface Water	132.3 (13500)/ 264.6 (27000)	15
	Black cotton Soil Due to Presence of Subsoil/ Surface Water and dry condition	132.3 (13500)	0
	Sandy Soil	264.6 (27000)	20
8	**For Normal Soil (Gujarat)**		
	Normal Dry Soil	268 (27350)	30
	Wet Soil Due to Presence of Subsoil/ Surface Water	134 (13675)/ 268(27350)	15
	Black cotton Soil Due to Presence of Subsoil/ Surface Water and dry condition	107.8 (11000)	0
	Sandy Soil	268 (27350)	20
9	Fissured Rock		
	a) Fissured rock in dry portion	613 (62500)	20
	b) Fissured rock in presence of water	613 (62500)	10
10	Hard Rock	1225.83 (125000)	

11	**Weight of earth for normal soil and black cotton soil**	**UNIT**	**VALUE**
	a) Dry	KN/M3 (Kg/M3)	14.12 (1440)
	b) In presence of Surface Water	KN/M3 (Kg/M3)	14.12 (1440)
	c) In presence of Subsoil Water	KN/M3 (Kg/M3)	9.22 (940)
12	**Weight of Fissured Rock**		
	a) Dry	KN/M3 (Kg/M3)	14.12 (1440)
	b) In presence of Subsoil Water	KN/M3 (Kg/M3)	9.22 (940)
13	**Ultimate bond between Steel & Grout for Hard Rock foundations**	KN/CM2 (Kg/CM2)	0.098 (10)
14	**Bond Stress for Hard Rock Foundation**		
	a) Between Hard Rock and Concrete	Kg/CM2	4.0
	b) Between Hard Rock and Grout	Kg/CM2	2.0

The above soil properties (except Ultimate Bond between Steel & Grout) of the earth will be measured by the Contractor at the various locations in conformity with the standard method of testing and the foundation design will be revised suiting the site conditions from such tests.

1.7 Properties of Concrete

The cement concrete used for the foundations shall generally be of grade M20 having 1:1.5:3 nominal volumetric mix ratio with 20 mm coarse aggregate graded downward for chimney portion and pyramid or slab portion. All the properties of concrete regarding its strength under compression, tension, shear, punching and bending etc. as well as workmanship will conform to IS 456.

Weigh batching in place of volumetric batching (1:1.5:3) as an alternative may be adopted. Further, use of self loaders viz Ajax Fiori / small portable weigh batcher may be permitted for batching and mixing of concrete, subjected to compliance of following: -

(i) Weight of cement, sand and aggregate equivalent to that of nominal mix of proportion 1:1.5:3 by volume basis shall be calculated. For finalisation of weight, average of 5 samples of cement, sand and aggregates shall be taken from measurement boxes. The volumetric conversions to the weight shall be noted and the same conversion shall be applied to the entire location.

(ii) For every change in source of sand/ aggregates, the weights shall be recorded.

(iii) The minimum cement content shall remains same i.e. 400 kg/m3.

(iv) Calibration certificate of self-loader/concrete producing equipment shall be checked before start of concreting works. The accuracy of the measuring equipment shall be within +/- 2% of the quantity of cement and within +/-3% of the quantity of aggregate.

(v) Preferably, print out of each load indicating weight of all the constituent's material i.e. Cement, Fine Aggregate, Coarse Aggregate, Water, Admixture (If

any) is to be ensured or proper records shall be maintained to ensure weight of constituents materials.

(vi) Necessary modification in weight of fine aggregate due to bulkage may be taken care in weigh batching. Water cement ration due to moisture content shall be suitably adjusted.

(vii) Concreting using RMC (Ready Mix Concrete) may also be carried out with weight ratio to be calculated as per S.No. (i) above.

