

STANDARD MANUFACTURING QUALITY PLAN (SMQP) FOR MULTISTRAND ACSR & AAC CONDUCTOR
C/QA/SMQP/ACSR/AAC-Rev 00



Sr. No.	Components/ Operations & Description of Test	Type of Check	Quantum of Check/ Sampling with basis	Reference document for Testing	Acceptance Norms	Format of Record	Applicable Codes						Remarks
							1	2	3	4	5	6	
B.	SECTION:IN PROCESS INSPECTION												
3.0	Aluminium Drawn Wire												
3.1	Diameter of Drawn Aluminium Wire	Dimensional	one sample from first, middle & last drawn wire coil from each wire rod	POWERGRID Spec.	As per Approved Technical specification	MFOR	A	J	S	W	-	N	
3.2	Breaking Load/ Tensile strength	Mechanical	one sample from first, middle & last drawn wire coil from each wire rod	IEC 60889 and POWERGRID Spec.	As per Approved Technical specification	MFOR	A	J	S	W	-	N	
3.3	Resistance	Electrical	one sample from first, middle & last drawn wire coil from each wire rod	IEC 60889 and POWERGRID Spec.	As per Approved Technical specification	MFOR	A	J	S	W	-	N	
3.4	Wrapping Test	Mechanical	one sample from first, middle & last drawn wire coil from each wire rod	IEC 60889 and POWERGRID Spec.	Wrap-8,unwrap-6 & wrap-6 turns on the wire itself. The wire shall not break.	MFOR	A	J	S	W	-	N	
4.0	Steel Stranding Process												
4.1	Lay Ratio/ Direction & Compactness	Measurement and Visual	At the beginning of Each set up	IEC 60888 and POWERGRID Spec..	As per Approved Technical specification	MFOR	A	J	S	W	-	N	
4.2	Pre-forming and post forming of Steel core	Visual	One sample from each length	POWERGRID Spec..	No Spreading of strands when complete core wire is cut	MFOR	A	J	S	W	-	N	
4.3	Check for Joints	Visual	100 % on each drum	IEC 60888 and POWERGRID Spec..	There shall be NO JOINT	MFOR	A	J	S	W	-	N	
4.4	Surface smoothness	Visual	100 % on each drum	IEC 60888 and POWERGRID Spec..	The wire shall be free from defects	MFOR	A	J	S	W	-	N	

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5.0	Final Conductor Stranding Process												
5.1	Lay Ratio/ Direction & Compactness	Physical	At the beginning of Each set up	IEC 61089 and POWERGRID Spec..	As per Approved Technical specification	MFOR	A	J	S	W	-	N	
5.2	Check for Joints	Visual	100 % on each drum	POWERGRID Spec..	There shall be NO JOINT in the outermost layer. Joints are allowed in inner layers but no two such joints shall be less than 15 meters apart in completed conductor.	MFOR	A	J	S	W	-	N	No weld joints are allowed in any layer of finished conductor for 7 strand conductor.
5.3	Surface smoothness of Strands and stranded conductor	Visual	100%	POWERGRID Spec..	The finished conductor shall be smooth, compact, uniform and free from all imperfections including kinks (protrusion of wires), wires cross over, over riding, looseness (wire being dislocated by finger/hand pressure and or unusual bangle noise on tapping), material inclusions, white rust, powder formation or black spot, dirt, grit, etc.	MFOR	A	J	S	W	-	N	



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5.4	Conductor Packing (in process)	Visual	100%	POWERGRID Spec..	Medium grade Kraft/crepe paper shall be used in between the layers of conductor. After reeling the conductor, the exposed surface of the outermost layer of conductor shall be wrapped with water proof thick bituminized paper.	MFOR	A	J	S	W	-	N	
C. Section: FINAL TESTING													
6.0	Routine Test on Finished Conductor												
6.1.	All acceptance tests	-	20 % of the drums	IEC 61089, 60888 and 60889 and POWERGRID Spec..	Shall pass all the requirements.	MFOR	A	J	S	Z	-	N	
6.2	Check for Joints, Surface condition of strands and stranded conductor.	-	100 % on each drum	IEC 61089, 60888 and 60889 and POWERGRID Spec..	Shall pass all the requirements.	MFOR	A	J	S	Z	-	Y	
7.0	Acceptance Tests on Finished Conductor.												
7.1	Lay Ratio / Direction & Compactness	Physical	One sample from every 10 Drums or part thereof	IEC 61089 and POWERGRID Spec..	As per Approved Technical specification	Inspection test report	A	J	U	Y	-	Y	CIP



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7.2 Acceptance Tests on Aluminum Strands of Finished Conductor.													
7.2.1	Diameter of Aluminium strands	Dimensional	One sample from every 10 Drums or part thereof	POWERGRID Spec.	As per Approved Technical specification	Inspection test report	A	J	U	Y	-	Y	CIP
7.2.2	Breaking Load/ Tensile strength	Mechanical	One sample from every 10 Drums or part thereof	IEC 60889 and POWERGRID Spec.	As per Approved Technical specification	Inspection test report	A	J	U	Y	-	Y	CIP
7.2.3	Resistance	Electrical	One sample from every 10 Drums or part thereof	IEC 60889 and POWERGRID Spec.	As per Approved Technical specification	Inspection test report	A	J	U	Y	-	Y	CIP
7.2.4	Wrapping Test	Mechanical	One sample from every 10 Drums or part thereof	IEC 60889 and POWERGRID Spec.	As per Approved Technical specification/relevant standard	Inspection test report	A	J	U	Y	-	Y	CIP
7.2.5	UTS test on welded joints of Aluminium strands by cold pressure butt welding machine	Mechanical	5 specimen against each lot	POWERGRID Spec.	The minimum breaking load shall be not less than the specified value in Data Sheet	Inspection test report	A	J	U	Y	-	Y	CIP
7.3 Acceptance Tests on Galvanised Steel strands of Finished Conductor													
7.3.1	Diameter	Dimensional	One sample from every 10 Drums or part thereof	POWERGRID Spec.	As per Approved Technical specification	Inspection test report	A	J	U	Y	-	Y	CIP
7.3.2	Tensile Strength/ Breaking Load	Mechanical	One sample from every 10 Drums or part thereof	IEC-60888 and POWERGRID Spec.	As per Approved Technical specification	Inspection test report	A	J	U	Y	-	Y	CIP
7.3.3	Elongation	Mechanical	One sample from every 10 Drums or part thereof	IEC-60888 and POWERGRID Spec.	As per Approved Technical specification	Inspection test report	A	J	U	Y	-	Y	CIP
7.3.4	Torsion Test	Mechanical	One sample from every 10 Drums or part thereof	IEC-60888 and POWERGRID Spec..	As per Approved Technical specification	Inspection test report	A	J	U	Y	-	Y	CIP
7.3.5	Wrapping Test	Mechanical	One sample from every 10 Drums or part thereof	IEC-60888 and POWERGRID Spec..	Wrap-8,unwrap-6 & wrap-6 On a mandrel having diameter equal to 4 x diameter of wire. The wire shall not break.	Inspection test report	A	J	U	Y	-	Y	CIP



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7.3.6	Adhesion Test	Mechanical	One sample from every 10 Drums or part thereof	IEC-60888 and POWERGRID Spec..	The Zinc coating shall remain adherent to the steel wire when wound 10 turns on a mandrel	Inspection test report	A	J	U	Y	-	Y	CIP
7.3.7	Preece Test (Dip Test)	Chemical	One sample from every 10 Drums or part thereof	POWERGRID Spec..	As per Approved Technical specification	Inspection test report	A	J	U	Y	-	Y	CIP
7.3.8	Mass of Zinc coating	Chemical	One sample from every 10 Drums or part thereof	IEC-60888 and POWERGRID Spec..	As per Approved Technical specification	Inspection test report	A	J	U	Y	-	Y	CIP
7.3.9	Chemical Composition of Aluminium Strand (If Aluminium wire Rod is imported from LME registered sources)	Chemical	One sample per lot	POWERGRID Spec.	AL 99.5% (min) Cu 0.04 % (max) Other elements as per GTP	Inspection test report	A/D	J/L	U	Y		Y	CIP
7.4	Length measurement of Finished Conductor												
7.4.1	Check for joints, surface finish and length measurement by rewinding	Visual & Measurement	One sample from every 10 Drums or part thereof	POWERGRID Spec..	No scale on the surface and the surface shall be free from any imperfections. No joint on the outermost layer. The conductor length should be as per the offered packing list & drums as per approved drawing.	Inspection test report	A	J	U	Y	-	Y	CIP
8.0	Drums and packing materials												
8.1	Dimensional check of drums	Dimensional	10% of offered drums	POWERGRID approved Drum drawing	POWERGRID approved drum drawing	Inspection test report	A	J	U	Y	-	Y	CIP



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8.2	Barrel Batten Test (For Wooden Drums)	Mechanical	One sample from every 10 Drums or part thereof	IS 1778	Barrel Batten strength Min. 300 Kgf.	Inspection test report	A	J	U	Y	-	Y	CIP
8.3	Chemical Test on water proof bituminised bamboo paper	Chemical	One sample per batch of paper	As per Plant Standard	Chloride - 0.05 % max., Sulphate- 0.25 % max., Copper - 0.01 % Max..	TPL report	D	L	V	Y	-	N	
8.4	Visual check of drums	Visual	100% drums	POWERGRID approved Drum drawing & Technical Specification	As per Technical Specifications. Already Covered in Notes (sl. No. 14 to 20)	Inspn. Report	A	J	U	Y	-	Y	CIP
8.5	Drum Strength Test (for Steel Drum)	Mechanical	One sample from every 10 Drums or part thereof	IS 15976 & POWERGRID Spec.	Roll down the drum three (3) times from 1 mtr. height on an inclined plane of 45 deg. No damage/bend to flange	Inspection test report	A	J	U	Y	-	Y	CIP
9.0	Packing, Marking and Dispatch												
9.1	Packing of Drum	Visual	100%	POWERGRID Spec..	As per Note sl. No. 15 to 19 / POWERGRID specs.	Joint Inspn. Report	A	J	S/U*	Y	-	N	
9.2	Contract/ Award Letter no.	Visual	100%	POWERGRID Spec..	POWERGRID Spec..	Packing List	A	J	S/U*	Y	-	N	This information shall be stenciled on each drum in indelible ink.
9.3	Name and address of consignee	Visual	100%	POWERGRID Spec..	POWERGRID Spec..		A	J	S/U*	Y	-	N	
9.4	Manufacturer's Name and Address	Visual	100%	POWERGRID Spec..	POWERGRID Spec..	Packing List	A	J	S/U*	Y	-	N	*100 % by Conductor manufacturer &
9.5	Drum No.	Visual	100%	POWERGRID Spec..	POWERGRID Spec..	Packing List	A	J	S/U*	Y	-	N	10 % by POWERGRID.
9.6	Size and Code Name of Conductor	Visual	100%	POWERGRID Spec..	POWERGRID Spec..	Packing List	A	J	S/U*	Y	-	N	



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**पावरग्रीड
POWERGRID**

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							1	2	3	4	5	6	
9.7	Length of Conductor	Visual	100%	POWERGRID Spec..	POWERGRID Spec..	Packing List	A	J	S/U*	Y	-	N	
9.8	Arrow Marking for rolling the conductor drum	Visual	100%	POWERGRID Spec..	POWERGRID Spec..	Packing List	A	J	S/U*	Y	-	N	
9.9	Position of the Conductor Ends	Visual	100%	POWERGRID Spec..	POWERGRID Spec..	Packing List	A	J	S/U*	Y	-	N	
9.10	No. of turns in outer most layer	Visual	100%	POWERGRID Spec..	POWERGRID Spec..	Packing List	A	J	S/U*	Y	-	N	This information shall be stenciled on each drum in indelible ink.
9.11	Gross weight of the drum (with protective lagging in case of wooden drums) including weight of conductor	Visual	100%	POWERGRID Spec..	POWERGRID Spec..	Packing List	A	J	S/U*	Y	-	N	
9.12	Weight of empty drum (with protective lagging in case of wooden drums)	Visual	100%	POWERGRID Spec..	POWERGRID Spec..	Packing List	A	J	S/U*	Y	-	N	
9.13	Net weight of the conductor in the Drum	Visual	100%	POWERGRID Spec..	POWERGRID Spec..	Packing List	A	J	S/U*	Y	-	N	*100 % by Conductor manufacturer & 10 % by POWERGRID.
9.14	Distance between outermost layer and inner surface of protective laggings	Visual	100%	POWERGRID Spec..	POWERGRID Spec... (Min - 75mm)	Packing List	A	J	S/U*	Y	-	N	
9.15	CIP/MICC	Visual	100%	POWERGRID Spec..	POWERGRID Spec..	Packing List	A	J	S	-	-	N	
9.16	Sealing of Drums 100% as per POWERGRID approved sealing procedure	Visual	100%	POWERGRID Spec..	POWERGRID Spec..		A	J	U	Y	-	Y	CIP 100% by POWERGRID
9.17	Tack welding on Nuts on the barrel and Hub Plates.	Visual	100%	POWERGRID Spec..	POWERGRID Spec..		A	J	SU*	W	-	N	*100 % by Conductor manufacturer & 10 % by POWERGRID

Note: Conductor manufacturer has to ensure marking of CIP/MICC no. on all drums before dispatch and a copy of CIP/MICC along with the test reports should be sent to the site along with the dispatches.



SECTION-VIII

COMPOSITE LONG ROD INSULATOR

TECHNICAL SPECIFICATIONS

SECTION-VIII

COMPOSITE LONG ROD INSULATOR

Revision History

Revision No.	Date	Clause Ref	Description
Rev-0	June'2021		First Release
Rev-1	Oct'2021		First Revision
Rev-2	Jan'2022		Second Revision
Rev-3	March'2024		Third Revision
Rev-4	October'2024		Fourth Revision

TECHNICAL SPECIFICATIONS

SECTION-VIII

COMPOSITE LONG ROD INSULATOR

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TECHNICAL SPECIFICATIONS

SECTION-VIII

COMPOSITE LONG ROD INSULATOR

1.0 Technical Description of Composite Long Rod Insulators

1.1 Details of Composite Long Rod Insulators

1.1.1 The insulators of the strings shall consist of composite long rod insulators for transmission system application in a very heavily polluted environment. Couplings shall be ball and socket type.

1.1.2 Bidder shall quote such composite insulators which have proven use under foggy/humid operational conditions in polluted industrial environment combined with smoke and dust particles. The Bidder shall furnish evidence in the form of certification from the power utilities that the similar type of product supplied to them had been performing satisfactorily. The Bidder shall also submit certified test report for an accelerated ageing test of 5000 hours such as that described in IEC 62730 (2012).

1.1.3 Insulators shall have sheds of the “open aerodynamic profile without any under ribs” with good self-cleaning properties. Insulator shed profile, spacing projection etc. shall be strictly in accordance with the recommendation of IEC 60815.

1.1.4 The size of long rod insulator, minimum creepage distance, the number to be used in different type of strings, their electromechanical strength and mechanical strength of insulator string alongwith hardware fittings shall be as per the standard technical particulars enclosed at **Annexure-B**.

1.1.5 Dimensional Tolerance of Composite Insulators

The tolerances on all dimensions e.g. diameter, length shall be allowed as follows:

$\pm (0.04d+1.5)$ mm when $d \leq 300$ mm.

$\pm (0.025d+6)$ mm when $d > 300$ mm with a maximum tolerance of +10 mm

Where, d being the dimensions in millimeters for diameter, length as the case may be.

The tolerance in creepage distance shall be based on design dimensions and their tolerances. However, no negative tolerance shall be applicable to creepage distance specified in *clause 1.1.4*.

1.2 Interchangeability

The composite long rod insulators inclusive of the ball & socket connection shall be standard design suitable for use with the hardware fittings of any make conforming to relevant Indian standards.

1.3 Corona and RI Performance

All surfaces shall be clean, smooth, without cuts, abrasions or projections. No part shall be subjected to excessive localized pressure. The insulator and metal parts shall be so designed and manufactured that it shall avoid local corona formation and shall not generate any radio interference beyond specified limit under the operating conditions.

1.4 Maintenance

1.4.1 The long rod insulators offered shall be suitable for employment of hot line maintenance technique so that usual hot line operation can be carried out with ease, speed and safety.

1.4.2 All insulators shall be designed to facilitate cleaning and insulators shall have the minimum practical number of sheds and grooves. All grooves shall be so proportioned that any dust deposit can be removed without difficulty either by wiping with a cloth or by remote washing under live line condition.

1.5 Materials

1.5.1 Core

It shall be a glass-fiber reinforced (FRP rod) epoxy resin rod of high strength. The rod shall be resistant to hydrolysis. Glass fibers and resin shall be optimized. The rod shall be electrical grade corrosion resistant (ECR), boron free, glass and shall exhibit both high electrical integrity and high resistance to acid corrosion. Glass Transition Temperature (T_g) for FRP rod to be minimum 140°C .

1.5.2 Housing & Weather sheds

The FRP rod shall be covered by a sheath of HTV silicone rubber compound of a thickness of minimum 5 mm. The housing & weather sheds should have silicon content of minimum 32% by weight. The minimum dielectric strength (BDV) of silicon rubber compound shall be 20kV/mm. It should protect the FRP rod against environmental influences, external pollution and humidity. In case any anti-fungal and avian replant admixtures/ additives are added by the manufacturer in the material, the details shall be included by the manufacturers in their MQP. It shall be extruded or directly molded on the core. The interface between the housing and the core must be uniform and without voids. The strength of the bond shall be greater than the tearing strength of the polymer. The manufacturer shall follow non-destructive technique (N.D.T.) to check the quality of jointing of the housing interface with the core. The technique to be followed with detailed procedure and sampling shall be furnished by the Supplier and finalized during finalization of MQP.

The weather sheds of the insulators shall be of alternate shed profile. The weather sheds shall be vulcanized to the sheath (extrusion process) or molded as part of the sheath (injection molding process) and free from imperfections. The vulcanization for extrusion process shall be at high temperature and for injection molding shall be at high temperature & high pressure. Any seams/ burrs protruding axially along the insulator, resulting from the injection molding process shall be removed completely without causing any damage to the housing. The track resistance of housing and shed material shall be class 1A4.5 according to IEC 60587. The strength of the weather shed to sheath interface shall be greater than the tearing strength of the polymer. The composite insulator shall be capable of high pressure washing.

1.5.3 End Fittings

End fittings transmit the mechanical load to the core. They shall be made of forged steel or cast steel; however, for socket ends malleable cast iron spheroidal graphite may also be used. They shall be connected to the rod by means of a controlled compression technique. The manufacturer shall have in-process Acoustic emission arrangement or some other arrangement to ensure that there is no damage to the core during crimping. This verification shall be in-process and done on each insulator. The system of attachment of end fitting to the rod shall provide superior sealing performance between housing and metal connection. The end fitting shall either be over-moulded or shall be sealed by a flexible silicone rubber compound. The sealing shall stick to both housing and metal end fitting. The sealing must be humidity proof and durable with time.

End fittings shall have suitable provisions for fixing grading rings at the correct position as per design requirements.

1.5.4 Grading Rings

Grading rings shall be used at each side of the insulators for ± 800 kV HVDC Insulators (420 kN & 160 kN) and at line end for metallic return insulators (160 & 210 kN) for reducing the voltage gradient on and within the insulator and to reduce radio and TV noise to acceptable levels. Covered grading rings (having minimum 2 mm thickness) shall be provided on tower side of vertical portion (II-portion) of 420 kN Insulators to be used in “Y-string” & 160 kN suspension Pilot insulator strings, of ± 800 HVDC lines, at cross-arm/ cold end as per the drawing attached at Section-III of Technical specification to reduce deposition of bird excreta on polymer insulator sheds.

For upto 765 kV voltage level, Grading rings shall be used for each composite insulator unit as per Standard Technical particulars enclosed at *Annexure-B* for reducing the voltage gradient on and within the insulator and to reduce radio and TV noise to acceptable levels. For Covered grading rings (having minimum 2 mm sheet thickness of the cover) shall be provided on suspension insulator strings at cross-arm/ cold end as per Standard Technical particulars enclosed at *Annexure-B*

and drawing attached in the relevant section of Technical specification to reduce deposition of bird excreta on polymer insulator sheds.

The covered grading ring shall have sloping surface so as to facilitate natural cleaning/ removal of any deposition on its surface. The open type grading ring shall essentially be a round extruded Aluminium Alloy tube of minimum 50 mm diameter, minimum wall thickness of 2.5 mm. The fixing arms of the grading ring shall consist of a holder & a keeper. While the holder shall be either welded or riveted on the corona ring, the keeper shall be bolted onto the holder. To avoid possibility of loosening/ opening of grading ring during service, suitable additional locking measures viz. Lock nut/ bolt patch/ locking washer etc. shall be provided by the supplier. Gap between holder & keeper shall be kept uniformly as 32mm for up to 120kN and 36mm for 160kN & 210kN.

The size and placement of the metallic grading rings shall be designed to eliminate dry band arcing/ corona cutting/ exceeding of permissible electrical stress of material. Also, for ensuring correct installation of grading rings, a proper slot shall be provided at the outside edge of the End fittings and on grading ring holders. The design of the grading rings shall be such that it will only fit in the designated slot facing correct installation direction. The position of the slots shall be at suitable distance on end fittings to ensure acceptable levels of radio and TV noise and voltage gradient on and within the insulator.

The insulator supplier shall furnish design calculations using appropriate electric field software with the proposed placement and design of corona. The insulator supplier must provide EFM report with all limits as per criteria mentioned below. Any modifications to achieve the same shall be done in Insulator assembly only.