1.7.1 The weight of concrete to be considered for design of foundations is given in ***Table 2.2.***

Table 2.2: Weight of Concrete

Type of concrete	**Weight of dry region KN/m³ (Kg/m³)**	**Weight in presence of sub-soil water KN/m³ (Kg/m³)**
Plain Concrete	21.96 (2240)	12.16 (1240)
Reinforced Concrete	23.54 (2400)	13.73 (1400)

1.7.2 The Quantity of minimum cement to be used per unit quantity of consumption for different mix (nominal mix) of concrete should be as follows:

Sl. No.	**Description**	**Unit**	**Quantity of Minimum cement to be used per Unit quantity of work (in kg)**
1.	1:1.5:3 nominal mix concrete	cum	400
2.	1:2:4 nominal mix concrete	cum	320
3.	1:3:6 nominal mix concrete	cum	220
4.	Random Rubble Masonry with 1:6 cement mortar	cum	83

In this regard utilisation record is to be maintained at site.

1..7.3 Alternatively, ready-mix concrete from batching plant as per IS 4925 can also be used with no extra payment and without any recovery. However, cement content shall be as per IS 456, unless otherwise specified herein. The ready-mix concrete shall conform to IS 4926. The selection and use of Materials for the ready-mix concrete shall be in accordance with IS 456. The concrete shall be of M25 grade

design mix as per IS 456. The transport of concrete and transportation time shall be as per IS 4926.

1.7.4 Ready-mix concrete of M25 grade design mix as per IS 456, shall be used for foundations of railway crossing locations.

1.7.5 Use of small batching machines/ self-loading mixers may be allowed after verification of cement consumption and mix by Employer site in-charge. The equipment shall have facility of checking the proportion of ingredients of concrete being made. The records of mix shall be maintained at site. The calibration of equipment shall be done at regular intervals.

1.7.6 Ready mix concrete of M25 grade shall be designed as per IS 456. However, minimum cement content shall not be less than 330 kg/m^3.

1.7.7 Cement used shall be ordinary Portland Cement, unless mentioned otherwise, conforming to the latest Indian Standard Code IS 269.

Alternatively, other varieties of cement other than ordinary Portland Cement such as Portland Pozzolana Cement conforming to IS 1489 (latest edition) or Portland Slag Cement conforming to IS 455 (Latest edition) can also be used. The Contractor shall submit the manufacturer's certificate, for each consignment of cement procured, to the Employer. However, Employer reserves the right to direct the Contractor to conduct tests for each batch/ lot of cement used by the Contractor and Contractor will conduct those tests free of cost at the laboratory so directed by the Employer. The Contractor shall also have no claim towards suspension of work due to time taken in conducting tests in the laboratory. Changing of brand or type of cement within the same structure shall not be permitted without the prior approval of the Employer. Sulphate Resistant Cement shall be used if Sulphate content is more than the limits specified in IS 456, as per Geotechnical investigation report.

Ordinary Portland Cement (OPC) and Portland Pozzolana Cement (PPC) or Portland Slag Cement are Technically Equivalent and there would not be any financial implication/ or recovery to be borne by Employer/ Contractor. However, the minimum cement content shall be as per above table for nominal mix concrete.

1.7.8 Coarse and fine aggregates shall confirm to IS 383.

1.7.9 The water used for mixing concrete shall be fresh, clean and free from oil, acids & alkalis, organic materials or other deleterious substances.

1.7.10 Reinforcement shall conform to IS 1786 for high strength steel bars (Fe 500/ Fe500D/ Fe 550 / Fe 550D). If mentioned in BPS, epoxy coated reinforcement conforming to IS 13620 shall be used. Thermo Mechanically Treated (TMT) bars

(equivalent grade) in place of cold twisted bars are also accepted. Hard drawn steel wire shall conform to IS 432. All reinforcement shall be clean and free from loose mill scales, dust, loose rust and coats of paint, oil or other coatings, which may destroy or reduce bond. Contractor shall supply, fabricate and place reinforcement to shapes and dimensions as indicated or as required to carry out the intent of approved foundation drawings and Specifications. The Contractor may also use pre-fabricated/ assembled reinforcement cage conforming to shape, dimension, size as per approved foundation drawing. Spacers, chairs, stays, hangers, overlaps/couplers and annealed steel wire for binding etc. as may be necessary, should be used for proper completion of the foundation job as per requirement. Spacers or chairs should be placed at a maximum spacing of 1m and closer spacing shall be provided wherever necessary.