- I. Below details shall be mentioned in the report: -
 - a. String configuration
 - b. The EFM analysis must be complied with satisfying all dimensions as per the drawings for the same type of insulator with hardware fittings as a whole.
 - c. Method and Software used for analysis with license number with images of the same.
 - d. Assumptions along with insulator dimension including arching distance.
 - e. Inputs for the software:
 - 1) Voltage & Relative Permittivity and conductivity of material i.e., for FRP Rod, silicon rubber insulator, Corona rings, ball and socket end fittings.
 - 2) Voltage applied on live side
 - 3) Dielectric strength of silicon rubber
- II. Criteria:

The electric field for dry uncontaminated polymer insulators shall not be more than the following critical values:

- a. The E-field on the end fittings seal should not exceed 3.5 kV/cm (rms)
 - b. Along the Insulator Sheath, the E-field should not exceed 4.2 kV/cm (rms) over a distance of more than 10mm.
 - c. Surface E-field magnitudes on end fittings & Corona rings: 18 kV/cm (rms).
 - d. Internal to the fiberglass rod & rubber weather shed material: 30 kV/cm (rms).
- III. The E-field stress analysis should be carried out both for live side and tower side at highest system voltage.
 - IV. Reports shall include images of E-field stress and its measured values of all the above factors taken from software.
 - V. The results should be provided in tabular form along with requirements.
 - VI. All drawings for insulator and hardware fittings used shall be submitted along with reports and supplier shall ensure same drawings shall only be used for on-going projects.

Grading rings shall be capable of installation and removal with hot line tools without disassembling any other part of the insulator assembly.

The design & supply of grading rings shall be in the scope of the composite insulator supplier.

Supplier shall supply extra 10% quantities of grading rings as O&M spares at no extra cost to the Purchaser.

- 1.5.5 Bolts and nuts for grading rings shall be galvanized as per IS 1367 (Part 13)/ IS 2629. Fully threaded bolts confirming to relevant Indian Standard shall be used. Dimensions of bolts/ nuts shall be M10x50mm. Bolts shall be of minimum 4.6 grade. In case bolts & nuts of other materials viz. stainless steel, aluminium alloy, etc. are proposed to be used by the supplier, these shall conform to relevant Indian/International standards and complete details shall be submitted by the supplier for review & approval by the Employer.

- 1.5.6 **The details of materials for different component are listed as in Table-I**
TABLE-1: (Details of Materials)

Sl. No.	Item	Material treatment	Reference Material Grade
1	Ball End	Forged Steel	Forged Steel, Class 4 as per IS 2004
			Forged Steel, EN8D as per BS970
			41Cr4 as per ISO 683-18-1996 or EN10083-3-2006
		Cast Steel	C40 as per EN-10083-2
			C45 as per EN-10083-2

2	Socket End	Forged Steel	Forged Steel, Class 4 as per IS 2004
			Forged Steel, EN8D as per BS970
			41Cr4 as per ISO 683-18-1996 or EN10083-3-2006
		Cast Steel	C40 as per EN-10083-2
			C45 as per EN-10083-2
		Spheroidal Graphite Cast Iron	SGCI-450/10 as per IS 1865:1991
3	Ring	Covered type: Aluminium Casting	LM6 as per BS 1490/ 4600 as per IS 617
		Open type: Aluminium Extrusion	High Strength Al. Alloy, 63400 as per IS 733, 63401 as per IS 5082
4	Holder/ Keeper	Mild Steel	E410 as per IS-2062
		Cast Steel	C45, EN-10083-2
			65-35 as per ASTM A27
			A 1020 ASTM A732
		Aluminium Extrusion	High Strength Al. Alloy, 63400 as per IS 733, 63401 as per IS 5082
		Aluminium Casting (for holder only)	LM6 as per BS 1490/ 4600 as per IS 617 (min. 8 mm thickness)
5	Silicone Rubber	High Temperature Vulcanised (HTV) Silicone Rubber	

1.6 Workmanship

- 1.6.1 All the materials shall be of latest design and conform to the best modern practices adopted in the extra high voltage field. Bidders shall offer only such insulators as are guaranteed by him to be satisfactory and suitable for transmission lines specified and will give continued good service.
- 1.6.2 The design, manufacturing process and material control at various stages shall be such as to give maximum working load, highest mobility, best resistance to corrosion, good finish and elimination of sharp edges and corners to limit corona and radio interference.
- 1.6.3 The design of the insulators shall be such that stresses due to expansion and contraction in any part of the insulator shall not lead to deterioration.
- 1.6.4 The core shall be sound and free of cracks, impurities and voids that may adversely affect the insulators.
- 1.6.5 Weather sheds/ Housing shall be uniform in quality. It shall be free from voids and impurities. Weather sheds/ Housing shall be clean, sound, smooth and free from gross defects and excessive flashing at parting lines.
- 1.6.6 End fittings shall be free from cracks, seams, shrinks, air holes and rough edges. End fittings should be effectively, sealed to prevent moisture ingress, effectiveness of sealing system must be supported by test documents. All

surfaces of the metal parts shall be perfectly smooth with the projecting points or irregularities which may cause corona. All load bearing surfaces shall be smooth and uniform so as to distribute the loading stresses uniformly.

- 1.6.7 All ferrous parts shall be hot dip galvanized to give a minimum average coating of zinc equivalent to 600 gm/sqm. and shall be in accordance with the requirement of ISO:1461 (E) and shall satisfy the tests mentioned in ISO:1460 (E).

However, under marine/ extreme environment/ coastal areas, as specifically mentioned in BPS, the end fittings shall have a minimum average coating of zinc equivalent of 790 gm /sqm (equivalent to 110 microns) of surface area and the steel holder/ keeper shall have a minimum overall zinc coating of 900 gm/ sqm of surface area. Also, in such case, stainless steel bolts/ nuts shall only be used.

Spring washers shall be electro-galvanised. Stainless steel washer may be used as an alternative.

The zinc used for galvanizing shall be of purity of 99.95%. The zinc coating shall be uniform, adherent, smooth, reasonably bright continuous and free from imperfections such as flux, ash rust stains, bulky white deposits and blisters. The galvanized metal parts shall be guaranteed to withstand at least six successive dips each lasting for one (1) minute duration under the standard preece test. However, fasteners shall withstand four dips while spring washers shall withstand three dips under the standard preece test. The galvanizing shall be carried out only after any machining.

- 1.6.8 The supplier shall guarantee that there shall not be any failure/ de-capping/ breaking of insulators on line under normal operating condition. In the event of any failure/ de-capping/ breaking/ rise in temperature of insulator housing & weather sheds by more than 5 degree w.r.t ambient temperature (suspected insulators) of insulators during the first ten years of service, Supplier shall supply to the Purchaser free of cost spare insulators equal to 10 times the failed/suspected insulator quantity. Further, in case of de-capping/ Breaking and subsequent line drop (i.e detachment of any sub-conductor from hardware fittings) during the first ten years of service, the supplier shall also have to pay Rs 1,00,000/- (Rupees one lakh only) per dropped string towards expenditure to be incurred by POWERGRID for this line repair.

2.0 Equipment Marking

- 2.1 Each composite long rod unit shall be legibly and indelibly marked with the trade mark of the manufacturer, name of POWERGRID and month & year of manufacture. The guaranteed combined mechanical and electrical strength shall be indicated in kilo Newton followed by the word 'kN' to facilitate easy identification and to ensure proper use. Holder of grading rings shall be legibly and indelibly marked with trade mark of the composite insulator supplier.
- 2.2 One 10 mm thick ring or 20 mm thick spot of suitable quality of paint shall be marked on the cap/ end fitting of each composite long rod of particular strength

for easy identification of the type of insulator. The paint shall not have any deteriorating effect on the insulator performance. Following codes shall be used as identification mark:

For 70 kN long rod unit	:	Black
For 90 kN long rod unit	:	Red
For 120 kN long rod unit	:	Yellow
For 160 kN long rod unit	:	Green
For 210kN long rod unit	:	Blue
For 320kN long rod unit	:	Pink
For 420 kN long rod unit	:	Purple

3.0 Bid Drawings

3.1 The Bidder shall furnish full description and illustration of the material offered.

3.2 The Bidder shall furnish along with the bid the outline drawing of each insulator unit along with grading rings including a cross sectional view of the long rod insulator unit. The drawing shall include but not limited to the following information:

- (a) Major Dimensions with manufacturing tolerances
- (b) Number of sheds
- (c) Minimum Creepage distance with positive tolerance
- (d) Protected creepage distance
- (e) Unit mechanical and electrical characteristics
- (f) Size and weight of ball and socket parts
- (g) Weight of composite long rod units
- (h) Materials

3.3 After placement of award, the Supplier shall submit full dimensioned insulator drawings containing all the details as given in Clause No. 3.2 above, in four (4) copies to Purchaser for approval. After getting approval from Purchaser, the Supplier shall submit 10 more copies of the same drawing along with a soft copy to the Purchaser for further distribution and field use at Purchaser's end.

3.4 After placement of award the Supplier shall also submit fully dimensioned insulator crate drawing for different type of insulators.

4.0 Tests and Standards

4.1 Type Tests

The required type tests on composite longrod units, components, materials and complete strings are stipulated hereunder.

The specified type tests under the following clause shall not be required to be carried out if a valid test certificate is available for a similar design. The tests certificate shall be considered valid if:

- i) Tests conducted earlier is either conducted in accredited laboratory (accredited based on ISO/IEC vide 25/17025 or EN 45001 by the National accreditation body of the country where laboratory is located) or witnessed by the representative(s) of POWERGRID or utility and
- ii) Type test reports contain valid Calibration reports of the relevant testing equipment and information pertaining to ratings, the relevant drawings, model number, test circuit, calculations (if any), photos, acceptance criteria/values specified in Technical Specification/relevant standards (IS/ IEC) and compliance to the same. and
- iii) Tests should have been conducted on the samples manufactured from same manufacturing works within last 5 (five) years as on the date of NOA.

Further, test certificates of samples manufactured from same manufacturing works shall also be considered valid, if the same has already been approved/ accepted by POWERGRID & tests have been conducted within the above mentioned validity period.

In case the test have been conducted earlier than the above stipulated period or carried out on samples manufactured from any other manufacturing works or in case of revision/ amendment in the provisions/ test procedure of the IS/ IEC as referred in the TS or in the event of any discrepancy in the test report (i.e., due to non-inclusion of valid calibration certificate, desired information etc. or any test not applicable due to any design/ material/ manufacturing process change including substitution of components or due to non-compliance with the requirement stipulated in the Technical Specifications), the tests shall be conducted by the Supplier at no extra cost to the Purchaser.

4.1.1 On the complete composite Long Rod Insulator String with Hardware Fittings:

Sl. No.	Tests	Ref	Strings on which test to be conducted
a)	Power frequency / DC voltage withstand test with corona control rings/grading ring and arcing horns under wet condition	IEC 383: 1993/ IEC 60-1	All strings that
b)	Switching surge voltage withstand test under wet condition (applicable for	IEC 383:1993	

	400kV & above voltage level)		shall be used in the transmission line portion covered under the package
c)	Impulse voltage withstand test under dry condition	IEC 383:1993	
d)	Corona (AC/ DC) and RIV test under dry condition (applicable for 400kV & above voltage level)	Annexure-A	
e)	Mechanical Strength test	Annexure-A	
f)	Vibration test	Annexure-A	
g)	AC Salt-fog pollution withstand test/ DC Pollution withstand test	Annexure-A	

Note: Tests indicated at f) & g) shall not be required to be carried out on Pilot strings for all voltage levels, DIS & DT strings of 132 & 220kV (single ZEBRA) TL and Single Tension strings of 220 kV (twin MOOSE), 400kV & 765 kV TL.

Altitude correction factor (For altitude mentioned in Section-1A) as per IEC-60071-2 shall be considered in the specified voltage withstand values for above tests.

These type tests on the insulator string assembly shall not be required to be repeated due to use of specified size of grading rings even in case valid type test reports for the offered composite longrod insulator strings are available with different size of grading rings.

4.1.2 On Composite Insulator Units

(a)	Tests on interfaces and connections of metal fittings	IS 16784
(b)	Assembled core load time test	IS 16784
(c)	Damage limit proof test and test of tightness of interface between end fittings and insulator housing.	IS 16784
(d)	High Pressure washing test	Annexure-A
(e)	Brittle fracture resistance test	Annexure-A
(f)	Dye penetration test	IS 16784 & IEC 62217:2012
(g)	Water diffusion test	IS 16784
(h)	Tracking and erosion test	IS 16784
(i)	Hardness test	IS 16784

(j)	Accelerated weathering test	IS 16784
(k)	Flammability test	IS 16784
(l)	Silicone content test	Annexure-A
(m)	Recovery of Hydrophobicity test & Corona test	Annexure-A
(n)	Torsion test	Annexure-A
(o)	Ozone Resistance test	IEC 61854; Clause 7.6.3 (on thin rectangular test strip clamped at a static elongation of 20%)
(p)	Water diffusion test followed by pull-off test	Annexure-A

Hardness test, accelerated weathering test & Flammability test, specified under Clause No.4.1.2 above shall be conducted on housing/ weather shed of anyone rating of composite long rod Insulator for the same type of material.

4.2 Acceptance Tests

4.2.1 For Composite Long Rod Insulator Units

a)	Verification of dimensions	IS 16784
b)	Galvanising test	IEC 60383
c)	Verification of end fittings	IS 16784
d)	Recovery of Hydrophobicity	Annexure-A
e)	Verification of tightness of interface between end fittings and insulator housing and of specified mechanical load	IS 16784
f)	Tests on interfaces and connections of metal fittings	IS 16784
g)	Silicone content test	Annexure-A
h)	Brittle Fracture Resistance Test	Annexure-A
i)	Dye Penetration Test	IS 16784
j)	Water Diffusion Test	IS 16784
k)	Hardness test	IS 16784
l)	Water diffusion test followed by pull-off test	Annexure-A

The test 4.2.1 (f) to (l) shall be carried out as acceptance test on any one lot.

In the event of failure of the sample to satisfy the acceptance test(s) specified in 4.2 above, the retest procedure shall be as per IS 16784.

4.3 Routine Tests

4.3.1 For Composite Long Rod Insulator Units

a)	Visual Examination	IS 16784
b)	Mechanical routine test	IS 16784

4.4 Tests During Manufacture

On all components as applicable

a)	Chemical analysis of zinc used for galvanizing	Annexure-A
b)	Chemical analysis, mechanical, metallographic test and magnetic particle inspection for malleable castings.	Annexure-A
c)	Chemical analysis hardness tests and magnetic particle inspection for forgings	Annexure-A
d)	Tracking and erosion test on insulating material	IEC 60587
e)	SEM (Scanning Electron Microscopic) Analysis with EDS (Energy Dispersive Spectroscopy) on FRP rod cross-section, Surface analysis by optical spectrograph, FTIR Signature analysis	Annexure-A

4.5 Testing Expenses

4.5.1 In the event of type testing, Bidder shall ensure that adequate facilities are available in the proposed laboratories and the tests can be completed in these laboratories within the time schedule.

4.5.2 For Type Tests which involves the tests on the complete insulator string with hardware fitting, standard hardware fittings similar to existing insulator strings shall be arranged and used by the insulator supplier at his own cost.

4.5.3 In case of failure in any type test the supplier is either required to modify the design of the material & repeat all the type tests once or to repeat that particular type test at least three times successfully at his own expenses. In case a fresh lot is manufactured for testing then the lot already manufactured shall be rejected.

If repeat type tests are required to be conducted, then all the expenses for deputation of Inspector/ Purchaser's representative shall be deducted from the contract price. Also, if on receipt of the Supplier's notice of testing, the Purchaser's representative does not find the material or test setup/ equipment to be ready for testing, the expenses incurred by the Purchaser for re-deputation shall be deducted from contract price.

- 4.5.4 The Supplier shall intimate the Purchaser about carrying out of the type tests along with detailed testing programme at least 3 weeks in advance (in case of testing in India) and at least 6 weeks advance (in case of testing abroad) of the scheduled date of testing during which the Purchaser will arrange to depute his representative to be present at the time of carrying out the tests.
- 4.5.5 The entire cost of testing for acceptance and routine tests and tests during manufacture specified herein shall be treated as included in the quoted Ex-works/ CIF Price, except for the expenses of the inspector/ Purchaser's representative.
- 4.5 **Sample Batch for Type Testing**
- 4.5.5 The Supplier shall offer material for sample selection for type testing only after getting Quality Assurance Programme approved by the Purchaser. The Supplier shall offer at least three times the quantity of materials required for conducting all the type tests for sample selection. The sample for type testing will be manufactured strictly in accordance with the Quality Assurance Programme approved by the Purchaser.
- 4.5.6 Before sample selection for type testing, the Supplier shall be required to conduct all the acceptance tests successfully in presence of Purchaser's representative. However, those acceptance tests, which are also required to be carried out afresh as type test, shall not be required to be carried out as acceptance test for sample selection for type testing.
- 4.6 **Schedule of Testing**
- 4.6.5 The Bidder has to indicate the schedule of following activities in their bids: -
- a) Submission of drawing for approval.
 - b) Submission of Quality Assurance Programme for approval.
 - c) Offering of material for sample selection for type tests.
 - d) Type testing.
- 4.7 **Additional Tests**
- 4.7.5 The Purchaser reserves the right of having at his own expenses any other test(s) of reasonable nature carried out at Supplier's premises, at site, or in any other place in addition to the aforesaid type, acceptance and routine tests to satisfy himself that the material complies with the Specifications.
- 4.7.6 The Purchaser also reserves the right to conduct all the tests mentioned in this specification at his own expense on the samples drawn from the site at Supplier's premises or at any other test center. In case of evidence of non-compliance, it shall be binding on the part of the Supplier to prove the compliance of the items to the technical specifications by repeat tests or correction of deficiencies or replacement of defective items, all without any extra cost to the Purchaser.
- 4.8 **Guarantee**

The Supplier of insulators shall guarantee overall satisfactory performance of the insulators.

4.9 Test Reports

4.9.5 Copies of type test reports shall be furnished in at least six (6) copies alongwith one original. One copy shall be returned duly certified by the Purchaser only after which the commercial production of the concerned material shall start.

4.9.6 Copies of acceptance test reports shall be furnished in at least six (6) copies. One copy shall be returned duly certified by the Purchaser, only after which the material shall be dispatched.

4.9.7 Record of routine test reports shall be maintained by the Supplier at his works for periodic inspection by the Purchaser's representative.

4.9.8 Test certificates of test during manufacture shall be maintained by the Supplier. These shall be produced for verification as and when desired by the Purchaser.

4.10 Inspection

4.10.5 The Purchaser's representative shall at all times be entitled to have access to the works and all places of manufacture, where insulator, and its component parts shall be manufactured and the representatives shall have full facilities for unrestricted inspection of the Supplier's and sub-Supplier's works, raw materials, manufacture of the material and for conducting necessary test as detailed herein.

4.10.6 The material for final inspection shall be offered by the Supplier only under packed condition as detailed in clause No.4.12 of the specification. The Purchaser shall select samples at random from the packed lot for carrying out acceptance tests. The lot should be homogeneous and should contain insulators manufactured in 3-4 consecutive weeks.

4.10.7 The Supplier shall keep the Purchaser informed in advance of the time of starting and the progress of manufacture of material in their various stages so that arrangements could be made for inspection.

4.10.8 No material shall be dispatched from its point of manufacture before it has been satisfactorily inspected and tested unless the inspection is waived off by the Purchaser in writing. In the latter case also, the material shall be dispatched only after satisfactory testing for all tests specified herein have been completed.

4.10.9 The acceptance of any quantity of material shall be no way relieve the Supplier of his responsibility for meeting all the requirements of the specification and shall not prevent subsequent rejection, if such material is later found to be defective.

4.11 Packing and Marking

4.11.5 All insulators shall be packed in suitable PVC/ plastic tubes of atleast 3 mm thickness or water-resistant packing material and the packaging shall not break during storage & transportation even in overhang condition during transportation. Further, last 20% quantity of insulators shall be packed in PVC/

- plastic tubes only to ensure long storage of about 5 years. The packing shall provide protection against rodent. The Supplier shall furnish detailed design of the packing. For marine transportation, crates shall be palletted.
- 4.11.6 The packing shall be of sufficient strength to withstand rough handling during transit, storage at site and subsequent handling in the field.
- 4.11.7 Suitable cushioning, protective padding, or dunnage or spacers shall be provided to prevent damage or deformation during transit and handling.
- 4.11.8 All packing cases shall be marked legibly and correctly so as to ensure safe arrival at their destination and to avoid the possibility of goods being lost or wrongly dispatched on account of faulty packing and faulty or illegible markings. Each case/crate shall have all the markings stenciled on it in indelible ink.
- 4.11.9 The Supplier shall guarantee the adequacy of the packing and shall be responsible for any loss or damage during transportation, handling, storage and installation due to improper packing.
- 4.11.10 #To prevent birds from pecking the insulators installed on transmission lines before charging, removable plastic/ polyethylene/ polypropylene covers for 10% of the insulators of each rating shall be supplied by the manufacturer. These covers should have provisions/ attachments for easy removal from the installed insulators and is in addition to the normal packing provided by the manufacturer.
- (# Clause 4.12.6, not applicable for insulator replacement/ AM packages)**
- 4.12 **Standards**
- The insulator strings and its components shall conform to the following Indian/ International Standards which shall mean latest revision, with amendments/ changes adopted and published, unless specifically stated otherwise in the Specification.
- 4.12.5 In the event of supply of insulators conforming to standards other than specified, the Bidder shall confirm in his bid that these standards are equivalent or better to those specified. In case of award, salient features of comparison between the standards proposed by the Bidder and those specified in this document will be provided by the Supplier to establish equivalence.