1.7.11 Use of crushed stone in place of natural sand, in case of non-availability or restriction by local authority, may be allowed by Employer site in-charge subject to sieve analysis meeting acceptance criteria as per relevant IS and complying of other requirement as per standard field quality plan.

1.7.12 For foundation in coastal areas or creek or aggressive soil areas or under marine environment, if mentioned in BPS, Ready Mix Concrete of M30 Grade shall be used to avoid use of locally available saline water. However, design mix concrete of M30 Grade conforming to IS 456 with potable water can be used at locations where transportation of ready-mix concrete is not feasible. Minimum cement content in any case shall not be less than 330kg/m3. Plain concrete/lean concrete shall of grade M20 nominal mix 1:1.5:3.The surface of the reinforcement steel shall be treated with epoxy-based coating to enhance corrosion performance of foundation. Use of epoxy coated reinforcement in foundation shall be as per IS 13620. In addition, 02 (two) numbers of coats of bituminous painting of minimum 5 sq. m/litre per coat shall be applied on all the exposed faces of the foundation (i.e. pedestal & base slab). Double coat of total 20 mm thick cement plaster shall be provided on all exposed concrete surface as well up to 300 mm below ground level to give protection to concrete surface from environmental and saline effect. Before coping of chimney top portion, three coats of anti-corrosive paint of minimum 30-35 microns dry film thickness each shall be applied on the stub in the 50 mm coping portion as well as up to 350mm above CL portion. Cost of the above shall be deemed to be included in the rates quoted.

Corrosion resistant steel (CRS) of grade Fe500 / Fe 500D / Fe 550 / Fe 550D conforming to IS 1786 may be adopted as an alternative to epoxy coated reinforcement for foundation in coastal areas or creek or aggressive soil areas or under marine environment.

In case of foundation in coastal areas or creek or aggressive soil areas or under marine environment, Portland Pozzolana Cement (PPC) or Portland Slag Cement shall be used .

1.8 Measurement, Unit Rates and Payment for Foundation

1.8.1 Measurement

1.8.1.1 The indicative shape of foundations is enclosed in this Specification. The bidder is required to quote the unit rates for different foundation types for a particular tower in the relevant Price Schedule.

1.8.1.2 The concrete volume and dimensions of the foundation shall be determined from the drawing approved. Measurement of concrete volume shall be in cubic meters and shall be worked out to the second place of decimal.

1.8.1.3 The excavation volumes for each tower footing shall be estimated assuming the faces of surrounding earth as vertical keeping a distance of 150 mm clearances from the extreme edge of the base slab of footing. For footings with undercut, excavation volumes shall be calculated as per drawings without any side clearance.

1.8.1.4 The steel required for reinforcement of foundation shall be provided by the Contractor. Measurement of reinforcement steel will be based on the calculated weights of actually used steel in tons corrected to third place of decimal, no allowance being made for wastage. No payments will be made for wire required for binding the reinforcement, chairs, bolsters and spacers, as the cost of these is deemed to be included in the unit rate quoted.

1.8.2 Payment for Foundation

1.8.2.1 Normal Foundations

1.8.2.1.1 The unit rate of foundation shall include transportation of construction materials to the Site, excavation, concreting, reinforcement, shoring, shuttering, dewatering, stock piling, dressing, curing, backfilling the foundation after concreting with excavated/ borrowed earth (irrespective of leads), consolidation of earth and carriage of surplus earth to the suitable point of disposal as required by the Employer or any other activities related to completion of foundation works.

The unit rate of foundation shall include the cost of supply, fabrication and placement of form boxes, cement, water, coarse and fine aggregates mixing and placing of concrete, curing of concrete and any other activities related/ required for completion of concreting works of foundation.

1.8.2.1.2 The unit rate of Foundation shall include supply and placement of reinforcement steel, stirrups, wire for binding the reinforcement, chairs, bolsters and spacers etc. as required to complete the foundation work. In case of actual unit weight of the reinforced steel is found less than standard unit weight, but within acceptable tolerance variation as per applicable standard, the same shall be accepted without

any compensation/ deduction. However, if unit weight is found to be beyond the negative (-ve) tolerance limits specified in IS, the material shall be rejected. Wastage overlaps, couplers (if provided), spacer bars, chairs, stays, hangers and annealed steel wire etc. shall not be measured for the payment and cost of these items shall be deemed to be included in the unit rate for foundation.

1.9 Construction of Tower Foundation

1.9.1 Testing of soil

1.9.1.1 The Contractor shall be required to undertake testing of soil for the tower locations in the manner specified under ***Clause 4.0 of Section-3*** of this Specification and shall submit his report about the subsoil water table, type of soil encountered, bearing capacity of soil, possibility of submergence and other soil properties required for the design of foundations. The Contractor shall also furnish soil resistivity values to the Employer along the line alignment.

1.9.2 Excavation

1.9.2.1 The excavation work for foundations shall be taken up by the contractor progressively stretch wise/ section wise after obtaining approval from Employer for the proposed stretch wise/ section wise tower schedule, profile etc. as per detailed survey along the approved route alignment.

1.9.2.2 Except as specifically otherwise provided, all excavation for footings shall be made to the lines and grades of the foundations. The excavation wall shall be vertical and the pit dimensions shall be based on an assumed clearance of 150 mm on all sides of the foundation pad. For footings with undercut, care shall be taken to carry out excavation as per drawing without any side clearance. For Fissured rock foundations, undercut as shown in the drawing is required and shall be provided accordingly. In cases where undercutting portion is excavated beyond stipulated dimension, the extended undercut portion shall be filled with additional concrete and reinforcement shall be extended into the undercut portion considering margin for concrete cover. However, payment of concrete & reinforcement shall be limited to design volumes of excavation, concrete, reinforcement etc. All excavation shall be protected so as to maintain a clean sub grade and provide worker safety until the footing is placed, wherever the soil is loose or collapsible or in case of water in excavated pit, using timbering, shoring, shuttering, dewatering arrangements etc. as approved by the Employer/ Site-In-Charge. Contractor shall especially avoid disturbing the bearing surface of the pad. Any sand, mud, silt or other undesirable materials which may accumulate in the excavated pit or borehole shall be removed by Contractor before placing concrete.

Keeping in view of safety aspect, in case any sloped/ stepped/ ramp excavation for easy movement of man and material in excavation pit is required the same

shall be done by the contractor. No Extra payment shall be admissible to the Contractor for the same.

1.9.2.4 The soil to be excavated for tower foundations shall be classified as follows depending upon the physical state of the soil at the time of excavation irrespective of the type of foundation installed.

a) **Dry Soil**

Soil removable either manually, by means of a spade and shovel or mechanically by poclains, excavators etc.

Excavation done in dry soil for wet, partially submerged, fully submerged and wet black cotton type of foundations shall also be covered under this.

b) **Wet Soil**

During excavation, if wet soil is encountered within the foundation depth, the type of soil shall be considered as Wet irrespective of whether pumping/ bailing out of water is required or not. The excavation done in wet soil in case of wet, wet cultivated, partially submerged, fully submerged and wet black cotton type of foundation shall also be covered under this.

c) **Dry Fissured Rock**

Limestone, laterite, hard conglomerate or other soft or fissured rock in dry condition which can be quarried or split with crowbars, wedges, pickaxes etc. However, if required, light blasting may be resorted to for loosening the material but this will not in any way entitle the material to be classified as hard rock.

d) **Wet Fissured Rock**

Above fissured rock, when encountered with subsoil water within the range of foundation depth or land where pumping or bailing out of water is required, shall be treated as wet fissured rock.

e) **Hard Rock**

Any rock excavation, other than specified under fissured rock above, for which blasting, drilling, chiseling is required. The unit rate quoted for hard rock excavation shall be inclusive of all costs for such drilling (including drilling required for anchoring), chiseling and blasting, etc.