Sl. No.	Indian Standard	Title	International Standard
1	IS 209	Specification for zinc	
2	IS 406	Method of Chemical Analysis of Slab Zinc	
3	IS 731	Porcelain insulators for overhead Power lines with a nominal voltage greater than 1000 V	
4	IS 2071 Part (I), Part(II) Part(III)	Methods of High Voltage Testing	
5	IS 2486 Part- I Part- II Part-III	Specification for Insulator fittings for Overhead Power Lines with a nominal voltage greater than 1000V General Requirements and Tests Dimensional Requirements Locking Devices	
6	IS 2629	Recommended Practice for Hot, Dip Galvanisation for iron and steel	
7	IS 2633	Testing of Uniformity of Coating of zinc coated articles	
8	IS 6745	Determination of Weight of Zinc Coating on Zinc coated iron and steel articles	
9	IS 8263	Methods of RI Test of HV insulators	
10	IS 8269	Methods for Switching Impulse test on HV insulators	
11		Thermal Mechanical Performance test and mechanical performance test on string insulator units	IEC 60575
12		Salt Fog Pollution Voltage Withstand Test	IEC 60507
14		Selection and dimensioning of high voltage insulators intended for use	IEC 60815-3

Sl. No.	Indian Standard	Title	International Standard
		in polluted conditions: Polymer Insulators for AC systems	
15		Tests on insulators of Ceramic material or glass or glass for overhead lines with a nominal voltage greater than 1000V	IEC 60383
16		Composite string insulator units for overhead lines with a nominal voltage above 1000V : Standard strength classes and end fittings	IEC 61466-1
17		Composite string insulator units for overhead lines with a nominal voltage above 1000V : Dimensional and electrical characteristics	IEC 61466-2
18		Electrical Insulating materials used under severe ambient conditions – Test methods for evaluating resistance to tracking and erosion	IEC 60587
19		Polymeric insulators for indoor and outdoor use with nominal voltage greater than 1000V- General definitions, tests, methods and acceptance criteria.	IEC 62217
20	IS 16784:2018	Insulators for Overhead Lines — Composite Suspension and Tension Insulators for a.c. Systems with a Nominal Voltage Greater Than 1 000 V — Definitions, Test Methods and Acceptance Criteria	

The standards mentioned above are available from:

Reference Abbreviation	Name and Address
BS	British Standards, British Standards Institution 101, Pentonville Road, N-19-ND, UK
IEC/CISPR	International Electro technical Commission, Bureau Central de la Commission, electro Technique international, 1 Rue de verembe, Geneva, SWITZERLAND
BIS/IS	Beureau Of Indian Standards. ManakBhavan, 9, Bahadur Shah ZafarMarg, New Delhi - 110001.INDIA
ISO	International Organisation for Standardization. Danish Board of Standardization Danish Standardizing Sraat, Aurehoegvej-12 DK-2900, Heeleprup, DENMARK
NEMA	National Electric Manufacture Association, 155, East 44th Street. New York, NY 10017 U.S.A.
ASTM	American Society for Testing and Materials, 1916 Race St. Philadelphia, PA19103 USA

Annexure-A

1.0 Tests on Complete Strings with Hardware Fittings

1.1 Corona Extinction Voltage Test (Dry)

The sample assembly consisting of complete insulator string when subjected to power frequency/ DC voltage shall have a corona extinction voltage of not less than the requirement stipulated in the table below: -

Voltage Level	Maximum Height of the conductor above ground (m)	Min. Corona extinction voltage (kV)
400 kV	8.84	320 (305 for RIV test)
765 kV	15	510
+/-500kV HVDC	Such that voltage gradient is not less than 22kV/cm	550
+/-800kV HVDC	Such that voltage gradient is not less than 22kV/cm	880

There shall be no evidence of corona on any part of the sample. The atmospheric condition during testing shall be recorded and the test results shall be accordingly corrected with suitable correction factor as stipulated in IEC: 60383.

1.2 RIV Test (Dry)

Under the conditions as specified under (1.1) above, the insulator string along with complete hardware fittings shall have a radio interference voltage level below 1000 micro volts at one MHz. The test procedure shall be in accordance with IS: 8263/ IEC 60437.

1.3 Mechanical Strength Test

1.3.1 Mechanical Strength Test for insulator strings.

The complete insulator string along with its hardware fitting excluding arcing horn, corona control ring, grading ring and suspension assembly/ dead end assembly shall be loaded to reproduce design conditions. The testing programme varies with string and tower types according to following table:

String Type	Total Test Load* (kN)	Direction** of Load	Duration of Load (Min.)	Sequence of Testing ***
132kV (SINGLE PANTHER)				
Double I Suspension	94	1	5	1
	140	1	1	2
	F****	1	-	3
Single I Suspension	60	1	5	1
	90	1	1	2
	F****	1	-	3
Single Tension	60	1	5	1
	90	1	1	2
	F****	1	-	3
Double Tension	120	1	5	1
	180	1	1	2
	F****	1	-	3
220 kV (SINGLE ZEBRA)				
Single I Suspension	47	1	5	1
	70	1	1	2
	F****	1	-	3
Single I Suspension Pilot	47	1	5	1
	70	1	1	2
	F****	1	-	3
Double I Suspension	94	1	5	1
	140	1	1	2
	F****	1	-	3
Single Tension	80	1	5	1
	120	1	1	2
	F****	1	-	3
Double Tension	160	1	5	1
	240	1	1	2
	F****	1	-	3
220 kV (TWIN MOOSE)				
Single I Suspension	80	1	5	1
	120	1	1	2
	F****	1	-	3

Single I Suspension Pilot	80	1	5	1
	120	1	1	2
	F****	1	-	3
Single Tension	80	1	5	1
	120	1	1	2
	F****	1	-	3
Double Tension	214	1	5	1
	320	1	1	2
	F****	1	-	3
400kV (TWIN MOOSE/ HTLS)				
Single V	80	2	5	1
	60	1	5	2
	90	1	1	3
	F****	1	-	4
Single I Suspension (120kN)	80	1	5	1
	120	1	1	2
	F****	1	-	3
Single I Suspension (160kN)	107	1	5	1
	160	1	1	2
	F****	1	-	3
Single I Suspension Pilot (120 KN)	80	1	5	1
	120	1	1	2
	F****	1	-	3
Single I Suspension Pilot (160 KN)	107	1	5	1
	160	1	1	2
	F****	1	-	3
Single Tension (120 KN)	80	1	5	1
	120	1	1	2
	F****	1	-	3
Single Tension (160 KN)	107	1	5	1
	160	1	1	2
	F****	1	-	3
Double Tension (2X160kN)	214	1	5	1
	320	1	1	2
	F****	1	-	3
Double Tension (2X210kN)	280	1	5	1
	420	1	1	2
	F****	1	-	3
400kV (TRIPLE SNOWBIRD)				
Double I Suspension	161	1	5	1
	240	1	1	2
	F****	1	-	3

Single I Suspension Pilot	80	1	5	1
	120	1	1	2
	F****	1	-	3
Single Tension	80	1	5	1
	120	1	1	2
	F****	1	-	3
Double Tension	281	1	5	1
	420	1	1	2
	F****	1	-	3
400kV (QUAD MOOSE)				
Double I Suspension	161	1	5	1
	240	1	1	2
	F****	1	-	3
Single I Suspension Pilot	80	1	5	1
	120	1	1	2
	F****	1	-	3
Single Tension	80	1	5	1
	120	1	1	2
	F****	1	-	3
Quad Tension	429	1	5	1
	640	1	1	2
	F****	1	-	3
±500kV HVDC (QUAD BERSIMIS)				
Single V	155	2	5	1
	130	3	5	2
	130	4	5	3
	210	3	1	4
	F****	3	-	5
Quadruple Tension (160 kN)	429	1	5	1
	640	1	1	2
	F****	1	-	3
±500kV HVDC (QUAD LAPWING)				
Single V	155	2	5	1
	130	3	5	2
	130	4	5	3
	210	3	1	4
	F****	3	-	5
Quadruple Tension (210 kN)	560	1	5	1
	840	1	1	2
	F****	1	-	3

765kV S/C (QUAD BERSIMIS)				
Double I	160	1	5	1
	240	1	1	2
	F****	1	1	3
Single V	155	2	5	1
	130	3	5	2
	130	4	5	3
	210	3	1	4
	F****	3	—	5
Double V	280	2	5	1
	260	3	5	2
	260	4	5	3
	420	3	1	4
	F****	3	—	5
Single Tension	80	1	5	1
	120	1	1	2
	F****	1	-	3
Quadruple Tension	540	1	5	1
	840	1	1	2
	F****	1	—	3
Single I & V Pilot	80	1	5	1
	120	1	1	2
	F****	1	—	3
765kV D/C (HEXA ZEBRA)				
Double I Suspension (2X160kN)	214	1	5	1
	320	1	1	2
	F****	1	-	3
Double I Suspension (2X210kN)	280	1	5	1
	420	1	1	2
	F****	1	-	3
Single I Suspension Pilot (1 x 160 kN)	107	1	5	1
	160	1	1	2
	F****	1	-	3
Single I Suspension Pilot (1 x 210 kN)	140	1	5	1
	210	1	1	2
	F****	1	-	3
Single Tension (1 x 160 kN)	107	1	5	1
	160	1	1	2
	F****	1	-	3
Single Tension (1 x 210 kN)	140	1	5	1
	210	1	1	2

	F****	1	-	3
Quad Tension (4X210kN)	560	1	5	1
	840	1	1	2
	F****	1	-	3
Quad Tension (4X320kN)	856	1	5	1
	1280	1	1	2
	F****	1	-	3
±800kV HVDC				
Single 'Y' suspension	340	2	5	1
	250	3	5	2
	250	4	5	3
	420	3	1	4
	F****	3	-	5
Triple Tension String	845	1	5	1
	1260	1	1	2
	F****	1	-	3
Single I Pilot	108	1	5	1
	160	1	1	2
	F****	1	-	3
132kV Metallic Return Strings				
Single I	108	1	5	1
	160	1	1	2
	F****	1	-	3
Double Tension	242	1	5	1
	420	1	1	2
	F****	1	-	3

Notes:

* : The total test must be established gradually at a steady rate.

**: Direction of load

1. following string axis
2. following bisector of string angle.
3. Following with respect to vertical, half the string angle, along the axis of one of the arm of the V-string
4. Following with respect to vertical, half the string angle +15 deg, along the axis of one of the arm of the V-string

*** : The insulator string must be completely unloaded and examined, then the proper direction of loading established before proceeding to the next sequential test.

****: F denotes Failure load

The insulator string shall be deemed acceptable if, for all tests loads except failure load, the string components do not show any visual signs of deformation or fracture, and the same components may be disassembled by hand, except for removal of cotter pins and initial loosening of the nuts. The failure load shall be recorded and must be greater than all previous tests loads.

1.4 **Vibration Test**

The suspension string shall be tested in suspension mode, and tension string in tension mode itself in laboratory span of minimum 30 meters. In the case of suspension string, a load equal to 600 kg shall be applied along the axis of the suspension string by means of turn buckle. The insulator string along with hardware fittings and each sub-conductor tensioned at 25% of conductor UTS shall be secured with clamps. The system shall be suitable to maintain constant tension on each sub-conductor throughout the duration of the test. Vibration dampers shall not be used on the test span. All the sub-conductors shall be vertically vibrated simultaneously at one of the resonance frequencies of the insulators string (more than 10 Hz) by means of vibration inducing equipment. The peak to peak displacement in mm of vibration at the antinode point, nearest to the string, shall be measured and the same shall not be less than $1000/f^{1.8}$ where f is the frequency of vibration in cycles/sec. The insulator string shall be vibrated for not less than 10 million cycles without any failure. After the test, the insulators shall be examined for looseness of pins and cap or any crack. The hardware shall be examined for looseness, fatigue failure and mechanical strength test. There shall be no deterioration of properties of hardware components and insulators after the vibration test. The insulators shall be subjected to the Mechanical performance test as per relevant standards.

1.5 **AC Salt-fog pollution withstand test**

This test shall be carried out in accordance with IEC:60507. The salinity level for composite long rod insulators shall be 160 kg/m³ NaCl.

1.6 **DC pollution withstand test**

This test shall be carried out as per IEC 61245 with solid layer method. The D.C. pollution withstand voltage (negative) shall be 500kV for ± 500 kV HVDC insulators as applicable at average ESDD of 0.1 mg / sq cm.

For ± 800 kV HVDC, the D.C. pollution withstand voltage (negative) shall be 800 kV as applicable at average ESDD of 0.1 mg / sq. cm. The test is to be performed on Single suspension 'Y' String and Triple tension string preferably in the same configuration. However, in case of laboratory limitations to carry out the test in tension mode for Triple tension strings, the test may be carried out in vertical mode at the same ESDD level.

2.0 **Composite Longrod Insulator Units**

2.1 **Brittle Fracture Resistance Test**

The test arrangement shall be according to Damage limit proof test with simultaneous application of 1N-HNO₃ acid directly in contact with naked FRP rod. The contact length of acid shall not be less than 40mm and thickness around the core not less than 10mm. The rod shall withstand 80% of SML for 96 hours.

2.2 **Recovery of Hydrophobicity & Corona Test**

- (1) The surface of selected samples shall be cleaned with isopropyl alcohol. Allow the surface to dry and spray with water. Record the HC Hydrophobicity classification. Dry the sample surface.
- (2) The sample shall be subjected to mechanical stress by bending the sample over a ground electrode. Corona is continuously generated by applying 12 kV to a needle like electrode placed 1mm above the sample surface. The test shall be done for 100 hrs.
- (3) Immediately after the corona treatment, spray the surface with water and record the HC classification. The surface should be hydrophilic, with an HC value of 6 or 7. If not, dry the surface and repeat the corona treatment for a longer time until an HC of 6 or 7 is obtained. Dry the sample surface.
- (4) Allow the sample to recover and repeat the hydrophobicity measurement at several time intervals. Silicone rubber should recover to HC 1 – HC 2 within 24 to 48 hours, depending on the material and the intensity of the corona treatment.

2.3 **Recovery of Hydrophobicity Test**

- (1) The surface of selected samples shall be cleaned with isopropyl alcohol. Allow the surface to dry and spray with water. Record the HC classification. Dry the sample surface.
- (2) Treat the surface with corona discharges to destroy the hydrophobicity. This can be done utilizing a high frequency corona tester, Holding the electrode approximately 3mm from the sample surface, slowly move the electrode over an area approximately 1" x 1". Continue treating this area for 2–3 minutes, operating the tester at maximum output.
- (3) Immediately after the corona treatment, spray the surface with water and record the HC classification. The surface should be hydrophilic, with an HC value of 6 or 7. If not, dry the surface and repeat the corona treatment for a longer time until an HC of 6 or 7 is obtained. Dry the sample surface.
- (4) Allow the sample to recover and repeat the hydrophobicity measurement at several time intervals. Silicone rubber should recover to HC 1 – HC 2 within 24 to 48 hours, depending on the material and the intensity of the corona treatment.

2.4 **Silicone content test**

Minimum content of silicone as guaranteed by supplier shall be verified through FT-IR spectroscopy & TGA analysis or any other suitable method mutually agreed between Purchaser & Supplier in Quality Assurance Programme.

2.5 **High Pressure washing test**

The washing of a complete insulator of each E&M rating is to be carried out at 3800kPa with nozzles of 6mm diameter at a distance of 3m from nozzles to the insulator. The washing shall be carried out for 10 minutes. There shall be no damage to the sheath or metal fitting to housing interface. The verification shall be 1 minute wet power frequency withstand test at 275kV rms for 132 KV, 460kV rms for 220 KV & Metallic return insulators, 680 kV rms for 400 KV & 830kV rms for 765 KV Lines and 1 minute DC withstand test at -500 kV DC for ± 500 kV HVDC & -800 kV DC for ± 800 kV HVDC insulators.

2.6 **Torsion Test**

Three complete insulators of each E&M rating shall be subjected to a torsional load of 55 Nm. The torsional strength test shall be made with test specimen adequately secured to the testing machine. The torsional load shall be applied to the test specimen through a torque member so constructed that the test specimen is not subjected to any cantilever stress. The insulator after torsion test must pass the Dye Penetration Test as per IS 16784.

2.7 **Water diffusion test followed by pull-off test**

The same test samples should be used for water diffusion and for pull-off tests. Samples with rubber housing and one shed are to be cut approximately perpendicular to the axis of the insulator with a diamond-coated circular saw blade under running cold water. Three samples with one shed, per insulator, cut from the top, middle and bottom sections are to be used.

The water diffusion test shall be carried out on samples as prepared above as per Clause no. 9.4.2 of IEC 62217, except that the current during the whole test shall not exceed 0.5mA(r.m.s).

The Pull-off test shall be performed at 4 locations per shed (separated radially by 90°), for each of the 3 test samples taken from the insulator. A sample for the pull-off test shall be prepared from the shed by first making two cuts through the rubber shed and sheath along the axis of the insulator using a knife. The separation between the two parallel cuts should be 8 ± 3 mm at the surface of the core. Thereafter two parallel cuts, perpendicular to the insulator axis and separated 15 ± 5 mm apart, should be made above and below the shed. In this way a rectangular sample surface is created at the interface between rubber and core materials. The ultimate force required to pull off the rubber sample from the core should be recorded using a tensile machine, applying a fixed rate of elongation of 50 mm/min. The force should be applied perpendicular to the insulator axis by clamping one terminal of the equipment to the shed of the

housing sample while keeping the rest of the insulator part fixed. After the separation, the actual rectangular cross-section area of the sample interface between the housing and the rod should be measured using a sliding calliper. The ultimate breaking stress should be calculated as maximum applied force divided by material cross section area at housing-core interface. The test is passed if the average stress is more than 1.5 N/mm² (for each sample). The fracture after each test shall be photographed with a note if the fracture was adhesive (in the interface) or cohesive (inside the rubber housing). If the cohesive fracture occurs, a rectangular cross section should be interpolated by measurement of the rectangular sample surface as described above for the adhesive fracture.

3.0 Tests on All components (As applicable)

3.1 Chemical Analysis of Zinc used for Galvanizing

Samples taken from the zinc ingot shall be chemically analysed as per IS 209:1979. The purity of zinc shall not be less than 99.95%.

3.2 Tests for Forgings

The chemical analysis hardness tests and magnetic particle inspection for forgings, will be as per the internationally recognized procedures for these tests. The sampling will be based on heat number and heat treatment batch. The details regarding test will be as discussed and mutually agreed to by the Supplier and Purchaser in Quality Assurance Programme.

3.3 Tests on Castings

The chemical analysis, mechanical and metallographic tests and magnetic, particle inspection for castings will be as per the internationally recognized procedures for these tests. The samplings will be based on heat number and heat treatment batch. The details regarding test will be as discussed and mutually agreed to by the Supplier and Purchaser in Quality Assurance Programme.

3.4 Tests on FRP rod and silicon rubber compound

The SEM (Scanning Electron Microscopic) Analysis with EDS (Energy Dispersive Spectroscopy) on FRP rod cross-section, Surface analysis by optical spectrograph & FTIR Signature analysis will be as per internationally recognized procedures for these tests. The details regarding test will be as discussed and mutually agreed to by the Supplier and Purchaser in Quality Assurance Programme

A) Standard Technical Particulars of Composite Long Rod Insulator unit:

1. For Transmission Line upto 400 kV

Sl. No.	Description	Unit	132 kV AC	220 kV AC (single ZEBRA)		220 kV AC (Twin MOOSE)		400kV			
			90 KN	70 KN	120 KN	120KN	160KN	90KN	120KN	160KN	210KN
1	Size and Designation of Ball & Socket assembly	mm	16 mm (Alt-B)	16 mm (Alt-B)	20 mm	20 mm	20 mm	16mm (Alt-B)	20 mm	20 mm	24 mm
2	Core diameter*	mm	20	20	20	20	24	20	20	24	24
3	Nominal length	mm	1450	2030	2175	2030	2210	3335	3335	3910	3910
4	Minimum Creepage distance	mm	4495	7595	7595	7595	7595	13020	13020	13020	13020
5	No. of grading rings (min.)	Nos.	1	1	1	1	1	2	2	2	2
6	Nominal Outer Diameter of grading ring										
a)	Covered ring ***	mm	NA	NA	NA	NA	NA	300	300	300	300
b)	Other rings (Open type)	mm	200	200	200	200	200	300	300	300	300
7	Depth of grading ring (open type)	mm	105-125	105-125	105-125	105-125	140-150	105-125	105-125	140-150	140-150

2. For Transmission Line above 400 kV

Sl. No.	Description	Unit	765kV				± 500kV HVDC		± 800kV HVDC		Metallic return for ± 800kV HVDC	
			120 KN	160 KN	210 KN	320 KN	160 KN	210 KN	160 KN	420 KN	160 NN	210 KN
1	Size and Designation of Ball & Socket assembly	mm	20 mm	20 mm	24mm	24 mm	20 mm	24mm	20 mm	28mm	20 mm	24mm
2	Core diameter*	mm	20	24	24	32**	24	24	24	40**	24	24
3	Nominal length	mm	2900	2975	2975	2975	3485/3230	3485	4560	4560	2550	2550
4	Minimum Creepage distance	mm	12400	12400	12400	12400	13750	13750	16800	16800	8000	8000
5	No. of grading rings (min.)	Nos.	2	2	2	2	2	2	2	2	2	2
6	Nominal Outer Diameter of grading ring											
a)	Covered ring ***	mm	300	300	300	300	300	300	As per Manufacturers' specification			
b)	Other rings (Open type)	mm	370	370	370	370	370	370	As per Manufacturers' specification			
7	Depth of grading ring (open type)	mm	125-155	125-155	140-155	As per Manufacturers' specification						

Note:

* The core dia of composite insulators mentioned at Row No.2 is for indicative purpose. The bidder shall offer composite long rod insulators of suitable core dia, not less than the value specified above, to meet specified E&M and torsion strength requirements.

**For offered core dia, less than indicated in table above, the bidder shall submit documentary evidence of past supplies & satisfactory operation of the same for minimum period of three years. However, the overall string length shall be within the limits specified in the drawing.

*** Covered ring shall be required for Single I/ Double I suspension insulator strings only.

B) Standard Technical Particulars of Insulator Strings

1. For 132 kV Transmission Line

Sl. No.	Description	Unit	Standard Technical Particular Value			
			Single 'I' suspension string	Double 'I' suspension string	Single Tension string	Double Tension string
1.0	No. of Insulator Units	Nos.	1 x 1	2 x 1	1 x 1	2 x 1
2.0	pf withstand voltage under wet condition	kV (rms)	275			
3.0	Impulse withstand voltage (dry)					
a)	Positive	kV _p	650			
b)	Negative	kV _p	650			
4.0	Dry Arcing distance	mm	1200			
5.0	Mechanical strength	KN	90	2 x 90	90	2 x 90

2. For 220 kV Transmission Line

a) For 220 kV Transmission Line with single ZEBRA/HTLS conductor

Sl. No.	Description	Unit	Standard Technical Particular Value				
			Single 'I' suspension on string	Single 'I' suspension Pilot string	Double 'I' suspension on string	Single Tension string	Double Tension string
1.0	No. of Insulator Units	Nos.	1 x 1	1 x 1	2 x 1	1 x 1	2 x 1
2.0	pf withstand voltage under wet condition	kV (rms)	460				
3.0	Impulse withstand voltage (dry)						
a)	Positive	kV _p	1050				
b)	Negative	kV _p	1050				
4.0	Dry Arcing distance	mm	1800				
5.0	Mechanical strength	KN	70	70	2X 70	120	2 x 120

b) For 220 kV Transmission Line with twin MOOSE conductor

Sl. No.	Description	Unit	Standard Technical Particular value			
			Single 'I' Suspension	Single 'I' Suspension Pilot	Single Tension	Double Tension
1.0	No. of Insulator Units	Nos.	1 x 1	1 x 1	1 x 1	2 x 1
2.0	pf withstand voltage under wet condition	kV (rms)	460			
4.0	Impulse withstand voltage (dry)					
a)	Positive (Peak)	kV _p	1050			
b)	Negative (Peak)	kV _p	1050			
5.0	Dry Arcing distance	mm	1800			
6.0	Mechanical strength	kN	120	120	120	2 x 160

3. For 400 kV Transmission Line

a) 400 kV Transmission Line with twin MOOSE/ HTLS Conductor

Sl. No.	Description	Unit	Standard Technical Particular Value				
			Single V Suspension	Single 'I' Suspension	Single 'I' Suspension Pilot	Single Tension	Double Tension
1.0	No. of Insulator Units	Nos.	2 x 1	1 x 1	1 x 1	1 x 1	2 x 1
2.0	pf withstand voltage under wet condition	kV (rms)	680				
3.0	Switching withstand voltage (dry)						
a)	Positive (Peak)	kV _p	1050				
b)	Negative (Peak)	kV _p	1050				
4.0	Impulse withstand voltage (dry)						
a)	Positive (Peak)	kV _p	1550				
b)	Negative (Peak)	kV _p	1550				
5.0	Dry Arcing distance	mm	3050				
6.0	Mechanical strength	kN	90	120/ 160	120/ 160	120/ 160	2 x160/ 2 x 210

b) 400 kV Transmission Line with twin ACSR LAPWING Conductor

Sl. No.	Description	Unit	Standard Technical Particular Value			
			Single 'I' Suspension	Single 'I' Suspension Pilot	Single Tension	Double Tension
1.0	No. of Insulator Units	Nos.	1 x 1	1 x 1	1 x 1	2 x 1
2.0	pf withstand voltage under wet condition	kV (rms)	680			
3.0	Switching withstand voltage (dry)					
a)	Positive (Peak)	kV _p	1050			
b)	Negative (Peak)	kV _p	1050			
4.0	Impulse withstand voltage (dry)					
a)	Positive (Peak)	kV _p	1550			
b)	Negative (Peak)	kV _p	1550			
5.0	Dry Arcing distance	mm	3050			
6.0	Mechanical strength	kN	160	160	160	2 x 210

c) 400 kV Transmission Line with triple ACSR SNOWBIRD Conductor

Sl. No.	Description	Unit	Standard Technical Particular Value			
			Double 'I' Suspension	Single 'I' Suspension Pilot	Single Tension	Double Tension
1.0	No. of Insulator Units	Nos.	2 x 1	1 x 1	1 x 1	2 x 1
2.0	pf withstand voltage under wet condition	kV (rms))	680			
3.0	Switching withstand voltage (dry)					
a)	Positive (Peak)	kV _p	1050			
b)	Negative (Peak)	kV _p	1050			
4.0	Impulse withstand voltage (dry)					
a)	Positive (Peak)	kV _p	1550			
b)	Negative (Peak)	kV _p	1550			
5.0	Dry Arcing distance	mm	3050			
6.0	Mechanical strength	kN	2 x 120	120	120	2 x 210

d) 400 kV Transmission Line with quad MOOSE Conductor

Sl. No.	Description	Unit	Standard Technical Particular Value			
			Double 'I' Suspension	Single 'I' Suspension Pilot	Single Tension	Quadruple Tension
1.0	No. of Insulator Units	Nos.	2 x 1	1 x 1	1 x 1	4 x 1
2.0	pf withstand voltage under wet condition	kV (rms)	680			
3.0	Switching withstand voltage (dry)					
a)	Positive (Peak)	kV _p	1050			
b)	Negative (Peak)	kV _p	1050			
4.0	Impulse withstand voltage (dry)					
a)	Positive (Peak)	kV _p	1550			
b)	Negative (Peak)	kV _p	1550			
5.0	Dry Arcing distance	mm	3050			
6.0	Mechanical strength	kN	2 x 120	120	120	4 x 160

4. For 765 kV Transmission Line

a) 765 kV Single Circuit Transmission Line

Sl. No.	Description	Unit	Standard Technical Particular Value						
			Single ' V' Suspension	Double ' I' Suspension	Double ' V' Suspension	Single ' V' Suspension Pilot	Single ' I' Suspension Pilot	Single Tension	Quadruple Tension
1.0	No. of Insulator Units	Nos.	2 x 2	2 x 2	2 x 2 x 2	2 x 2	1 x 2	1 x 2	4 x 2
2.0	pf withstand voltage under wet condition	kV (rms)	830						
3.0	Switching withstand voltage (dry)								
a)	Positive (Peak)	kV _p	1550						
b)	Negative (Peak)	kV _p	1550						
4.0	Impulse withstand voltage (dry)								
a)	Positive (Peak)	kV _p	2400						
b)	Negative (Peak)	kV _p	2400						
7.0	Dry Arcing distance	mm	5100						
8.0	Mechanical strength	kN	210 along each	240	2 x 210 along each	120 along each	120	120	4 x 210

b) 765 kV Double Circuit Transmission Line

Sl. No.	Description	Unit	Standard Technical Particular Value			
			Double 'I' Suspension	Single 'I' Suspension Pilot	Single Tension	Quadruple Tension
1.0	No. of Insulator Units	Nos.	2 x 2	1 x 2	1 x 2	4 x 2
2.0	pf withstand voltage under wet condition	kV (rms)	830			
3.0	Switching withstand voltage (dry)					
a)	Positive (Peak)	kV _p	1550			
b)	Negative (Peak)	kV _p	1550			
4.0	Impulse withstand voltage (dry)					
a)	Positive (Peak)	kV _p	2400			
b)	Negative (Peak)	kV _p	2400			
5.0	Dry Arcing distance	mm	5100			
6.0	Mechanical strength	kN	2 x 160/ 2 x 210	160/ 1 x 210	160/ 1 x 210	4 x 210/ 4 x 320

5. For ± 500 kV HVDC Transmission Line

a) ± 500 kV HVDC Line with quad ACSR BERSIMIS Conductor

Sl. No	Description	Unit	Standard Technical Particular Value	
			Single 'V' Suspension string	Quad Tension string
1.0	No. of Insulator Units	Nos.	2 x 2	4 x 2
2.0	DC withstand voltage under wet condition	kV	550 (negative)	
3.0	Impulse withstand voltage (dry)			
a)	Positive (Peak)	kV _p	1800	
b)	Negative (Peak)	kV _p	1800	
4.0	Switching Withstand voltage (dry)			
a)	Positive (Peak)	kV _p	1000	
b)	Negative (Peak)	kV _p	1000	
5.0	Dry Arcing distance	mm	3050	
6.0	Mechanical strength	kN	2 x 210	4 x 160

b) ± 500 kV HVDC Line with quad ACSR LAPWING Conductor

Sl. No	Description	Unit	Standard Technical Particular Value	
			Single 'V' Suspension string	Quad Tension string
1.0	No. of Insulator Units	Nos.	2 x 2	4 x 2
2.0	DC withstand voltage under wet condition	kV	550 (negative)	
3.0	Impulse withstand voltage (dry)			
a)	Positive (Peak)	kV _p	1800	
b)	Negative (Peak)	kV _p	1800	
4.0	Switching Withstand voltage (dry)			
a)	Positive (Peak)	kV _p	1000	
b)	Negative (Peak)	kV _p	1000	
5.0	Dry Arcing distance	mm	3050	
6.0	Mechanical strength	kN	2 x 210	4 x 210

6. For ± 800 kV HVDC Transmission Line

Sl. No.	Description	Unit	± 800kV HVDC Strings			132kV Metallic Return Strings	
			Single ‘Y’ Suspension string	Triple Tension string	Single I Suspension Pilot string	Single ‘I’ Suspension string	Double Tension string
1.0	No. of Insulator Units	Nos.	2x2 (V-portion) & 1x2 (II-portion)	3 x 3	1 x 3	1 x 1	2 x 1
2.0	Mechanical strength of complete insulator string along with hardware fittings	kN	420 (along one limb of V-portion and along II portion)	3 x 420	1 x 160	160	2 x 210
3.0	DC withstand volt-age for DC/ Power frequency withstand voltage for metallic return of string with arcing horns, corona control rings/ grading rings under wet condition	kV (rms)	800 (negative)			460	
4.0	Impulse withstand voltage (dry)						
a)	Positive (Peak)	kV _p	2250			1050	
b)	Negative (Peak)	kV _p	2250			1050	
5.0	Switching Withstand voltage (dry)						
a)	Positive (Peak)	kV _p	1850			NA	
b)	Negative (Peak)	kV _p	1850			NA	
6.0	Minimum corona extinction voltage under dry condition	kV	880			NA	
7.0	Radio interference voltage at one MHZ when the string subjected to conductor surface gradient of 22kV/cm (±DC)	Micro volt	<1000			NA	
8.0	DC pollution withstand voltage test	kV	800 (negative)			NA	

SECTION-IXA

PILE FOUNDATION

TECHNICAL SPECIFICATIONS

SECTION-IXA

PILE FOUNDATION

Revision History

Revision No.	Date	Clause Ref	Remarks
Rev-0	June'2021		First Release
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TECHNICAL SPECIFICATIONS

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SECTION- IXA

PILE FOUNDATION

1.0 Scope and General Information

1.1 General

This section covers the specification for pile foundation work envisaged in the packages under this technical specification.

1.2 Applicable When Design of Pile foundation is in Contractor's Scope

1.2.1 Scope

1.2.1.1 The work to be performed under this specification consists of design of pile foundation as per soil investigation reports, design criteria & other hydrological parameters, boring in all kinds of soil including weathered rock, fissured rock, hard rock, shale etc., providing and installation of cast-in-situ RCC vertical bored piles of diameter 750 mm or more of suitable length as per design, providing all labor, materials, supervision, dewatering, scaffolding, platforms, boring and construction equipment's & machineries, tools, tackles and plants, supplies, power, fuel, transportation on land and water, all incidental items not shown or specified but reasonably implied or necessary for successful and timely completion of work including Contractor's supervision in strict accordance with IS Codes, Employer's design criteria and specifications. The nature of work shall generally involve design, construction/ installation of cast-in-situ RCC vertical bored piles of suitable diameter of any length, pile caps, pedestals, tie beam (if required) etc. as per the site condition & Geo-technical investigation/ hydrological reports and also co-ordination with tower erection contractor for setting of stubs/ fixing of anchor bolts (as the case may be) for River crossing locations and installation of earthing for installed pile foundations. After review of each design/ drawing by the employer, the same shall be vetted by reputed institutions like IIT/NIT etc., which shall be finally approved by Employer based on the recommendation of the institution.

1.2.1.2 The bidder shall furnish in their bid complete data regarding his previously designed & successfully installed pile foundation experience and method of installation of the pile foundations, complete list of equipment's, tools and tackles, rigs, men, materials to be deployed for the work etc. Bidder has to furnish one sample calculation for one pile foundation designed/ got designed & installed successfully along with the bid. The above data is for assessing the present design capability of the Bidder and should not be construed as review/ approval of correctness of drawings/ designs by the Employer. Subsequent to the award,

successful Bidder shall have to comply to the technical specifications irrespective of the drawings/ designs submitted at the bidding stage without any financial implication to the Employer.

- 1.2.1.3 The rates quoted by bidder in the BPS shall be treated as firm. In case any significant deviation from the input parameters is noticed during the actual execution at site and the Employer considers it to be fit for change of price, mutually agreed rates for the pile foundation shall be derived on the basis of rates available in the Contract.
- 1.2.1.4 The Bidder's offer should be based on the mobilization of at least one no. piling rig for each tower location together with all associated working gangs, tool etc. (including at least one no. of Rotary Hydraulic drilling rig capable of boring suitable diameter piles up-to designed depth below existing ground level with necessary tools/ accessories for boring). However, if extra rigs are required to be deployed by the Contractor to match with the project construction schedule, the same shall be deployed without any additional cost to the Employer. The contractor has to execute the complete job as per soil strata actually encountered at the time of construction.
- 1.2.1.5 The Contractor shall be responsible for the soundness of the above pile foundations designed & installed/ constructed by them.
- 1.2.1.6 After completion of installation/ construction of piles, pile integrity test shall be conducted for each pile by the contractor, in presence of Employer's representative, to establish its soundness. The numbers and procedure for conducting of pile integrity test is given briefly at *Clause 4.0* of this Section. Cost of carrying these tests is deemed to be included in the price quoted by the bidder for pile design & installation. Bidder has to quote the price accordingly.
- 1.2.1.7 The setting of stub/ fixing of foundation anchor bolts (as indicated in the drawing) shall be the responsibility of the Contractor.
- 1.2.1.8 The Bidder shall quote against the quantity furnished in BPS. Approach road, provision of platforms/ barges etc. for construction/ installation of pile foundations is deemed to be included in the scope of works. No deviation in this respect will be acceptable and any bid quoted based on different Bill of Quantities shall be liable for rejection.
- 1.2.2 **Sub-Soil Data**
- The detailed soil investigation for the river crossing locations where pile foundations are envisaged shall be carried out by the Employer and provided to the bidders.

1.2.3 Design and Drawings

The Contractor shall develop the pile foundation design and drawing based on the soil investigation report, site conditions for the particular location and design criteria as mentioned below and submit for employer's approval as per mentioned in **Clause no. 1.2.1.1** above.

1.2.4 Design Criteria for Pile Foundation

1.2.4.1 General

The pile design shall be done in accordance with the latest version of IS 2911 (Part-I/ Section 2).

1.2.4.2 Spacing of piles

The minimum center to center spacing of piles shall be as following:

- a) Piles in rock / Resting on rock: 2 times diameter of pile.
- b) Piles deriving the capacity mainly from end bearing i.e. good value of ϕ ($\phi \geq 30^\circ$): 2.5 times diameter of pile.

For all other type of soils (where the load carrying capacity of the pile is mainly due to friction): 3 times diameter of pile.

1.2.4.3 Mean Scour Depth

- a) The mean depth of scour below HFL for the design of Pile located in/ around river shall be taken as per Clause 703 of IRC 78: 2014 or Lacey formula.
- b) Formula given in Clause 703 of IRC 78 shall be used for natural channel or river with defined boundary whereas Lacey formula shall be used for rivers with undefined boundaries. The maximum discharge/ maximum velocity furnished by CWC/ Local Authority/ Employer shall be used for determination of Scour depth.
- c) Silt factor shall be calculated based on weighted mean diameter (in mm) of the particle size of silt furnished by soil investigating agency based on laboratory test result of samples collected from bore hole for particular location for river bed/ bank obtained upto level of anticipated deepest scour.

1.2.4.4 Maximum Scour Depth:

- a) For Piles located in midstream/ near the river bank/ erodible strata/ location prone to erosion due to river course meandering, maximum depth of Scour shall be taken as 2 (two) times of the mean scour depth. The portion of pile upto Scour depth shall not be considered for calculating capacity of pile.
- b) If piles are provided for location other than river/ bank of the river/ erodible strata, where possibility of scouring is nil/ negligible and corrected SPT value is not more than 10, the soil upto that depth shall not be considered to provide any support to pile system/ group.

1.2.4.5 Fixity

- a) Piles shall be designed as per Annexure 'C' of IS 2911 (Part 1/Sec 2) for Lateral load. To calculate fixed head moment ' M_F ' of the equivalent cantilever, Pile embedded into pile cap shall be treated as partially fixed (i.e., restrained against rotation, not restraint against position). Accordingly, equivalent length of cantilever piles shall be taken as 1.2 times of total virtual cantilever length (i.e. $E + Z_F$) of pile.
- b) Then fixed end moment given in Clause 6.5.2 & C-4.3 of Annexure 'C' of IS 2911(Part I/Sec 2: 2010) shall be

$$M_F = 0.6 \times H \times (E + Z_F)$$

Where H = lateral load in kN

E = cantilever length above ground/ bed to the point of load application, in m

Z_F = depth to point of fixity

1.2.4.6 Factor of Safety (F.O.S)

- a) Factor of Safety is the ratio of ultimate load capacity of a pile to safe load on the pile.
- b) The Ultimate load capacity of Pile/ pile group shall be determined as per Clause 6.3 and Annexure-B of IS 2911 (Part 1/Sec 2):2010 using Static formula.
- c) Minimum F.O.S as per Clause 6.8 of IS 2911 (Part 1/Sec 2) using static formula shall be considered.

1.2.4.7 Bearing Capacity factors

Bearing Capacity factors shall be as per IS 2911 (Part 1/sec 2): 2010.

1.2.4.8 Other design parameters

Other design parameters such as Angle of wall friction (δ), Earth pressure coefficient (K), Effective over burden (P_{DI}), Embedment of pile in pile cap, Stiffness factors (T & R) and Socket length of pile in weathered / soft rock /hard rock shall be as per IS 2911 (Part 1/ Sec 2):2010.

1.2.5 Billing Breakup

For progressive payments, the billing break-up shall be made during execution.

1.3 Applicable When Design of Pile foundation is not in Contractor's Scope and Employer shall provide construction drawings to the Contractor

1.3.1 Scope

1.3.1.1 The work to be performed under this specification consists of boring in all kinds of soil including weathered rock, fissured rock, hard rock, shale etc., providing and installation of cast-in-situ RCC vertical bored piles of diameter, as specified in BPS, providing all labor, materials, supervision, dewatering, scaffolding, platforms, boring and construction equipment's & machineries, tools, tackles and plants, supplies, power, fuel, transportation on land and water, all incidental items not shown or specified but reasonably implied or necessary for successful and timely completion of work including Contractor's supervision in strict accordance with IS Codes, drawings and specifications. The nature of work shall generally involve construction/installation of cast-in-situ RCC vertical bored piles of specified diameter, pile caps, pedestals, tie beam (if required) etc. as per the Employer's construction drawings and also co-ordination with tower erection contractor for setting of stubs/ fixing of anchor bolts (as the case may be) for River crossing locations

1.3.1.2 The bidder shall furnish in their bid complete data regarding method of installation of the pile foundations, complete list of equipment's, tools and tackles, rigs, men, materials to be deployed for the work etc.

1.3.1.3 The Bidder's offer should be based on the mobilization of at least one no. piling rig for each tower location together with all associated working gangs, tool etc. (including at least one no. of Rotary Hydraulic drilling rig capable of boring of specified diameter piles up-to designed depth below existing ground level with necessary tools/accessories for boring). However, if extra rigs are required to be deployed by the Contractor to match with the project construction schedule, the same shall be deployed without any additional cost to the Employer. The contractor has to execute the complete job as per soil strata actually encountered at the time of construction.

- 1.3.1.4 The Contractor shall be responsible for the soundness of the above pile foundations designed & installed/constructed by them.
- 1.3.1.5 After completion of installation/ construction of piles, pile integrity test shall be conducted for each pile by the contractor, in presence of Employer's representative, to establish its soundness. The numbers and procedure for conducting of pile integrity test. Cost of carrying these tests is deemed to be included in the price quoted by the bidder for pile design & installation. Bidder has to quote the price accordingly.
- 1.3.1.6 The setting of stub/ fixing of foundation anchor bolts (as indicated in the drawing) shall be the responsibility of the Contractor.
- 1.3.1.7 Approach road, provision of platforms, cofferdam, transportation through barges/ jetties, river training etc., if required for construction/ installation of pile foundations is in the scope of works.

In case pile foundation location is at river bank or outside of river banks (non-midstream location), the cost of these items or any other item, if required for completion of pile foundation work shall be deemed to be included by the bidder in the quoted price of BPS items other than for midstream locations.

In case pile foundation location is in midstream of river (mid stream location) i.e. between river banks irrespective of presence of water, or in island within river banks, the bidder may quote price for approach road, provision of platforms, cofferdam, transportation through barges/ jetties, river training etc. in BPS under head " Extra rate over item..... in midstream location" as described in BPS

No deviation in this respect shall be acceptable and any bid quoted based on different Bill of Quantities shall be liable for rejection.

The categorization of a location falling under non-midstream location or midstream location shall be decided by Region with due approval from Head of Region.

1.3.2 Sub-soil Data

The detailed soil investigation for the locations where pile foundations are envisaged shall be carried out by the Contractor (if mentioned in the BPS).

1.3.3 Design and Drawings

Employer shall develop the pile foundation design based on the soil investigation

report for the particular location. The construction drawings required for execution of pile foundations shall be given to the contractor as per site requirement during execution stage.

2.0 Construction of Bored Cast-In-Situ Pile Foundation

2.1 General Requirement

2.1.1 The specification covers the technical requirements for piling work, general description of work, quality and workmanship. In every case, work shall be carried out to the satisfaction of the Employer in accordance with the Technical Specifications and conform to location, lines, grades and cross sections shown on the construction drawing or as directed by the Employer. The specifications are not, however, intended to cover all the minute details and the work shall be executed according to the specified Indian Codes. In absence of the IS Codes, work shall be executed according to the best prevailing local Public Works Department practice or to the recommendations of the relevant International Standards or to the instructions of the Employer. This specification shall have precedence in case anything contrary to this is stated anywhere in this Bid Document. In case of conflict between the Specification and Codes, the former shall prevail.