1.9.2.5 No extra payment shall be admitted for the removal of fallen earth into a pit or borehole once excavated.

1.9.2.6 Where rock is encountered, the holes for tower footings shall preferably be drilled. Blasting where resorted to as an economy measure, if permitted by the Employer, shall be done with utmost care to minimise fracturing rock and using extra concrete for filling the blasted area. All necessary precautions for handling

and use of blasting materials shall be taken. In case where drilling is done, the stubs may be shortened suitably with the approval of the Employer.

In cases where unnecessarily large quantities are excavated/ blasted for fissured rock/ hard rock, resulting in placement of large volumes of concrete, payment of concrete shall be limited to design volumes of excavation, concreting, reinforcement etc.

In cases where unnecessarily excavation is done beyond foundation depth for normal foundation other than Hard rock, the same shall be filled with additional Plain cement concrete (PCC) corresponding to a 1:3:6 nominal mix without any additional financial implication to Employer. However, minimum thickness of PCC above founding level as shown in the construction drawing of foundation shall be provided.

1.9.2.7 The Contractor shall arrange and supply requisite blasting material, and be responsible for its storage and use, without any extra cost to the Employer.

1.9.2.8 Indian Standard IS 3764 shall be followed regarding safety of excavation work.

1.9.3 **Setting of Stubs**

1.9.3.1 The stubs shall be set correctly and precisely in accordance with approved method at the exact location, alignment and levels with the help of stub setting templates and leveling instruments. Minimum clearance between chimney concrete level and ground level shall be ensured as per foundation drawing. Stubs setting shall be done in the presence of Employer's representative available at site where required and for which adequate advance intimation shall be given to Employer by Contractor. Tolerances as per provisions of IS 5613 shall be allowed for stub setting.

1.9.3.2 Setting of stub at each location shall be approved by Employer.

1.9.3.3 Individual Leg stub setting template may also be used by the contractor with prior approval from Employer Site-In-Charge. An indicative drawing for individual leg stub setting template is attached with the specification. Proper care shall be taken by the contractor for accurate setting & alignment of stub levels

1.9.3.4 Alternatively, props may be used with complete accuracy and high skilled supervision. No recovery shall be made on account of using Props for stub setting.

1.9.4 Stub Setting Templates/ Props

1.9.4.1 Stub setting templates shall be arranged by the Contractor at his own cost for all heights of towers. Stub templates shall be of adjustable type. The Contractor shall also arrange for props for setting of stubs at specific locations. Stub templates/ props should be painted.

1.9.4.2 The Contractor shall deploy sufficient number of templates/ props for timely completion of the line without any extra cost to Employer.

1.9.4.3 However, the number of templates to be deployed shall depend upon type of terrain condition, number of types of towers etc. Hence, the quantity of template to be deployed for timely completion of the line shall be finalized in consultation with Site-In-Charge without any extra cost to the Employer.

The number of sets of props to be arranged, will depend as per actual site condition and completion schedule of line.

1.9.4.4 One set of each type of stub setting template/ props (if used) shall be supplied to the Employer, on completion of the project, at no extra cost to Employer.

1.9.5 Mixing, Placing and Compacting of Concrete

1.9.5.1 The concrete shall be mixed in the mechanical mixer. However, in case of difficult terrain, hand mixing may be permitted at the discretion of the Employer. The water for mixing concrete shall be fresh, clean and free from oil, acids and alkalis. Saltish or blackish water shall not be used.

Alternatively, Ready Mix concrete from batching plant as per IS 4925 can also be used with no extra payment and without any recovery. However, Cement content shall be as per IS 456, unless otherwise specified herein. The ready-mix concrete shall conform to IS 4926. The selection and use of Materials for the ready-mix concrete shall be in accordance with IS 456. The concrete shall be of M25 grade design mix as per IS 456. The transport of concrete and transportation time shall be as per IS 4926. Record of delivery ticket information as per Annexure-G of IS 4926 has to be maintained.