2.1.2 The work shall include mobilization of all necessary equipments, providing necessary engineering supervision through qualified and technical personnel, skilled and unskilled labour, etc. as required to carry out the complete piling work. The minimum capacities of some key equipment are listed below. However, bidder has to furnish information regarding the equipments they intend to deploy for the project as per Performa stipulated in the relevant schedules of the BPS: -

Sl. No.	Description	Capacity
1.	Tripod height	6m to 10m (clear drop)
2.	Rig (winch) capacity	3 T to 5T
3.	Weight of chisel	2T to 3T
4.	Mud pump capacity	15 HP to 25 HP
5.	Dia. of outlet pipe for bentonite	2.5 inch
6	Hydraulic rotary drilling rig along with all accessories	Minimum torque of 12T

Note: Bidder may have to provide higher capacity equipments than mentioned above, as per the actual requirement for the execution of the job, without any additional financial implication to Employer.

2.2 Layout and Levels

2.2.1 Layout and levels of structures etc. shall be made by the Contractor, at his own cost, from the general grid of the plot and the bench marks given by the Employer. The Contractor shall make his own arrangements, at his own cost, for locating the co-ordinates and position of piles as per approved drawings and for determining the Reduced Level (R.L.) of the locations with respect to the single bench mark indicated by the Employer. Two established reference lines in mutually

perpendicular direction shall be indicated to the Contractor. The Contractor shall provide at site all the required survey instruments, materials and men to Employer for verification of the detailed layout and correctness of the layout and levels to the satisfaction of the Employer so that the work can be carried out accurately according to specifications and approved drawings. The contractor shall be solely responsible for the correctness of layout and levels. Approach road details also to be included in the layout.

2.3 Site Preparation

This section of the specification covers site preparation of the areas as indicated in the drawings.

- 2.3.1 The area shall be stripped to remove roots of grass, rubbish and slush, shrubs or other organic materials. Spoiled materials shall be burnt or removed to approved disposal areas on or near the job site as directed by the Employer.

2.4 Properties of Construction Materials

This clause specifies the properties of common building materials unless otherwise mentioned in the drawings or schedule of items.

All materials viz., cement, steel, aggregates, water etc. which are to be used for pile construction are detailed below. However, aggregates more than 20mm shall not be used, except for lean concrete.

2.4.1 Coarse aggregates/ Stone

- 2.4.1.1 All coarse aggregates shall be as per IS 383 consisting of hard, strong, compact grained and durable pieces of crushed stone having uniform in texture and colour and free from decay, flaws, veins, cracks and sand holes. Coarse aggregates should be of angular shape & rectangular surface and shall be free from organic or clay coatings and other impurities like disintegrated stones, soft flaky particles, adherent coatings, clinkers, slag, mica and any other materials liable to affect the strength, durability or appearance of concrete. The surface of a freshly broken stone shall be bright, clean, and free from any dull, chalky or earthy appearance. Coarse aggregates with round surface shall not be used. Coarse aggregates shall not absorb more than 5% of its weight of water after 24 hours immersion. Samples shall be submitted by the Contractor and approved samples shall be retained by the Employer for comparison of bulk supply.

- 2.4.1.2 Sieving and washing of aggregates by approved method shall be carried out wherever required.

2.4.1.3 Grading of coarse aggregate shall generally conform to IS 383 and shall be such as to produce a dense concrete of the specified proportions and strength and of consistency that will work readily into position without segregation.

2.4.1.4 The maximum size of aggregate shall be as follows unless specified otherwise:

- | | | |
|------|---|--------|
| i) | Reinforced concrete with very narrow space: | 10mm |
| ii) | Reinforced concrete & Plain Concrete | : 20mm |
| iii) | Lean Concrete 1:3:6 or 1:4:8 | : 40mm |

2.4.2 Cement

Cement used shall generally be ordinary Portland Cement conforming to the latest Indian Standard Code IS 8112 or IS 12269. Alternatively, other varieties of cement other than ordinary Portland Cement such as Portland Pozzolana Cement conforming to IS 1489 or Portland Slag Cement conforming to IS 455 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 and as mentioned in the construction drawing. No additional payment shall be made for using Sulphate Resistant Cement.

For foundation in creek, exposed to sea water/ coastal environment, or buried aggressive soil areas, tidal zone etc., ready mix concrete/ design mix concrete using Portland Pozzolana Cement conforming to IS 1489 shall preferably be used.

2.4.3 Sand

Sand shall be hard, durable, clean and free from any adherent coatings or organic matter and shall not contain clay balls or pellets. The sand shall be free from impurities such as iron pyrites, alkalis, salts, coal, mica, shale or other laminated materials, in such forms or quantities as to affect adversely the hardening, strength, durability or appearance of concrete or to cause corrosions to any metal in contact with such concrete. In no case the cumulative percentage of impurities in sand shall be more than 5% by weight. All sand shall be properly graded. Unless otherwise directed by the Employer all sand shall pass through IS Sieve no. 2.36 mm. Sand for concrete shall conform to IS 383.

2.4.4 Water

Water shall be clean, fresh and free from organic matters, acids or soluble salts and other deleterious substances which may cause corrosion, discoloration, efflorescence etc. Potable water is generally considered fit for use. Water to be used shall comply with the requirements of IS 456. Average 28 days compressive strength of at least three 15 cm. cubes of concrete prepared with proposed water shall not be less than 90% of average strength of three similar cubes prepared with distilled water. PH of water shall generally be not less than 6.

2.4.5 Reinforcement

Reinforcement steel shall be clean and free from loose mill scales, dust, loose rust, oil and grease or other coatings which may impair proper bond. Reinforcement shall conform to IS 1786 for deform and cold twisted bars (Fe 500/ Fe500D/ Fe 550 / Fe 550D). If mentioned in the approved drawing, epoxy coated reinforcement shall conform to IS 13620. 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. Hard drawn steel wire fabric shall conform to IS 1566. All steel bars including and above 6mm diameter shall be of tested for quality. Substitution of reinforcement, other than those mentioned above, shall not be permitted without the prior approval of the Employer. 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. Spacers, chairs, stays, hangers and annealed steel wire for bending etc. as may be necessary, should be used for proper completion of foundation job. Spacers or chairs should be placed at a maximum spacing of 1 m and closer spacing shall be provided wherever necessary.

For foundation in creek, exposed to sea water /coastal environment, or buried aggressive soil areas, tidal zone etc., epoxy coated reinforcement conforming to IS 13620 shall be used.

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

2.5 Storage & Handling of construction Materials

All materials shall be stored by the Contractor in a manner aiding convenient access for identification and inspection at all times. The storage arrangements shall be subject to the approval of the Employer. Storage of materials shall be as described in IS 4082.

All materials shall be so stored as to prevent deterioration or intrusion of foreign matter and to ensure the preservation of their quality and fitness for the work. Any material which has deteriorated or has been damaged or is otherwise considered defective by the Employer shall not be used for concrete, and shall be removed from site immediately, failing which, the Employer will get the materials removed and the cost thereof shall be recovered from contract price. The Contractor shall maintain up to date accounts of receipt, issue and balance (stock wise) of all materials.

2.5.1 Cement

The cement shall be stored in dry enclosed shed, well away from the walls and insulated from the floor to avoid contact with moisture. The cement shall be stacked in easily countable stacks to facilitate removal of first in first out basis. The cement bags shall be gently kept on the floor to avoid leakage of cement from the bags. Sub-standard or partially set cement shall be immediately removed from the site as soon as it is detected. Cement stored for period beyond 90 days shall be tested before use.

2.5.2 Coarse Aggregates and Sand

All coarse aggregates & sand shall be stored on brick soling or an equivalent platform so that they do not come in contact with dirt, clay, grass or any other injurious substance at any stage. Aggregate of different sizes shall be kept in separate and easily measurable stacks. If so desired by the Employer, aggregates from different sources shall be stacked separately with proper care to prevent intermixing.

2.5.3 Reinforcement

For each classification of steel, separate areas shall be earmarked. It is desirable that ends of bars and sections of each class be painted in distinct separate colors. Steel reinforcement shall be stored in such a way as to avoid distortion and to prevent deterioration and corrosion. It is desirable to coat reinforcement with cement wash before stacking to prevent scaling and rusting in case of storage time exceeding one month. In store, reinforcement bar shall be stacked above ground level by at least 150mm either on brick/cement/stone platform or concrete/brick planks.

2.6 Cement Concrete

2.6.1 General

- 2.6.1.1 This section of the specification deals with cement concrete, plain or reinforced, and covers the requirement for concrete mix design, strength and quality, pouring

at all levels, forming, protection, curing finishing, admixtures, inserts and other miscellaneous works.

2.6.1.2 The provisions of IS 456 shall be complied with, unless permitted otherwise. Any other Indian Standard Code shall form the part of the specification to the extent it has been referred to or applicable within this specification.

2.6.1.3 The Contractor shall furnish all labour, material and equipment to form, place and finish all structural concrete, concrete works and miscellaneous items complete, as described herein.

2.6.2 **Admixtures**

2.6.2.1 The admixtures in concrete for promoting workability, improving strength or for any other purpose shall be used only after the written permission from the Employer. The Admixtures shall conform to IS 9103.

2.6.2.2 Admixtures should not impair durability of concrete nor combined with the constituent to neither form harmful compounds nor increase the risk of corrosion of reinforcement.

2.6.2.3 Addition of admixtures should not reduce the specified strength of concrete in any case. The workability, compressive strength and the slump loss of concrete with and without the use of admixtures shall be established during the trial mixes before use of admixtures.

2.6.2.4 The chloride content of admixtures shall be independently tested for each batch before acceptance.

2.6.2.5 If two or more admixtures are used simultaneously in the same concrete mix, data shall be provided to assess their interaction and to ensure their compatibility.

2.6.2.6 In case admixtures are used in the concrete for any structure, fresh mix design shall be done considering the admixture with the specific approval from Employer. No extra payment shall be made to the Contractor on this account.

2.6.3 **Grades of Concrete**

2.6.3.1 The minimum grade of concrete to be used for piling shall be M25 with minimum cement content 400 kg/m³ and maximum water cement ratio of 0.5. Concrete shall conform to the controlled design mix as specified in IS 456. For lean concrete of nominal mixes of 1:3:6 and/ or 1:4:8 (with aggregates of nominal size 40 mm maximum, by weight converted to equivalent volume) shall also be used as per field quality plan. The concrete in aggressive surroundings due to presence of sulphate, etc., shall conform to IS 456. The slump of concrete shall be maintained

between 150 to 180 mm.

- 2.6.3.2 The Contractor shall carry out concrete mix design in accordance with IS 10262 and submit mix design calculations and get them approved from the Employer well in advance of installation of pile foundations. The Contractor shall carry out adequate number of tests in accordance with IS 456 to ensure concrete of the minimum specified strength at requisite workability (i.e. slump).
- 2.6.3.3 For foundation in coastal areas or creek or aggressive soil areas or under marine environment, Ready Mix Concrete of grade as specified in BPS/Section-I shall be used in RCC vertical bored piles, pile caps, pedestal/ Chimney, tie beam. However, design mix concrete of Grade, as mentioned in above, conforming to IS 456 with potable water can be used at locations where transportation of ready-mix concrete is not feasible. Minimum cement content shall be as per IS 456. However, in any case cement content shall not be less value than 400 kg/m³. 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/ chimney/ tie beam & base slab/ pile cap). 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. Three coats of anti-corrosive paint of minimum 30-35 microns dry film thickness each shall be applied on the stub upto 50 mm below chimney level and 350 mm above chimney level. 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.

2.6.4 **Workmanship**

All workmanship shall be according to the current Industry standard and best practices.

Before starting a pour the Contractor shall obtain the approval of the Employer in a "Pour Card" maintained for this purpose. He shall obtain complete instructions

about the material and proportions to be used, Slump/ workability, quantity of water per unit weight of cement, number of test cubes to be taken, type of finishing to be done, any admixture to be added, any limitation on size of pour and stopping of concrete in case of premature stopping of pours.

Mixing of Concrete

- 2.6.4.1 All design mix concrete shall be mixed in mechanically operated mixer of an approved size and type capable of ensuring a uniform distribution on the materials through the mass. However, contractor can also use central batching plant situated within the area allocated for the Contractor's particular use.
- 2.6.4.2 The proportions of sand, coarse aggregate, cement and water shall be as determined by the mix design. However, in case of nominal mix concrete (for lean concrete only) the proportions of sand, coarse aggregate, cement and water shall be fixed. The proportions, as determined for design mix concrete and shall always be approved by the Employer. The quantities of the cement, sand and coarse aggregates shall be determined by weight. The water shall be measured accurately after giving proper allowance for surface water present in the aggregate for which regular check shall be made by the Contractor.
- 2.6.4.3 The water shall not be added to the mix until all the cement and aggregates consisting the batch are already in the drum and dry mixed for at least one minute. Mixing of each batch shall be continued until there is a uniformity in colour and consistency but in no case shall mixing be done for less than two (2) minutes and at least forty (40) revolutions after all the materials and water are in the drum. When absorbent aggregates are used or when the mix is very dry, the mixing time shall be extended as may be directed by the Employer. Mixers shall not be loaded above their rated capacity as it prevents thorough mixing. If there is segregation after unloading from the mixer the concrete should be remixed.
- 2.6.4.4 The entire contents of the drum shall be discharged before the ingredients for the next batch are fed into the drum. No partly set or remixed or excessively wet concrete shall be used and it shall be immediately removed from site. Each time the work stops, the mixer shall be thoroughly cleaned and when the next mixing commences, the first batch shall have 10% additional cement at no extra cost to the Employer to allow for loss in the drum.
- 2.6.5 **Conveying Concrete**
- 2.6.5.1 Concrete shall be handled and conveyed from the place of mixing to the place of final laying as rapidly as practicable, by approved means, before the initial setting of the cement starts. Concrete should be conveyed in such a way as will prevent segregation of Concrete which may occur during transportation of concrete. In case of any such segregation during transport, the concrete shall be re-mixed.

During very hot or cold weather, if directed by the Employer, concrete shall be transported in deep containers, having mortar leak proof, which will reduce the rate of water loss by evaporation and loss of heat. Conveying equipment for concrete shall be well maintained and thoroughly cleaned before commencement of concrete mixing. Such equipment shall be kept free from set concrete.

2.6.6 Placing of Concrete

- a) Formwork and placement of reinforcement shall be approved in writing by the Employer before concrete is placed. The forms shall be well wetted and oil shavings, dirt and water that may have collected at the bottom shall be removed before concrete is placed. Concrete shall be deposited in its final position without segregation, re-handling or flowing. The interval between adding the water to the dry materials in the mixer and the completion of the final placing inclusive of compaction of the concrete shall be well within the initial setting time for the particular cement in use or as directed by the Employer. As far as possible, concrete shall be placed in the formwork by means approved by the Employer and shall not be dropped from a height or handled in a manner which may cause segregation. Any drop over 1800 mm shall have to be approved by the Employer. Once the concrete is deposited in its final position, it shall not be disturbed. Care should be taken to avoid displacement of reinforcement or movement of formwork.
- b) The placing of concrete shall be a continuous operation with no interruption in excess of 30 minutes between the placing of continuous portions of concrete.
- c) After the concrete has been placed it shall be spread and thoroughly compacted by approved mechanical vibration to a maximum subsidence without segregation and thoroughly worked around reinforcement or other embedded fixtures into the correct form and shape. Vibrators shall not be used for pushing and shoveling concrete into adjoining areas. Vibrators must be operated by experienced men and over-vibration shall not be permitted. Head tamping in some case may be allowed subject to the approval of the Employer. Care must be taken to ensure that the inserts, fixtures, reinforcement and form work are not displaced or disturbed during placing of concrete. No concrete shall be placed in open while it rains. If there has been any sign of washing of cement and sand, the concrete shall be entirely removed immediately. Suitable precautions shall be taken in advance to guard against rains before leaving the fresh concrete unattended. No accumulation of water shall be permitted on or around freshly laid concrete. Tie beams, pile caps, footings shall be poured in one operation normally, in special circumstances with the approval of the Employer these can be poured in horizontal layers not exceeding 500 mm in depth. When poured in layers, it must be ensured that the under layer, is

not already hardened. Blending of under layer if any, shall be effectively removed.

- d) Wherever vibration has to be applied externally the design of formwork and the disposition of vibrators shall receive special consideration to ensure efficient compaction and to avoid surface blemishes.

2.6.7 Inserts

All anchors, anchor bolts, inserts, stubs, etc. and any other items those are required to be embedded in the concrete shall be placed in correct position before pouring. Extra care shall be taken during pouring operation to maintain their position as indicated in the drawings. These inserts shall be welded to the nearest reinforcement to keep them in position and all such welding shall be deemed to be included in the unit rate quoted and no extra payment shall be made on this account.

2.6.8 Blockouts

Blockouts in concrete as indicated in the drawing or as directed by the Employer shall be provided wherever required. No extra payment shall be made to the Contractor on this account.

2.6.9 Repairs and Finishes of Concrete

All concrete surfaces shall have even and clean finish, free from honeycombs, air bubbles, fins or other blemishes. The formwork joints marks for concrete work exposed to view shall be rubbed with carborandum stone and defects patched up with a paste of 1-part sand and 1-part cement and cured. The finish shall be made to the satisfaction of the Employer.

The unit rate of pile foundation/ unit rate of concrete (as the case may be) work shall be inclusive of the cost of cleaning and finishing exposed surface as mentioned above.

2.7 Reinforcement Steel

This section of the specification shall cover providing reinforcement steel and its cleaning, bending, binding, placing with arrangements for chairs, supports and suitable covers for all reinforced concrete works, below and above ground level as per drawings and specifications.

2.7.1 General Requirements

- 2.7.1.1 Reinforcement steel of same type & grade shall be used for structural

reinforcement work as detailed in the drawing released by the Employer. No work shall be commenced without proper verification with the bar-bending schedule provided in the drawing.

2.7.1.2 Contractor shall supply, fabricate and place reinforcement to shapes and dimensions as indicated on the drawings and as per specifications. The reinforcement shall be either plain or deformed steel bars or welded wire fabric conforming to relevant IS specifications.

2.7.1.3 Any adjustment in reinforcement to suit field conditions and construction joints other than shown on drawings shall be subjected to the approval of Employer.

2.7.2 **Bending**

2.7.2.1 Unless otherwise specified, reinforcement steel shall be bent in accordance with procedure specified in IS 2502. Bends and shapes shall comply strictly with the dimensions in the approved Bar Bending Schedule. Contractor shall be entirely responsible for its correctness. Bars correctly bend shall only be used.

2.7.2.2 No reinforcement shall be bent when in position in the work without approval of the Employer, whether or not it is partially embedded in concrete. Bars shall not be straightened in a manner that will injure the material. Re-bending can be done only if approved by the Employer. Reinforcement bars shall be bent by machine or other approved means producing a gradual and even motion. All the bars shall be cold bent unless otherwise approved.

2.7.3 **Placing in position**

2.7.3.1 All reinforcement shall be accurately fixed and maintained in position as shown on the drawings by approved means as mild steel chairs, and/or concrete spacer blocks. Bars intended to be in contact, at crossing points, shall be securely bond together at all such points by two number No.20G annealed soft-iron wire.

Binders shall tightly embrace the bars with which they are intended to be in contact and shall be securely held. The vertical distance between successive layers of bars shall be maintained by provision of mild steel spacer bars. They should be so spaced that the main bars do not sag perceptibly between adjacent spacers.

2.7.3.2 The placing of reinforcements shall be completed well in advance of concrete pouring. Immediately before pouring, the reinforcement shall be checked by the Employer for accuracy of placement and cleanliness and necessary correction as directed by him shall be carried out. The cover for concrete over the reinforcements shall be as shown on the approved drawings unless otherwise directed by the Employer. Care should be taken to ensure that projecting ends of ties and other embedded metal do not encroach into the concrete cover. Where

concrete blocks are used for ensuring the cover and positioning reinforcement, they shall be made of mortar 1:2 (one-part cement: two parts sand) by volume and cured for at least (7) days. The sizes and locations of the concrete blocks shall be approved by the Employer.

- 2.7.3.3 Longitudinal reinforcement in pile shall be high yield strength cold twisted deformed steel bars conforming to IS 1786. Thermo-mechanically Treated (TMT) bars (equivalent grade) in place of Cold twisted deformed steel bars are also accepted. Lateral reinforcement in pile shall be of Tor Steel conforming to IS 432 (Part-I).
- 2.7.3.4 The longitudinal reinforcement shall project 52 times its diameter above cut-off level unless otherwise indicated in the drawing.
- 2.7.3.5 The minimum diameter of the links or spirals bar shall be 8mm and the spacing of the links or spiral shall not be less than 150mm and in no case more than 250 mm. The laterals shall be tied to the longitudinal reinforcement to maintain its shape and spacing.
- 2.7.3.6 Reinforcement cage shall be sufficiently rigid to withstand handling and installation without any deformation and damage. As far as possible, number of joints (laps) in longitudinal reinforcement shall be minimum. In case the reinforcement cage is made up of more than one segment, these shall preferably be assembled before lowering into casing tube/ pile bore by providing necessary laps as per IS 456.
- 2.7.3.7 The minimum clear distance between the two adjacent main reinforcement bars shall normally be 100 mm for the full depth of cage, unless otherwise specified.
- 2.7.3.8 The laps in the reinforcement shall be such that the full strength of the bar is effective across the joint and the reinforcement cage is of sound construction. Laps and anchorage lengths of reinforcing bars shall be in accordance with IS 456, unless otherwise specified. If the bars in a lap are not of the same diameter, the smaller will guide the lap length.
- 2.7.3.9 Laps shall be staggered as far as practicable and as directed by the Employer. Not more than 50% bars shall be lapped at a particular section. Lap joints shall be staggered by at least 1.3 times the lapped length (Center to Center).
- 2.7.3.10 Proper cover and central placement of the reinforcement cage in the pile bore shall be ensured by use of suitable concrete spacers or rollers, as required, without any additional cost to the Employer.
- 2.7.3.11 Minimum clear cover to the reinforcement shall be 75 mm unless otherwise mentioned.

2.7.3.12 Unless otherwise specified by the Employer, reinforcement shall be placed within the following tolerance as specified in IS 456: -

- a) For effective depth 200mm or less +10mm
- b) For effective depth more than 200mm +15mm

The cover shall in no case be reduced by more than one-third of specified cover or 5mm whichever is less.

2.7.3.13 Welding of reinforcement bars shall be avoided. However, welding may be done in specific case subject to prior permission from the Employer/ prior written consent of Engineer-in-charge. Welding must be staggered and shall be done in accordance with IS 2751. Couplers as per IS 16172 may be used for jointing of reinforcement bars.

2.8 Construction of Pile Cap, Pedestal, Tie Beam etc.

The Contractor shall deploy all labour, equipment, tools & tackles and materials required for complete execution of the work in accordance with the drawings and as described herein.

2.8.1 Excavation

2.8.1.1 The Contractor shall control the grading in the vicinity of all excavation so that the surface of the ground will be properly slopped or diked to prevent surface water from running into the excavated areas during construction.

2.8.1.2 Excavation shall include the removal of all materials required to execute the work properly and shall be made with sufficient clearance to permit the placing, inspection and setting of forms and completion of all works for which the excavation was done.

2.8.1.3 Side and bottoms of excavation shall be cut sharp and true, undercutting shall not be permitted. Each side of excavation shall be used in lieu of formwork for placement of concrete unless authorized, in special cases, by the Employer, where limitation of space for larger excavation necessitate such decision.

2.8.1.4 When machines are used for excavation, the last 300mm before reaching the required level shall be excavated by hand or by such equipment that will leave the soil at the required final level, in its natural conditions.

2.8.1.5 Suitability for bearing of the bottoms of excavations shall be determined by the Employer.

2.8.1.6 The bottom of excavation shall be trimmed to the required level and when carried below such levels, by error, shall be brought to level by filling with lean concrete 1:4:8 mix, with aggregate of 40mm maximum nominal size at no additional cost to the Employer.

2.8.1.7 The Contractor shall be responsible for assumptions and conclusions regarding the nature of materials to be excavated and the difficulty of making and maintaining the required excavations and performing the work required as shown on the drawing and in accordance with these specifications. The Contractor shall be responsible for any damage to any part of the work and property caused by collapse of sides of excavations. Materials may be salvaged, if it can be done with safety for the work and structure, as approved by the Employer.

However, no extra claim shall be entertained for materials not salvaged or any other damage to Contractor's property as a result of the collapse. He shall not be entitled to any claim for redoing the excavation as a result of the same.

2.8.1.8 Excavations for foundations specified shall be carried out at least 75mm or as specified in relevant drawings below the bottom of structural concrete and then be brought to the required level by placing lean concrete of 1:4:8 mix or as specified in drawings with aggregate of 40mm maximum nominal size.

2.8.1.9 When excavation requires coffer dams, sheet piling, bracing, sheeting, shoring, draining, dewatering etc. the Contractor shall have to provide the same as required and the cost there of shall be included in the unit rate quoted for the item of excavation and contractor shall submit necessary drawings showing arrangement and details of proposed installation and shall not proceed until he has received approval from the Employer.

2.8.1.10 The Contractor shall have to constantly pump out the water collected in pits due to rain water, springs, seepage etc. and maintain dry working conditions at no extra cost to the Employer.

2.8.1.11 For the purpose of excavation in earthwork, all types of soil including kankar, morum, shingle and boulders up to 150mm size are included and no separate payment shall be made for different type of soils encountered.

2.8.2 Form work

2.8.2.1 General

2.8.2.1.1 If it is so desired by the Employer, the Contractor shall prepare, before commencement of the actual work, design and drawings for form work and centering and get them approved by the Employer. The form work shall conform

to the shape, alignment and dimensions as shown in the drawings.

Form work shall be composed of steel and/or best quality shuttering wood of non-absorbent type or plywood. Timber shall be free from significant knots and shall be of medium grain as far as possible and hard woods shall be used as caps and wedges under or over posts. Plywood or equivalent shall be used where specified to obtain smooth surfaces for exposed concrete work. Struts shall generally be mild steel tubes, and strong sal ballis of 150mm in diameter or above. Bamboos, small diameter ballis, etc. shall not be used unless approved by the Employer in specified cases.

Supports or props should not be supported on an un-propped lower suspended floor or beam unless calculations are submitted to the Employer to confirm the strength of the lower floor or beam and no propping shall be taken out until the Employer approval has been given.

- 2.8.2.1.2 The form work shall be true and rigid and thoroughly braced both horizontally and diagonally. The forms shall be sufficiently strong to carry without undue deformation, the dead weight of the concrete as well as working load. Where the concrete is vibrated, the formwork shall be strong enough to withstand the effects of vibration, without appreciable deflection, bulging, distortion or loosening off its components. The joints in the formwork shall be sufficiently tight to prevent any leakage of mortar. The formwork shall be such as to ensure a smooth uniform surface free from honeycombs, air bubbles, bulges, fins and other blemishes. Any blemish or defect found on the surface of the concrete must be brought to the notice of Employer immediately and rectified free of charge as directed by him. To achieve the desired rigidity, the bolts, space blocks, the wires and clamps as approved by the Employer shall be used but they must in no way impair the strength of concrete or leave stains or marks on the finished surface, where there are chances of these fixtures being embedded, only mild steel or concrete of adequate strength shall be used. Bolts passing completely through liquid retaining walls/ slabs for the purpose of securing and aligning the formwork should not be used.
- 2.8.2.1.3 Temporary openings for cleaning, inspection and for pouring concrete may be provided at the base of vertical forms and as may be directed by the Employer. The temporary openings shall be so formed that they can be conveniently closed when required and must not leave any mark on the concrete.
- 2.8.2.2 **Cleaning and Treatment of Forms**
- 2.8.2.2.1 All forms shall be thoroughly cleaned of old concrete wood shavings, saw dust, dirt and dust sticking to them before they are fixed in position. All rubbish loose concrete, chippings, shavings, saw dust etc. shall be scrupulously removed from the interior of the forms before the concrete is poured. Along with wire brushes,

brooms, etc. compressed air jet and/or water jet shall be kept handy for cleaning, if directed by the Employer.

2.8.2.2.2 Before shuttering is placed in position the form surface in contact with concrete shall be treated with approved non-standing oil or composition of other material approved by the Employer. Care shall be taken that the oil or composition does not come in contact with reinforcing steel or existing concrete surface. They shall not be allowed to accumulate at the bottom of the shuttering.

2.8.2.2.3 If formwork for pedestal/ chimney is erected for the full height of the section, as placing of concrete proceeds, wedges, spacer bolts, clamps or other suitable means shall be provided to allow accurate adjustment of the formwork and to allow it to be removed gradually without jarring the concrete.

2.8.2.3 Removal of Forms

2.8.2.3.1 The Contractor shall begin the removal of formwork only after approval of Employer. He shall place on record the date on which the concrete is placed in different parts of the work and the date of the removal of formwork there from. This record shall be checked and countersigned by the Employer. The Contractor shall be responsible for the safe removal of formwork but the Employer may delay the time of removal if he considers it necessary. Any work showing signs of damage through premature removal of formwork or loading shall be entirely reconstructed without any extra cost to Employer.

2.8.2.3.2 Forms for various types of structural components shall not be removed before the minimum periods specified below which shall also be subject to the approval of the Employer.

2.8.2.3.3 No supporting forms shall be removed suddenly in such manner as to create shock loading. Forms for sides shall not be removed before 2 days. Bottom forms shall not be removed before 28 days unless this period is reduced with specified concurrence of the Employer.

However, in any case, formwork shall not be struck until the concrete has reached a strength at least twice the stress to which the concrete may be subjected to, at the time of removal of forms.

2.8.2.4 Re-use of Forms

Before re-use, all forms shall be thoroughly scrapped cleaned and joints, etc. shall be examined, when necessary repaired and inside surface treated as specified. Formwork shall not be used/ re-used, if declared unfit or unserviceable by the Employer.

2.8.3 Back Filling

2.8.3.1 General Requirement

- 2.8.3.1.1 After completion of foundation footings, pile caps, pedestals, tie beams and other constructions below the elevation of the grades, and prior to back filling, all forms of temporary shoring, timber etc. shall be removed and the excavation cleaned of all trash, debris and perishable materials, back filling shall begin only with the approval of the Employer.
- 2.8.3.1.2 The soil to be used for back filling purpose shall be inorganic material and shall be free from any foreign substance which can harm or impair the strength of footing in any manner. In any case the soil to be used for back filling purpose shall have the prior approval of the Employer.
- 2.8.3.1.3 The soil to be used for back filling purpose shall be either from the excavated earth or from the borrow pits, as directed by the Employer. The soil may have to be brought from a distance up to 2 km. By the shortest haulage route as approved by the Employer. If directed by the Employer, the excavated earth from the adjoining areas (which is to be disposed-off up to a distance of 500 meters by manual labour) shall be used as for back filling purpose.
- 2.8.3.1.4 Back filling shall not be dropped directly upon or against any structure where there is danger of displacement or damage.
- 2.8.3.1.5 Back filling shall be placed in horizontal layers not to exceed 200mm in thickness. Each layer shall be compacted with proper moisture content and with such equipment as may be required to obtain a density equal to or greater than 95% of maximum dry density as determined by the relevant Indian Standard. The method of compaction shall be subject to the approval of the Employer. Pushing of earth for back filling shall not be adopted under any circumstances.
- 2.8.3.1.6 On completion of structures, the earth surrounding them shall be accurately finished to line and grade as shown on the drawings or as per the instruction of the Employer. Finished surface shall be free of irregularities and depressions and shall be within 50mm of the specified level.
- 2.8.3.1.7 Any additional quantity of back filling, if required, beyond the excavation payment line shall be done by the contractor at his own expense.

2.8.4 Construction Joints

- a) When the work is to be interrupted, the concrete shall be rebated at the joint to such shape and size as may be required by the Employer or as shown on

the drawings. All vertical construction joints shall be made with stone boards, which are rigidly fixed and slotted to allow for the passage of the reinforcing steel. If desired by the Employer, keys and/or dowel bars shall be provided at the construction joints. Construction joints shall be provided in positions as shown or described on the drawing. Where it is not described, the joints shall be in accordance with the following:

- i) In a column, the joint shall be formed about 75mm below the lowest soffit of the beams framing into it.
 - ii) Concrete in tie beam shall be placed throughout without a joint, but if the provision or a joint is unavoidable, the joint shall be vertical and at the middle of the span.
 - iii) In forming a joint, concrete shall not be allowed to slope away to thin edge. The locations of construction joints shall be planned by the Contractor well in advance of pouring and have to be approved by the Employer.
- b) Before fresh concrete is placed, the cement skin of the partially hardened concrete shall be thoroughly removed and surface made rough by hacking, sand blasting, water jetting, air jetting or any other method as directed by the Employer. The rough surface shall be thoroughly wetted for about two hours and shall be dried and coated with 1:1 freshly mixed cement sand slurry immediately before placing the new concrete. The new concrete shall be worked against the prepared surface before the slurry sets. Special care shall be taken to see that the first layer of concrete placed after a construction joint is thoroughly rammed against the existing layer. Old joints during pour shall be treated with 1:1 freshly made cement sand slurry only after removing all loose materials.
- c) The unit rate of pile foundation/ unit rate of concrete work (as the case may be) shall include the cost of construction joints.

2.8.5 Curing and Protection of Concrete

Newly placed concrete shall be protected by approved means from rain, sun & wind. Concrete placed below ground level shall be protected from falling earth during and after placing. Concrete placed in ground containing deleterious substances shall be kept free from contact with such ground or with water leaking from such ground during placing of concrete and for a period of three days or as otherwise instructed by the Employer after placing of concrete. The ground water around newly poured concrete shall be kept to an approved level by pumping or other approved means of drainage. Adequate steps shall be taken to prevent floatation or flooding. Steps, as approved by the Employer, shall also be taken to

protect immature concrete from damage by debris, excessive loading, vibration etc. which may impair the strength or durability of the concrete.

All fresh concrete shall be covered with a layer of Hessian or similar absorbent material and kept constantly wet for a period of seven days or more from the date of placing of concrete as per directions of the Employer. Curing can also be made by pounding. Concrete shall be cured by flooding with water of minimum 25mm depth for the period mentioned above. Step shall also be taken to protect immature concrete from damage debris by excessive loading, vibrations, abrasions, deleterious ground water, mixing with earth or foreign materials, floatation etc. that may impair the strength and durability of the concrete. Approved curing compound can be used with the permission of the Employer. Such compound shall be applied to all exposed surfaces of the concrete as soon as possible after the concrete has set.

2.9 Pile Installation

Installation of piles shall be carried out as per pile layout drawings, installation criteria and in line with the specification.

2.9.1 Equipment and Accessories

2.9.1.1 The equipment and accessories for installation of bored cast-in-situ piles shall be selected giving due consideration to the sub soil conditions, ground water conditions and the method of casting, etc. These shall be of standard type and shall have the approval of the Employer.

2.9.1.2 The capacity of the rig shall be adequate so as to reach the specified founding level.

2.9.1.3 Provision shall be kept for chiseling within the pile bore, as specified in this specification. Chiseling shall be carried out only with the approval of Employer. The contractor must have the provision of equipment/ accessories which can bore in the hard rock strata if required, without any additional cost implication to the Employer.

2.9.2 Installation Criteria

2.9.2.1 The Contractor while boring the pile bore, shall constantly collect the bore spoils and these shall be compared with the layer wise soil classifications reported in the bore-log details of the location, reported in the soil investigation report. Should there be any variation between the two soil classifications, these shall be immediately reported to the Employer.

2.9.2.2 Whenever the rock strata are encountered in the pile bore, the Contractor shall

immediately report the matter to the Employer and shall take up the work of rock chiseling or any other suitable method only after the certification/ approval of the Employer. Since the piles are required to be terminated in the firm/ hard strata and as stipulated in the construction drawing the Contractor shall demonstrate such founding strata and seek approval of the Employer before terminating the piles.

2.9.2.3 The pile should be socketed and founded in good rock only. Whenever rock strata is encountered at any pile bore and the level of good rock (i.e. rock strata is not highly fractured and weathered and core recovery is not less than 80% with RQD 70%) is different than that is given in the Geotechnical Investigation report, in that case to establish the level of good rock, core drilling as per IS 6926 shall be carried out at least upto 5m depth in rock strata encountered by the contractor without any additional cost implication to Employer and no time extension will be permitted on this account.

2.9.2.4 In order to verify the terminating depth, where rock strata is met with, the rock samples obtained from the bore spoils of pile shall also be tested for point load strength index and these shall then be compared/ correlated to the values of uniaxial compression strength test shown in the soil investigation report. Accordingly, the termination of piles in the socketing zone shall be done with prior approval of the Employer.

2.9.3 **Control of position and alignment**

2.9.3.1 Piles shall be installed vertically as accurately as possible as per the construction drawing. The permissible limits for deviation with respect to position and inclination/alignment shall conform to IS 2911 (Part I/Sec. 2), as reproduced below.

2.9.3.2 Maximum permissible deviation in alignment is 1.5%. Piles should not deviate more than 75mm or D/10 whichever is more from their positions at the working level. In case of piles deviating beyond these limits, the piles should be replaced or supplemented by one or more additional piles including the revised cap size (as the situation may be) at no additional cost to the Employer. Any extra claim whatsoever from the contractor on this account shall not be entertained.

2.9.4 **Boring**

2.9.4.1 Boring operations shall be done by rotary or percussion type drilling rigs using Direct Mud Circulation (DMC), Reverse Mud Circulation (RMC) methods or grab method. In soft clays and loose sands bailer method, if used, shall be used with caution to avoid the effect of suction. In cohesive soils, use of water for boring shall be restricted to a minimum, while boring in cohesion less deposits water level in the bore hole shall be maintained at or slightly above the standing water

table.

Boring operations by any of the above methods shall be done using drilling mud. The bidder shall be required to furnish along with their bid, complete details regarding the installation of piles and the method by which they wish to install the piles.

- 2.9.4.2 The Contractor shall satisfy himself about the suitability of the method to be adopted for site. If DMC or RMC is used, bentonite slurry shall be pumped through drill rods by means of high-pressure pumps. The cutting tools shall have suitable pores for the bentonite slurry to flow out at high pressure. If the Contractor fails to make proper bore for any reason, the Contractor has to modify the boring technique and switchover to other boring methods as approved by the Employer at no extra cost to the Employer.
- 2.9.4.3 Working level shall be above the pile cut off level. After the initial boring of about 1.0 to 2.0m temporary guide casing shall be lowered in the pile bore. The diameter of guide casing shall be of such diameter to give the necessary finished diameter of the concrete pile. The center line of guide casing shall be checked before continuing further boring. Guide casing shall be minimum 2.0m length. Additional length of guide casing shall be used depending on the conditions of the strata, ground water level etc. as required by the Employer without any additional cost to the Employer.
- 2.9.4.4 Use of drilling mud (bentonite slurry) for stabilising the sides of the pile bore is necessary wherever subsoil is likely to collapse in the pile bore. Drilling mud to be used shall meet the requirement as given in **Annexure-A**.
- 2.9.4.5 The bentonite slurry and the cuttings, which are carried to the surface by the rising flow of the slurry shall pass through settling tanks of adequate size to remove the sand and spoils from the slurry before the slurry is re-circulated back to the boring. The bentonite slurry mixing and re-circulation plant shall be suitably designed and installed.
- 2.9.4.6 The bentonite slurry shall be maintained at 1.5m above the ground water level during boring operations and till the pile is concreted. When DMC or RMC method is used the bentonite slurry shall be under constant circulation till start of concreting.
- 2.9.4.7 Size of cutting tools shall be such that so as to achieve required diameter of pile as per design drawing.

2.9.5 **Chiseling**

Chiseling, if required, may be resorted to with the permission of the Employer

below the socketing horizon. The chiseling tool or bit shall be of adequate size and weight so as to reach the desired depth.

2.9.6 **Cleaning of Pile bore**

2.9.6.1 After completion the pile bore up to the required depth, the bottom of the pile bore shall be thoroughly cleaned. Cleaning shall ensure that the pile bore is completely free from sludge/ bored material, debris of rock/boulder etc. Necessary checks shall be made as given in this Section to confirm the thorough cleaning of the pile bore.

2.9.6.2 Pile bore shall be cleaned by fresh drilling mud through tremie pipe before start of concreting and after placing reinforcement.

2.9.6.3 Pile bore spoil along with used drilling mud shall be disposed-off from site up to 2 km or as directed by the Employer.

2.9.7 **Adjacent Structures**

When working near existing structures care shall be taken to avoid any damage to such structures.

2.9.8 **Concreting**

2.9.8.1 Concreting shall not be done until the Employer is satisfied that the bearing strata (soil/rock) met with the termination level of pile, satisfied the installation criteria/ approved founding depth.

2.9.8.2 The time between the completion of boring and placing of concrete shall not exceed 8 hrs for piles upto 25 meter length and 12 hrs for piles above 25 meter length. In case the time of interval exceeds specified time, the pile bore shall be abandoned. However, the Employer may allow concreting, provided the Contractor extends the pile bore by 0.5 m beyond the proposed depth, and clean the pile bore properly. The entire cost of all operation and materials for this extra length shall be borne by the Contractor.

2.9.8.3 Pile bore bottom shall be thoroughly cleaned to make it free from sludge or any foreign matter before and after placing the reinforcement cage.

2.9.8.4 Proper placement of the reinforcement cage to its full length shall be ensured before concreting.

2.9.8.5 Entire concreting in pile bores shall be done by tremie method. The operation of tremie concreting shall be governed by IS 2911 (Part I, Sec. 2). Drilling mud shall be maintained sufficiently above the ground water level.

- 2.9.8.6 Concreting operations shall not proceed if the contaminated drilling mud at the bottom of the pile bore possess density more than 1.12T/ cum. or sand content more than 7%. The drilling mud sample shall be collected from the bottom of pile bore. This shall be checked at regular intervals, as decided by the Employer thereafter.
- 2.9.8.7 Consistency of the drilling mud suspension shall be controlled throughout concreting operations in order to keep the bore stabilised as well as to prevent concrete getting mixed up with the thicker suspension of the mud.
- 2.9.8.8 It shall be ensured that volume of concrete poured is at least equal to the theoretically computed volume of pile shaft being cast.
- 2.9.8.9 The temporary guide casing shall be entirely withdrawn cautiously, after concreting is done up to the required level. While withdrawing the casing concrete shall not be disturbed.
- 2.9.8.10 Tests on concrete cubes shall be carried out as specified in this section of the Specifications.
- 2.9.9 **Cut-off-level (COL)**
- 2.9.9.1 Cut-off-level of piles shall be as indicated in approved construction drawings or as directed by the Engineer-in-Charge.
- 2.9.9.2 The top of concrete in pile shall be brought above the COL to remove all laitance and weak concrete and to ensure good concrete at COL for proper embedment into pile cap.
- 2.9.9.3 When the pile cut off level is less than 1.0 meter below the working level, concrete shall be cast up to the piling platform level to permit overflow of concrete for visual inspection. In case COL of pile is more than 1.0 meter below working level then concrete shall be cast to minimum of one meter above COL.
- 2.9.9.4 In the circumstances where COL is below ground water level, the need to maintain a pressure on the unset concrete equal to or greater than water pressure shall be observed and accordingly length of extra concrete above COL shall be determined by the Contractor with prior approval of Employer.
- 2.9.10 **Sequence of Piling**
- 2.9.10.1 Each pile shall be identified with a reference number and date wise proper record of construction shall be maintained by the Contractor.