1.9.5.2 Mixing shall be continued until there is uniform distribution of material and mix is uniform in colour and consistency, but in no case the mixing be carried out for less than two minutes. Normal mixing shall be done close to the foundation but exceptionally, in difficult terrain**,** the concrete may be mixed at the nearest convenient place. The concrete shall be transported from the place of mixing to the place of final deposit as rapidly as practicable by methods which shall prevent the segregation or loss of any ingredient. The concrete shall be placed and compacted before setting commences.

1.9.5.3 To avoid the possibility of reinforcement rods being exposed due to unevenness of the bottom of the excavated pit, a pad of lean concrete 50 mm thick and corresponding to a 1:3:6 nominal mix shall be provided at the bottom of the pad. The coarse aggregate shall be of 20mm size and shall conform to IS 383**.**

1.9.5.4 Form boxes shall be used for casting all types of foundations except at an undercut interface for which the adjoining subsurface material shall provide adequate support. Form boxes shall conform to the shape, lines & dimensions of the foundation drawing and shall be constructed so as to be rigid during the placing and compacting of concrete. Contractor shall ensure that Form boxes are in good

condition. Repeated use & maintenance of form box shall be as per IS 456 & IS 14687.

1.9.5.5 The concrete shall be laid down in 150mm layers and consolidated well, so that the cement cream works, up to the top and no honey-combing occurs in the concrete. A mechanical vibrator shall be employed for compacting the concrete. Monolithic casting of foundation must be carried out. However, in case of unavoidable circumstances, a key construction joint can be provided at the chimney-pad interface subject to approval of the Employer or as directed by the Engineer-in-charge. Number of such joints shall be kept minimum. Joints shall be kept as straight as possible & such construction joints should comply with IS 456. There shall not be any construction joint near stub & cleat portion of frustum. However, nothing extra shall be paid to the Contractor for providing such construction joints. For raised chimney, joint in concrete shall be of 3 m in chimney portion if casting of full chimney is not possible in one stretch.

1.9.5.6 After concreting the chimney portion to the required height, in the top 50 mm portion between CL & GL coping shall be done after erection of tower and the top surface should be finished smooth with a slight slope towards the outer edge for draining rain water.

Further, in case of Wet, Wet cultivated, PS, FS & WBC foundation before coping of chimney top portion, three coats of anti-corrosive paint (As recommended by paint manufacture for structural steel application) of minimum 30-35 microns dry film thickness each shall be applied on the stub in the 50 mm coping portion as well as upto 350 mm above CL portion. Cost of supply and application of anti-corrosive paint shall be deemed to be included in the unit rate of concreting.

1.9.5.7 Wet locations shall be kept completely dewatered, both during and 24 hours after placing the concrete, without disturbance of the concrete.

1.9.5.8 If minor defects in concrete surface is found after the form work has been removed, the damage shall be repaired with a rich cement sand mortar to the satisfaction of the Employer before the foundation is back filled.

1.9.6 **Curing**

The concrete shall be cured by maintaining the concrete wet for a period of at least 10 days after placing. Once the concrete has set for 24 hours the pit may be backfilled with selected moistened soil and well consolidated in layers thereafter both the backfill earth and exposed chimney shall be kept wet for the remainder of the prescribed 10 days. The exposed concrete chimney shall also be kept wet by wrapping gunny bags around it and wetting the bags continuously during the initial 10 days period.

Alternatively, membrane curing may also be carried over all exposed surface of concrete in line with IS 456.

1.9.7 Backfilling and Removal of Stub Templates

1.9.7.1 After opening of formwork and removal of shoring, shuttering etc., backfilling shall be done with the excavated soil, unless it consists of large boulders/ stones, in which case the boulders/ stones shall be broken to a maximum size of 80 mm or disposed-off. At locations, where borrowed earth is required for backfilling, Contractor shall bear the cost of the borrowed earth irrespective of leads & lift.