- 2.9.10.2 The convenience of installation may be considered while scheduling the sequence of piling in a group. This scheduling shall avoid piles being bored close to other recently constructed piles.

2.9.11 **Building up of Piles**

If any pile, already cast as per construction drawing, requires any extra casting due to any change in cut off level or the top level of cast pile is less than the specified level or due to any other reason, then the pile shall be built up by using, same grade of concrete, ensuring proper continuity with the existing concrete and to the satisfaction of the Employer. Necessary reinforcement as per design requirement and suitable shuttering shall be provided before casting the concrete. Surrounding soil shall also be built up to the required level by proper compaction to ensure lateral capacity of the pile.

2.9.12 **Breaking off of Piles**

If any pile already cast requires breaking due to lowering in cut off level or for any other reason, then the same shall be carried out, (not before seven days of casting of concrete in the piles) without affecting the quality of existing pile such as loosening, cracking etc. to the satisfaction of the Employer. No extra payment shall be made on this account.

2.9.13 **Preparation of Pile head**

- 2.9.13.1 The soil surrounding the piles shall be excavated up to the bottom of the lean concrete below the pile cap with provision for working space sufficient enough to place shuttering, reinforcement, concreting and any other related operations.
- 2.9.13.2 The exposed part of concrete above the COL, shall be removed/ chipped off and made square at COL not before seven days of casting of pile.
- 2.9.13.3 The projected reinforcement above COL shall be properly cleaned and bent to the required shape and level to be anchored into the pile cap as shown in the drawing.
- 2.9.13.4 The pile top shall be embedded into the pile cap by minimum 50mm or clear cover to reinforcement, whichever is higher.
- 2.9.13.5 All loose material on the top of pile head after chipping to the desired level shall be removed and disposed-off up to a lead of 2 km or as directed by the Employer.

2.9.14 **Rejection and Replacement of Defective Piles**

- 2.9.14.1 The Employer reserve the right to reject any pile which in his opinion is defective with reference to technical specification & construction drawings on account of

load capacity, structural integrity, position, alignment, concrete quality etc. Piles that are judged defective shall be pulled out or left in place as decided by the Employer without affecting the performance of adjacent piles. The Contractor shall install additional piles to substitute the defective piles as per the directions of the Employer at no extra cost to the Employer.

- 2.9.14.2 During execution of pile foundation work, if the bore holes need to be abandoned due to any reason and pile position to be shifted or realigned, other than for any design requirement by the Employer, fresh bore holes are to be executed at a suitable new position, which may vary from 2D to 3D (where, D is diameter of pile) as decided by the Employer, which may demand for resizing of pile cap including possible increase in reinforcement quantity due to resizing of pile cap. In all such cases the abandoned bore holes are to be filled up with plain cement concrete (1:3:6) so that no cavity remains in the bore hole of the abandoned pile. Any extra claim whatsoever from the contractor on account of abandoned bore hole, filling up of abandoned bore hole with concrete and any extra cost due to resizing of pile cap including increase in reinforcement quantity shall not be entertained by the Employer & the same have to be borne by the contractor.

2.9.15 Criteria for Terminating the Piles

- 2.9.15.1 The piles can be terminated at a depth based on design developed/ approved by the Employer, where loads on the piles can be transmitted to the soil in a proper manner or the depth where specified 'N' value is achieved, whichever occurs later. However, in no case piles should be terminated at a higher level than that indicated in the construction drawing.
- 2.9.15.2 Standard penetration test (SPT) shall be carried out starting from 1.0 m above the specified pile termination depth and there after @ 1m up to the pile termination depth. For number of SPT to be carried out, refer Standard Field Quality Plan (SFQP)
- 2.9.15.3 The Standard Penetration Test (SPT) shall be carried out based on the following test procedures:
- The test shall be conducted by driving a standard split spoon sampler in the borehole by means of a 63.5 Kg hammer having a free fall of 0.75 m. The sampler shall be driven for 450 mm using the hammer and the number of blows shall be recorded for every 150mm penetration. The number of blows for the last 300 mm drive shall be reported as N value. The test shall be discontinued when the blow count is equal to 100 or the penetration is less than 25mm for 50 blows, whichever is earlier.
 - At the location where the test discontinued, the penetration and the number of blows shall be reported. Sufficient quantity of disturbed sample shall be

collected from the split spoon sampler for identification/ classification of soil. The sample shall be visually classified and recorded at the site.

- c) The specification for the equipments and other accessories, procedure for conducting the test and collection of the disturbed soil sample shall conform to IS 2131.

2.9.16 Recording of Piling Data

- 2.9.16.1 The Contractor shall record all the information during installation of piles. Typical data sheet for recording pile data as shown in Appendix D of IS 2911 (Part I, Sec. 2) shall be maintained by the contractor. The pile data shall also include all the details as in **Annexure-B**. On completion of each pile installation, pile record in triplicate shall be submitted to Employer within two days of completion of concreting of the pile.

2.9.17 Check for Pile bore

- 2.9.17.1 On completion of boring and cleaning the bottom of each pile bore shall be checked by the methods as approved by the Employer, to ensure that it is free from pile bore spoil/ debris and any other loose material, before concreting. Concreting shall be done only after the approval of the Employer.
- 2.9.17.2 For sampling of drilling mud from the pile bore the following method or any other suitable method shall be adopted.

A solid cone shall be lowered by a string to the bottom of pile bore. A sampler tube closed at top with a central hole (hollow cylinder) is lowered over the cone, then a top cover shall be lowered over the cylinder. Care shall be taken for proper fittings of assembly to minimise the leakage while lifting the cone assembly to the ground surface. The slurry collected in the sampler tube shall be tested for density and sand content.

2.9.18 Properties of drilling mud

- 2.9.18.1 Properties of drilling mud shall be checked as per requirements indicated in **Annexure-A** prior to the commencement of piling work and thereafter at least once in a week or as found necessary by the Employer, one sample consisting of 3 specimens shall be tested.
- 2.9.18.2 Density and sand content of the drilling mud shall be checked in each pile.

2.10 Erection of Steel Embedded Parts

2.10.1 General

- 2.10.1.1 This covers the technical requirements for the supply and fabrication and/or erection of all embedded steel parts by the Contractor. The extent and type of embedded steel parts to be erected shall be as per detailed drawings.
- 2.10.1.2 The supply of embedded steel parts like ladders, steel pieces set in concrete inserts, dowel bars required for construction joints etc. are in the scope of the Contractor. However, supply of anchor bolts/ stubs, as the case may be, will be supplied by tower contractor.
- 2.10.1.3 Embedded steel parts shall include items such as foundation anchor bolts, stubs, ladders, steel pieces set in concrete inserts, dowel bars for concrete work etc. shown on the drawing or as required by the Employer. Material shall also include setting in forms for connecting in place and grouting as required. The grouting operations, if required, shall be performed as per the direction of Employer.
- 2.10.1.4 The Contractor shall erect all embedded steel parts in accordance with the drawings and this specification including setting materials in concrete or grouting pieces in place, furnishing all labour, materials, scaffolding, tools and services necessary for and incidental to the work to its transporting, unloading, storing, handling and erection. Contractor shall furnish welding rods and arrange for field welding as required in accordance with IS 816.
- 2.10.1.5 Exposed surfaces of embedded material are to be painted with one coat of approved anticorrosive and/or bituminous paint without any extra cost to the Employer. The threads of holding down bolts shall be greased and protected with water proof tape.
- 2.10.2 **Installation**
- 2.10.2.1 During erection, the Contractor shall provide necessary temporary bracing or supports to ensure proper installation of the materials. All materials shall be erected in the true locations as shown in the drawings, plumb and level. Extreme care shall be taken to ensure that the threads of holding down bolts and comparable items are protected from damage.
- 2.10.2.2 Groups of holding down bolts shall be set in such a manner that the tolerance of whole group is not more than 3mm from its true position in plan at the top of the bolt and not more than 3mm from the required level. The top ends of all bolt shanks shall be in one plane to the tolerance stated above.

Holding down bolt assemblies shall be set vertically to a tolerance of not more than 1:500.

2.10.3 Protection Against Damage in Transit

2.10.3.1 All steel work shall be efficiently and sufficiently protected against damage in transit to site from any cause whatsoever. All protecting plates or bars and all ends of members at joints shall be stiffened, all straight bars and plates shall be bundled, all screwed ends and machined surface shall be suitably packed and all bolts, nuts, washers and small loose parts shall be packed separately in cases so as to prevent damage or distortion during transit. Should there be any distortion of fabricated members, the Contractor shall immediately report the matter to the Employer. Distorted reinforcement bars or plates received from stores or distorted during transport from stores to the fabrication yard shall not be used in fabrication unless the distortions are minor which in the opinion of the Employer can be removed by acceptable methods. The cost of all such straightening shall be borne by the Contractor within his unit rates.

2.10.3.2 These distortions shall be rectified by the Contractor by cold bending. If heating is necessary to rectify the defects, the details of the procedure shall be intimated to the Employer whose approval shall be taken before such rectification. The temperature of heat treatment shall not exceed the limits beyond which the original properties of steel are likely to be impaired.

2.11 Foundations Bolts/ Stub

2.11.1 The foundation bolts/ stubs, as required, for the tower structures shall be supplied by the respective tower contractor. These shall be embedded in concrete while the foundation is cast. The Contractor shall ensure the proper alignment of these bolts to match the holes in the base plate and also co-ordinate with the respective tower contractor for its correctness. The final adjustment of these bolts and their grouting are included in the scope of this contract. Grouting of block outs and the gap between the base plate and top of concrete shall be done by the Contractor after finalisation of alignments. The unit rate of concreting/ unit rate of pile foundation (as the case may be) shall include the cost of above adjustments, grouting, and skins etc. required for this purpose.

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

2.11.3 Before erection of towers, by tower contractor, on the foundations the top surface of base concrete shall be thoroughly cleaned with wire brushes and by chipping to remove all laitance and loose materials and shall be chipped with a chisel to ensure proper bond between the grout and the foundation concrete. The piling Contractor shall also be responsible for bringing down the top of concrete to the desired level by chipping. In case the foundation as cast is lower than the desired level, the Contractor shall make up the difference by providing additional

pack plates without extra cost for any such work or material. No steel structures shall be erected on their foundations unless such foundations have been certified fit for erection by the Employer. Adequate number of air release holes and inspection holes shall be provided in the base plate.

2.12 Stability of Structure

2.12.1 The Contractor 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. Guying and bracing shall be done for erection equipment and their operations. Guying and bracing shall be done in such a way that it does not interface with the movement or working of other agencies working in the area. For the purpose of guying, the Contractor shall not use other structures in the vicinity which are likely to be damaged by the guy.

2.12.2 Such temporary bracings shall neither be included in the measurement nor extra rate shall be payable. Such temporary bracings used shall be the property of the Contractor and may be removed by him at the end of the job from the site of work.

2.13 Grouting and under Pinning

2.13.1 General requirement

2.13.1.1 Furnishing of all labour materials and equipment and performance of all operations necessary to complete the work of grouting of block outs and foundation bolt holes and under pinning of base plates is in the scope of the Contractor. The cost of the above shall be included in the unit concreting rate.

2.13.1.2 Grouting shall be adopted for filling the block outs, pockets below foundation bolt holes. The block out and bolt holes which have to be grouted shall be cleaned thoroughly by use of compressed air immediately before taking up the grouting operations.

2.13.1.3 Cement and aluminium powder or anti-shrinkage admixture of approved quality shall be first blended thoroughly in the required proportions as per manufacturer's specification. The mix of grouting shall contain one part of cement and two parts of coarse sand. Admixture should be according to IS 9103.

2.13.1.4 The quantity of aluminum powder shall usually be of the order of 0.005% by weight of cement. Any grout which has been mixed for a period longer than half an hour shall not be used on the work. Immediately after preparation the grout shall be poured into the block outs, pockets and foundation bolt holes either from the sides or through the holes provided for this purpose in the base plate, by using

special equipment for pressure grouting. It shall be ensured by rodding and by tapping of bolts that the block out is completely filled without leaving any voids. The pouring shall cease as soon as each hole is filled and any excess grout found on the surface of the concrete foundation shall be completely removed and the surface dried.

- 2.13.1.5 Under pinning shall be resorted to for filling the space between the underside of base plate and the top of foundation concrete. After grouting has been completed as specified above, space between the top surface of the foundation concrete and the underside of the base plate shall be filled with mortar or concrete depending upon thickness to be filled as follows: -

Less than 40mm	Dry packed cement mortar
Over 40mm	Dry packed fine concrete

- 2.13.1.6 Mortar, fine concrete shall be blended with aluminium powder about 0.005% by weight of cement or with anti-shrinkage admixture in a suitable proportion to the cement mortar in accordance with the recommendations of the manufacturer and subject to the approval of the Employer. Mortar shall comprise cement, sand and water in proportion of approx. 1:3:0.4 by weight. Concrete shall comprise cement, sand, 10mm max. sized aggregate and water in proportion of 1:1.25:2:0.4 by weight. In all cases minimum 28 days cube strength should not be less than 25N/mm².

Shims provided for the alignment of bases shall be positioned at the edges of the base to permit subsequent removal which shall take place not less than 7 days after the underpinning has been executed. The resulting cavities shall be made good with the same grade of mortar or concrete as has been used for the underpinning of the rest of the base plate.

- 2.13.1.7 Cement, sand and aluminium powder or approved anti-shrinkage admixture, shall first be blended thoroughly in the required proportion. The mortar shall then be prepared by mixing with quantity of water which will produce a sufficiently workable mix to enable complete and proper compaction of the mortar.
- 2.13.1.8 The mortar shall then be placed below the base plate and rammed in a horizontal direction for each edge until the mortar oozes out through the grout holes provided in the base plate.
- 2.13.1.9 When it is clear that the center of base has been properly filled, the mortar outside the base plate shall be briefly rammed to ensure compaction below the edges. Any mortar which has been mixed for a period longer than half an hour, shall not be used in the work.

2.13.2 **Materials**

- 2.13.2.1 Cement shall conform to the stipulations contained in IS 8112 and shall have a fineness (specific surface of cement) not less than 225 sqm/kg when tested for fineness by Blaine's air permeability method as per IS 4031.
- 2.13.2.2 Sand shall conform to the stipulations contained in IS 383.
- 2.13.2.3 Water shall be clean and fresh and shall be of potable quality.
- 2.13.2.4 Aluminium powder or anti-shrinkage admixture like 'Groutex' CRS-NS grout (by Cement Research Institute of India) or its equivalent shall be of standard brand from reputed manufacturer and shall be approved by the Employer prior to its use for work.

2.13.3 **Curing**

The work shall be cured for a period of 7 days commencing 24 hours after the completion of the grouting and under pinning operations. The curing shall be done by covering the surfaces with wet gunny bags.

2.13.4 **Bar Grips**

- 2.13.4.1 This covers the technical requirement for furnishing and installation of bar grips complete including all labour materials, equipments, staging, etc.
- 2.13.4.2 The Contractor shall furnish and install the bar grips for various dia of deformed bars as indicated in drawings and as required by these specifications. The bar grip splicing system shall be of approved manufacturer and of the best quality available subject to approval of the Employer.

2.13.5 **Splicing**

- 2.13.5.1
 - a) The reinforcement bars are to be joined without any gap and the sleeve placed in position.
 - b) Pressure is applied by means of a hydraulic press which swages the sleeve down on the bar ends in a series of bites which are applied at high pressure.
 - c) The job can also be done in two stages. The 1st stage is to press the half sleeve on the loose bar at the reinforcement yard. The 2nd stage work is to be done at the actual site after the loose bar is inserted through the un-presented end of the sleeve and pressed in-situ.
- 2.13.5.2 The joints shall be staggered as far as possible. Necessary staging arrangements are to be made by the Contractor.

- 2.13.5.3 It may be necessary to fix the sleeve to the reinforcement bars at one end in the open yard for the facility of working. All these working details are to be furnished earlier subject to the approval of the Employer.
- 2.13.5.4 The length of the sleeve should be adequate, that it is safe under the pull-out loading conditions.
- 2.13.5.5 One percent representative samples of each diameter, bars shall be sent for laboratory testing at the cost of the Contractor to check the efficiency of the joints under ideal condition. These samples of sleeves will be sent in the Laboratory for pull out tests.
- 2.13.5.6 All bar grips installation shall be subject to inspection and approval by the Employer before concreting operation are performed. In case of any defect or joint being not up to mark, the same shall be replaced by the Contractor at no extra cost.

2.14 MS Liner

MS liner shall be provided wherever included in the construction drawings approved by the employer and/ or otherwise required by the employer. Detailed technical requirements of MS liner are stipulated in **Clause 5.0** shall apply.

3.0 Rates and Measurement

3.1 Rates and Measurement Applicable When Design of Pile foundation is in Contractor's Scope

The Rate quoted by bidder includes Design & Installation of 750 mm or more diameter pile of suitable length, which inter-alia includes the design & vetting of pile foundation, excavation, boring, form work for placement of concrete, supply & placement of reinforcement steel & MS liner, concreting and PCC, back filling and conducting Standard Penetration Test & Integrity test etc. as specified in relevant clause of this section.

The details of items for completeness of pile foundation works include the following items:

3.1.1 Design of Pile foundation

The design of pile foundation shall be carried out as per, design criteria for pile foundation specified in clause 1.2.4 of this section, the soil parameters provided by employer, other hydrological report/ data collected from CWC/ Local authority. After completion of design works, each pile design along with design

calculations & drawings shall be vetted from reputed institutions like IITs/NITs and submitted for employer's approval.

3.1.2 Excavation

3.1.2.1 The unit of measurement for excavation shall be in cum. The design excavation volume shall be calculated considering dimension of pile cap plus 150mm on all sides of the pile cap and depth as shown in the drawing approved by employer below the lean concrete level. The excavation covers all types of soil including sheet piling, sheeting, shoring, bracing, draining, dewatering, cofferdams etc. as required for successful completion of job. The excavation shall be carried out in accordance with the stipulations in **clause 2.0** of this Specification.

3.1.2.2 The Contractor shall arrange to transport the excavated soil to a distance as directed by Employer and the rates quoted in Price schedule shall include all lead, lift, carriage etc.

3.1.3 Cement Concrete

3.1.3.1 Actual volume of work as executed or as per drawing, measured in cubic meter corrected up to second place of decimal shall be considered for measurement purpose. Deductions for openings, conduits, pipes, ducts, pockets etc. shall only be made provided they are larger than 0.1 sqm. in area (for each opening).

3.1.3.2 No deduction shall be made for embedded fixtures including reinforcement, sleeves, anchor bolts and similar items.

3.1.3.3 The volume for structural concrete and lean concrete shall be measured separately.

3.1.4 Form Work

3.1.4.1 Formworks of different types/ shapes shall be measured with reference to actual surface area in contact with the concrete. The unit of measurement will be in sqm corrected upto second place of decimal.

3.1.4.2 Opening up to 0.1 sqm of boxing left for inserts etc. shall not be considered as if non-existent for the purpose of formwork measurement of surface in which the opening occurs. If the cross-sectional area of any openings exceeds 0.1 sqm., area of such openings shall be measured and deducted from the area payable for the total form work.

3.1.4.3 The total formwork should be water proof and includes the supports, scaffolding, centering, approaches, and fillets for rounding of chamfering junctions, corners etc.

3.1.5 Back filling

3.1.5.1 The actual volume of backfilling shall be measured in cubic meter rounded off up to 2nd place of decimal shall include all the necessary operations required to complete the work as per drawing & **Clause 2.0** of this section. The rate quoted by bidder includes the backfilling works also.

3.1.6 Reinforcement Steel

3.1.6.1 The bidder shall supply and place reinforcement steel of specific grade, stirrups, annealed wire for binding the reinforcement, chairs, hangers, spacers, welding, tack welding etc. as required to complete the RCC work in pile, pile cap, pedestal/ chimney, tie beam (if required) including cleaning, straightening, cutting, bending, binding etc. Contractor shall also place of reinforcement cage in pile shaft/bore and all other cost for tools, plants, materials, labour, transportation to site are to be borne by the bidder. Wastage, overlaps, spacer bars, chairs, stays, hangers, annealed steel wire shall not be measured and cost of these items shall be deemed to be included in the quoted price of pile foundation.

3.1.6.2 Standard hooks, cranks, bends, authorized laps, etc. shall be measured.

3.1.6.3 Separator pieces between two or more layers of steel shall not be measured.

3.1.6.4 For supporting horizontal reinforcement at heights, drawings for supports, spacers, chairs, hangers, etc. larger than 300mm, shall be prepared by the Contractor and got it approved from Employer.

3.1.6.5 No extra payment shall be made for modification of already embedded reinforcement, if required due to faulty fabrication or placement.

3.1.6.6 Dowels as required for completion of the work shall be provided by the contractor which will not be separately calculated for payment.

3.1.7 Piling work

3.1.7.1 The items of works are briefly described in the BPS. The various items in the BPS shall be read in conjunction with the corresponding sections in the Technical Specifications, including amendments, and additions, if any. The rate quoted for items shall include all the activities covered in the description of the item as well as all necessary operations described in the specification and any other specific requirements.

3.1.7.2 The rate shall also include all minor activities which are obviously and fairly intended, though may not have been clearly brought out in the description of

items or in these documents, but are essential for the satisfactory completion of the work.