1.9.7.2 The backfilling materials shall be clean and free from organic or other foreign materials. The earth shall be deposited in various layers, levelled, wetted if necessary and shall be fully compacted. All excavated earth shall be placed over the filled in pit to allow further settlement, if any, by gravity**.**

1.9.7.3 The backfilling and grading shall be carried to an elevation of about 75 mm above the finished ground level to drain out water. After backfilling 50 mm high, earthen embankment (band) will be made along the sides of excavation pits and sufficient water will be poured in the backfilling earth for at least 24 hours. After the pits have been backfilled to full depth the stub template can be removed.

1.9.8 Benching

When the line passes through hilly/ undulated terrain, levelling the ground may be required for casting of tower footings. All such activities shall be termed benching and shall include cutting of excess earth and removing the same to a suitable point of disposal as required by Employer. Benching in sandy soil shall be payable only when it requires cutting of excess soil by any excavator or JCB. Benching shall not be payable in case benching is done in moving sand dunes. Benching shall be resorted to only after approval from Employer. Volume of the earth to be cut shall be measured before cutting and approved by Employer for payment purposes. Further, to minimise benching, unequal leg extensions/ raised chimney shall be considered and provided if found economical. The proposal shall be submitted by the Contractor with detailed justification to the Employer.

1.9.9 Protection of Tower and Tower Footing

1.9.9.1 Tower shall be spotted such that the quantities of revetment are optimum. For tower locations in undulated terrain such as hill/ mountain slopes, options like use of unequal leg extensions for towers, unequal chimney extensions etc. shall be explored by the contractor for optimizing the need for revetment & benching.

1.9.9.2 The work shall include all necessary stone revetments, concreting and earth filling above ground level, the clearing from site of all surplus excavated soil, special measures for protection of foundation close to or in nalas, river bank/ bed, undulated terrain, protection of uphill/ downhill slopes required for protection of tower etc., including suitable revetment or galvanised wire netting and meshing packed with boulders. The top cover of stone revetment shall be sealed with 1:2:4 nominal mix concrete. Contractor shall recommend protection at such locations

wherever required. Details of protection of tower/ tower footing are given in drawing enclosed with these specifications for reference purpose only.

1.9.9.3 Tower footings shall generally be backfilled using soil excavated at site unless unsuitable for backfilling. In the latter case, backfilling shall be done with borrowed earth of suitable quality irrespective of leads and lift. The unit rate for backfilling quoted in BPS shall include the required lead and consolidation and leveling of earth after backfilling.

1.9.9.4 The provisional quantities for protection work of foundations are furnished in BPS. The unit rates shall also be applicable for any quantity variations during execution. The same unit rates shall hold good for protection work carried out on down hills or up hills slopes applicable for the tower locations.

1.9.9.5 The unit rate for random rubble masonry revetment quoted in price schedule shall also include excavation & (1:5) random masonry. For payment purposes the volume of random rubble masonry revetment shall be measured from bottom of RRM to bottom of M15 sealing and paid at the unit rates indicated in the Contract.

No extra payment shall be made for allied works such as excavation for revetment, packed stone at head of weep holes etc. However, no deduction shall be made for the volume enclosed by weep holes.

1.9.9.6 For some of the locations in nalas, river bed or undulated terrain etc., boulders of minimum. 150mm size bounded and packed in galvanised wire net/ mesh of 8 SWG wire and 10000 square mm (maximum) mesh are to be provided. These stones shall be provided in crates size of 2.0 m x 2.0 m or as deemed suitable for a particular location. Measurement shall be taken in cubic meters and 15% deduction will be made for void from cage/ stack measurements.

1.9.10 After completion of foundation, stub levels, back to back dimensions, diagonal dimensions etc. shall be measured jointly by the Engineer of Contractor and Employer before taking up erection of tower and same shall be recorded for future reference. In case of any deviations beyond permissible limits as per IS 5613, the foundation shall be rectified or re-casted by the contractor at his own cost.