- 3.1.7.3 rate shall also include for all safety measures as required by Codal provisions, local regulations, acts, bye-laws, etc. and mobilization of all plant, equipment, scaffolding, materials, skilled and unskilled labour, de-mobilisation after completion of work, supervision, establishing level and coordinates at each location by carrying levels from one established bench mark and distances from one set of grid lines furnished by the Employer.
- 3.1.7.4 The rate quoted by bidder shall be inclusive of cost of boring by approved method, bailing out all the pile bore spoils from the pile bore, keeping the bore hole free from bored material/ debris etc. and disposing same along with the drilling mud up to a distance of 2 km, flushing the pile bore by fresh bentonite before concreting, collection of samples from bottom of pile bore, transporting to laboratory, testing and reporting of results including necessary materials, equipment and manpower.
- 3.1.7.5 The rate quoted shall include shifting of plant and equipment from one pile location to another location, providing temporary casing as required and removal of the same after completing concreting. The quoted rate shall also include the boring/ installation of pile and is inclusive of the empty boring and extra concreting required above the pile cut off level.
- 3.1.7.6 The rate quoted shall also include chiseling through rock, if required, in the pile up to the specified level bailing out the pile bore debris/ spoils from the pile bore and disposing off the chiseled materials/debris along with the sludge/ mud up to 2 km, flushing the pile bore by fresh betonies before concreting, collection of samples from bottom of the pile bore, transporting to laboratory, testing and reporting of results.
- 3.1.7.7 The rate shall also include concreting in piles by tremie method only, cost of preparation of pile head and disposal of debris etc., resulting from breaking off of pile up to cut off level (COL), up to a distance of 2 km.
- 3.1.7.8 The rate shall include for all quality assurance requirements, but not limited to providing for technical inspection, transportation of samples to laboratory, testing samples, maintaining and submitting all test records, etc.
- 3.1.7.9 The rate quoted shall be inclusive of performing point load test on the rock samples obtained from bore spoils during the chiseling operations, and shall be inclusive of transportation to laboratory, testing and reporting of the results.
- 3.1.7.10 Measurement for the item of boring as per BPS through soil including all kind of rocks shall be done by linear measurement for the length bored from the bottom

of pile cap or ground level whichever is lower through soil all kind of rocks up to termination/ founding level as per drawing or actual length achieved of the pile in meters, up to second place of decimal.

3.1.7.11 Contractor may design pile foundation with bottom of pile cap above ground level and decide height of chimney accordingly, depending on economy and feasibility of construction at site. However, no extra amount shall be paid on account of works related to placement of bottom of pile cap above GL or increase in chimney height.

3.1.7.12 To establish the quality of rock as hard rock, core drilling as per IS 6926 shall be carried out in rock strata encountered by the contractor without any additional cost implication to Employer. Rock shall be considered as Hard rock if the core recovery is more than 80% with minimum RQD as 70%.

3.1.7.13 In case boulders are recovered during pile boring works, the same shall not be considered as rocks.

3.1.8 **Standard Penetration Test (SPT)**

The actual quantity of SPT done shall be calculated in nos. and the rate quoted shall include all the necessary equipment, labour, materials, operations etc. required to complete the work as per **Clause 2.0** of this section.

3.1.9 **MS Liner**

3.1.9.1 The measurement shall be made in Metric Ton (MT) corrected upto third place of decimal based on the calculated weight of the MS liner as per construction drawing and with reference to the sectional weights of respective thickness of MS plate as per Indian Standards or MS liner actually provided, whichever is less. The rate quoted shall be inclusive of all wastage.

3.1.9.2 The rates shall also include all minor activities which are obviously and fairly intended, though may not have been clearly brought out in the description of items or in these documents, but are essential for the satisfactory completion of the work.

3.1.10 **Pile Integrity Test**

The actual quantity of pile integrity test done shall be calculated in numbers and the rate quoted by the bidder shall include all necessary equipments, manpower, labour, materials, operations etc. required to complete the work as **per Clause 4.0** of this section. The work shall be deemed to be complete only after submission of complete report of pile integrity test on all piles. Minimum one integrity test per

pile installed/casted has to be carried out by the bidder.

3.2 Rates and Measurement Applicable When Design of Pile foundation is not in Contractor's Scope and Employer shall provide construction drawings to the Contractor

3.2.1 Excavation

3.2.1.1 The unit rate for excavation shall be quoted by the Bidder in the respective schedule of BPS. The unit rate quoted shall hold good for excavation (other than boring) for all depth and size in all types of soil including sheet piling, sheeting, shoring, bracing, draining, dewatering, cofferdams etc. as required for successful completion of job. The excavation shall be carried out in accordance with stipulations in Clause 2.0 of this section.

3.2.1.2 The unit of measurement shall be in cum. The design excavation volume shall be calculated considering dimension of pile cap plus 150mm on all sides of the pile cap and depth as shown in the drawing below the lean concrete level. The payment shall be made based on unit rate quoted, for excavation actually carried out or as per the design excavation volume as calculated above, whichever is less. No extra payment shall be admissible for excavations if required to be carried out in slope to maintain stability of pit.

3.2.1.3 The Contractor shall arrange to transport the excavated soil to a distance as directed by Employer and the rates quoted for excavation in Price schedule shall include all lead, lift, carriage etc.

3.2.2 Cement Concrete

3.2.2.1 Actual volume of work as executed or as per drawing issued, whichever is less, measured in cubic meter corrected up to second place of decimal shall be considered for payment as per unit rate quoted in BPS. Deductions for openings, conduits, pipes, ducts, pockets etc. shall only be made provided they are larger than 0.1 sq. in area (for each opening).

3.2.2.2 No deduction shall be made for embedded fixtures including reinforcement, sleeves, anchor bolts and similar items.

3.2.2.3 The volume for structural concrete and lean concrete shall be measured separately.

3.2.3 Form Work

3.2.3.1 Formworks of different types/ shapes shall be measured with reference to actual

surface area in contact with the concrete and paid on area basis. The unit of measurement will be in sqm corrected up-to second place of decimal.

3.2.3.2 No payments for formwork for construction joints shall be made.

3.2.3.3 Opening up to 0.1 sqm. of boxing left for inserts etc. shall not be considered as if non-existent for the purpose of formwork measurement of surface in which the opening occurs. If the cross-sectional area of any openings exceeds 0.1 sqm, area of such openings shall be measured and deducted from the area payable for the form work.

3.2.3.4 No payment shall be made for making the formwork water proof or for supports, scaffolding, centering, approaches, etc.

3.2.3.5 No separate payment shall be made for using fillets for rounding of chamfering junctions, corners, etc.

3.2.4 **Back filling**

The actual volume of backfilling shall be measured in cubic meter rounded off up to 2nd place of decimal and the unit rate shall include all the necessary operations required to complete the work as per drawing & **clause no. 2** of this section.

3.2.5 **Reinforcement Steel**

3.2.5.1 The unit rate for reinforcement steel shall include supply and placement of reinforcement steel of specific grade, stirrups, annealed wire for binding the reinforcement, chairs, hangers, spacers, welding, tack welding etc. as required to complete the RCC work in pile, pile cap, pedestal/ chimney, tie beam (if required) including cleaning, straightening, cutting, bending, binding etc. The unit rate shall also include placement of reinforcement cage in pile shaft/ bore and all other cost for tools, plants, materials, labour, and transportation to site by appropriate means as required. The measurement for payments shall be made in Metric Ton (MT) corrected up to third place of decimal based on the calculated weight of reinforcement steel as per construction drawing and with reference to the sectional weights of respective size of reinforcement bars as per Indian Standards or reinforcement bars actually provided, whichever is less. The unit rate quoted shall be inclusive of all wastage.

3.2.5.2 Standard hooks, cranks, bends, authorised laps, etc. shall be measured.

3.2.5.3 Separator pieces between two or more layers of steel shall not be measured.

3.2.5.4 No payment shall be made for supports, spacers, chairs, hangers, etc. of height/ length of 300 mm and less, required for keeping the steel in position. For

supporting horizontal reinforcement at heights, drawings for supports, spacers, chairs, hangers, etc. larger than 300 mm, shall be prepared by the Contractor and got it approved from Employer. Payment shall be made for these supports as approved by the Employer, or as actually provided, whichever is less, as per the unit rate quoted for reinforcement.

3.2.5.5 No extra payment shall be made for modification of already embedded reinforcement, if required due to faulty fabrication or placement.

3.2.5.6 Dowels as required for completion of the work shall be provided by the contractor which will not be separately calculated for payment.

3.2.6 **Piling work**

3.2.6.1 The items of works are briefly described in the BPS. The various items in the BPS shall be read in conjunction with the corresponding clause in this section including amendments, and additions, if any. The unit rate quoted for items shall include all the activities covered in the description of the item as well as all necessary operations described in the specification and any other specific requirements.

3.2.6.2 The unit rates shall also include all minor activities which are obviously and fairly intended, though may not have been clearly brought out in the description of items or in these documents, but are essential for the satisfactory completion of the work.

3.2.6.3 Unit rates shall also include for all safety measures as required by Codal provisions, local regulations, acts, bye-laws, etc. and mobilization of all plant, equipment, scaffolding, materials, skilled and unskilled labour, de-mobilisation after completion of work, supervision, establishing level and coordinates at each location by carrying levels from one established bench mark and distances from one set of grid lines furnished by the Employer.

3.2.6.4 Unit rate on per meter length basis for a particular diameter of pile shall remain unchanged irrespective of the actual length/depth of individual piles executed at any location

3.2.6.5 Unit rate shall be inclusive of cost of boring by approved method, bailing out all the pile bore spoils from the pile bore, keeping the bore hole free from bored material/ debris etc. and disposing same along with the drilling mud up to a distance of 2 km, flushing the pile bore by fresh bentonite before concreting, collection of samples from bottom of pile bore, transporting to laboratory, testing and reporting of results including necessary materials, equipment and manpower.

3.2.6.6 Unit rate quoted shall include shifting of plant and equipment from one pile

location to another location, providing temporary casing as required and removal of the same after completing concreting. The quoted rate shall also include the boring/ installation of pile and is inclusive of the empty boring and extra concreting required above the pile cut off level

- 3.2.6.7 Unit rate quoted shall also include chiseling through rock, if required, in the pile up to the specified level, bailing out the pile bore debris/ spoils from the pile bore and disposing off the chiseled materials/debris along with the sludge/ mud up to 2 km, flushing the pile bore by fresh betonies before concreting, collection of samples from bottom of the pile bore, transporting to laboratory, testing and reporting of results.
- 3.2.6.8 Unit rate of pile boring shall include concreting in piles by tremie method only, cost of preparation of pile head and disposal of debris etc., resulting from breaking off of pile up to COL, up to a distance of 2 km.
- 3.2.6.9 Unit rates shall include for all quality assurance requirements, but not limited to providing for technical inspection, transportation of samples to laboratory, testing samples, maintaining and submitting all test records, etc.
- 3.2.6.10 The rate quoted for boring and installation shall be inclusive of performing point load test on the rock samples obtained from bore spoils during the chiseling operations, and shall be inclusive of transportation to laboratory, testing and reporting of the results.
- 3.2.6.11 Measurement for the item of boring through soil including all kind of rocks shall be done by linear measurement for the length bored from the pile cut off level or ground level whichever is lower through soil/ all kind of rocks up to termination/ founding level as per drawing or actual length achieved of the pile in meters, up to second place of decimal.
- 3.2.6.12 To establish the quality of rock as hard rock, core drilling as per IS 6926 shall be carried out in rock strata encountered by the contractor without any additional cost implication to Employer. Rock shall be considered as Hard rock if the core recovery is more than 80% with minimum RQD as 70%.
- 3.2.6.13 The payment for boring in hard rock upto depth of 10 meter in each bore (either cumulative or in single layer) shall be considered as per BPS. In case boring in hard rock is more than 10 meters in each bore, the payment shall be based on mutually agreed rates, to be derived on the basis of rates available in the Contract.
- 3.2.6.14 In case boulders are recovered during pile boring works, the same shall not be considered as rocks.
- 3.2.6.15 i) In case bottom of pile cap is placed above existing ground level (upto 3m from

EGL) and boring is not done for the part of pile above existing ground level, payment for boring is not admissible. However, payment for concreting work in Pile for upto 3m from EGL shall be done from unit rate of concrete quoted for pile caps, pedestal/chimney etc. as per BPS & payment for Pile work beyond 3m from EGL shall be as mutually agreed between Purchaser & contractor. The grade of concrete for the portion of pile above ground level shall be same as that of grade of concrete in bore below ground level. No additional payment shall be admissible on account of shuttering of pile (if required), necessary arrangements required for concreting in pile and/or pile cap above ground level.

ii) Payment for concreting/shuttering/reinforcement for chimney height upto 6m from top of Pile cap shall be done based on quoted unit rate of these items in BPS. Payment for concreting/shuttering/reinforcement for chimney height beyond 6m from top of Pile cap shall be as mutually agreed between Purchaser & contractor. No additional payment shall be admissible on account of other necessary arrangements required for casting of chimney.

3.2.7 **Standard Penetration Test (SPT)**

The actual quantity of SPT done shall be calculated in nos. and the unit rate quoted shall include all the necessary equipments, labour, materials, operations etc. required to complete the work as per **clause 2.0** of this section.

3.2.8 **MS Liner**

3.2.8.1 The items of works are briefly described in the BPS. The various items in the BPS shall be read in conjunction with the clause 5.0 of this section. The unit rate quoted for items shall include all the activities covered in the description of the item as well as all necessary operations described in the specification and any other specific requirements.

3.2.8.2 The unit rates shall also include all minor activities which are obviously and fairly intended, though may not have been clearly brought out in the description of items or in these documents, but are essential for the satisfactory completion of the work.

3.2.8.3 The measurement for payments shall be made in Metric Ton (MT) corrected upto third place of decimal based on the calculated weight of the M.S. liner as per construction drawing and with reference to the sectional weights of respective thickness of MS plate as per Indian Standards or MS liner actually provided, whichever is less. The unit rate quoted shall be inclusive of all wastage.

3.2.9 **Pile Integrity Test**

The actual quantity of pile integrity test done shall be calculated in nos. and the

unit rate quoted shall include all necessary equipments, manpower, labour, materials, operations etc. required to complete the work as per **clause 4.0** of this section. The payment shall only be made after successful completion of the job and submission of complete report of pile integrity test on all piles.

4.0 Testing and Acceptance Criteria

4.1 Construction Materials

4.1.1 Any material considered to be sub-standard or not meeting the requirement of **clause 2.0** of this section and as declared/ certified accordingly by the Employer shall not be used by the Contractor and shall be removed from the site immediately at no extra cost to the Employer.

4.2 Cement Concrete

4.2.1 Testing

4.2.1.1 The Contractor shall carry all sampling and testing in accordance with the Standard Field Quality Plan (SFQP) which is available on the POWERGRID Website under compendium of vendor section, 7 (seven) days prior to the actual date of bid opening, relevant Indian Standards and this Specification at his own cost in field and in a laboratory approved by the Employer. For the tests carried in the laboratory, Contractor shall submit the test results to the Employer in triplicate within 7 (seven) days after completion of the test.

4.2.1.2 Facilities required for sampling and testing materials, concrete, etc. in field and in laboratory shall be provided by the Contractor. Where no specific testing procedure is mentioned the tests shall be carried out as per the prevalent accepted engineering practice to the directions of the Employer. In field Tests shall be done in the presence of the Employer or his authorized representative. For the tests to be performed in the laboratory other than field, shall be done in the independent certified lab approved by Employer. In case the Employer requires additional test, the Contractor shall arrange to get these tests done and submit to the Employer the test results in triplicate within three days after completion of any test.

4.2.1.3 The Contractor shall maintain records of all inspection and testing, which shall be made available to the Employer, whenever required.

4.2.1.4 The testing apparatus/ equipment installed in the field laboratory shall be calibrated/ corrected by the qualified person as frequently as possible to give accurate testing results.

4.2.1.5 Frequency of sampling and testing, etc. and Acceptance Criteria should be as per

SFQP. However, Employer shall have the full authority to call for tests as frequently as he may deem necessary to satisfy himself that the materials and works comply with the Specifications. The materials shall be tested to meet all the specified requirements before acceptance at manufacturers' premises or at independent government approved laboratory. Tests indicated in the tables of Standard Field Quality Plan are for cross checking at site to ascertain the conformity of the materials to the Specifications.

4.2.1.6 One sample consisting of six test cubes shall be made from the concrete used in each pile, three to be tested after 7 days and three after 28 days.

4.2.1.7 In preparation of test cubes/ specimens, vibrators shall not be used.

4.2.1.8 Concrete shall be tested for slump at every 1-hour interval.

4.2.2 Acceptance Criteria for Concrete

- a) The acceptance criteria of concrete shall be in accordance with Standard Field Quality Plan (SFQP) and as per **clause 2.0** of this Specification.
- b) Concrete work found unsuitable for acceptances shall have to be dismantled and replacement is to be done as per specification by the Contractor. No payment for the dismantled concrete, the relevant form work and reinforcement, embedded fixtures, etc. wasted in the dismantling shall be made to the Contractor. If any damage is done to the embedded items of adjacent structures, the same shall be made good free of charge by the Contractor, to the satisfaction of Employer.
- c) The dimensions of concrete as cast, when compared with the drawing, shall be within the tolerances given below. Steps in surface alignment shall not exceed 2mm. No reduction will be permitted in the cover to reinforcement because of a specified negative tolerance in a concrete section.

Structural Element Detail	Permissible Deviation in mm	
Faces of concrete in foundations and structural members against which backfill is placed	+25	-5
Exposed concrete foundations	+10	-5
Top surfaces of Pedestal/chimney and for concrete to receive grouted plant or structural steel work	+5	-5
Alignment of tie beams, Pedestal/chimney, pile cap	+5	0
Cross sectional dimensions of tie	+5	-5

beams, Pedestal/chimney, cap		
Level and alignment of holding down bolts	+5	-5
Level of holding down bolt assemblies	+10	-5
Alignment of holding down bolt assemblies	+5	-5
Centers of pockets or holes with greatest lateral dimensions not exceeding 150mm	+5	-5
Centers of pockets or holes with greatest lateral dimension exceeding 150mm	+10	-5

4.2.3 Acceptance criteria of Finished Concrete

- 4.2.3.1 Finished concrete shall be true to shape, lines, levels plumb and dimensions as shown on drawings.
- 4.2.3.2 All embedded fixtures shall be of correct type and in correct position as shown in drawings.
- 4.2.3.3 Finished concrete surface shall be free from blemishes like honey-combs, air bubbles, fins, etc.
- 4.2.3.4 Exposed concrete surface shall be free from rust stains, grease and mould oil stains etc. and shall have uniform pleasing appearance to the satisfaction of the Employer.
- 4.2.3.5 The finished concrete shall be of a standard quality and equal to the accepted sample.

4.3 Reinforcement Steel

Reinforcement shall be checked for cleanliness, proper bending, binding, placing and securing in position with provision for proper cover. The reinforcement should conform to the requirement of under **clause 2.0** of this section.

4.4 Testing for position and alignment

- 4.4.1 Each pile shall be checked for its position with respect to specified location. Each pile bore shall be checked for its alignment.
- 4.4.2 Permissible limits for deviation shall be as specified under **clause 2.0** of this section.

4.5 Properties of drilling mud

4.5.1 Properties of drilling mud shall be checked as per requirements indicated in **Annexure A**. Prior to the commencement of piling work and thereafter at least once in a week or as found necessary by the Employer, one sample consisting of 3 specimens shall be tested.

4.5.2 Density and sand content of the drilling mud shall be checked in each pile.

4.6 Check for Pile bore

4.6.1 On completion of boring and cleaning the bottom of each pile bore shall be checked by the methods as approved by the Employer, to ensure that it is free from pile bore spoil/ debris and any other loose material, before concreting. Concreting shall be done only after the approval of the Employer.

4.6.2 For sampling of drilling mud from the pile bore the following method or any other suitable method shall be adopted.

A solid cone shall be lowered by a string to the bottom of pile bore. A sampler tube closed at top with a central hole (hollow cylinder) is lowered over the cone, then a top cover shall be lowered over the cylinder. Care shall be taken for proper fittings of assembly to minimise the leakage while lifting the cone assembly to the ground surface. The slurry collected in the sampler tube shall be tested for density and sand content.

4.7 Pile Integrity Test

4.7.1 Pile Integrity test is used to assess the as-installed pile characteristics as well quality achieved during the construction of pile. The parameters to be evaluated through the Pile Integrity Test (also known as low-strain dynamic test/ sonic echo test/ low-strain integrity test) should generally cover pile continuity, defects such as cracks, necking, soil incursions, changes in cross section and approximate pile lengths changes in cross-section if any etc.

4.7.2 The equipment consists of an electronic control unit, a hand-held instrumented hammer and an accelerometer and computer. The test shall be conducted as per IS 14893:2001.

4.7.3 The results to be stored in a compact control unit and transferred to computer and detail analysis to be carried out.

4.7.4 The contractor is to submit a detailed report for the data specified in **clause 4.7.1** above and as required by the Employer.

5.0 Structural steel MS liner for RCC Vertical bored piles

5.1 General Requirements

This specification covers general requirements for supply, fabrication, shop painting (if required), and delivery at site mild steel liners of specified diameters and lengths for piles.

MS liner shall be provided to piles at locations, as directed by the Employer and design guidelines mentioned in the Design & Drawings clause of this section. The extent up to which the MS liners for piles required to be provided shall be as shown in the approved drawings and as per direction and written approval of the Employer.

5.2 Drawings

5.2.1 Contractor shall submit calculations and fabrication details for connection/ splice/ joint for fabrication of liners and get these approved by the Employer before starting any fabrication works. The approval of fabrication drawings prepared by the Contractor shall not relieve the Contractor of the responsibility for the liners in place.

Fabrication drawing (drawn to large enough scale) to convey all information clearly shall include the following:

- i) Reference of the design drawings based on which fabrication had been prepared. The reference should include and indicate the latest revision of design drawing.
- ii) layout, elevations and sections with erection marking of all members.
- iii) Quality of Structural Steel, Welding electrodes, and standards to which these conform to.
- iv) Detailing of structural joints and shop/field splices.
- v) Details of shop and field joints/connections.
- vi) Bill of material indicating size and weight of members/ component.
- vii) Erection assemblies and sub-assemblies identifying all transportable parts.
- viii) Method of erection, special erection instructions, and special precautions to be taken during erection, as required.

5.2.2 Employer reserves the right to make changes in the fabrication drawings. Revisions to drawings may be made to reflect more updated requirements. Revisions to drawings and any new drawings made to include additional work by

Contractor shall be considered as a part of this specification and the Employer shall entertain no extra claim on this account. All revisions in the drawings should be highlighted in the drawing distinctly.

5.2.3 Unless otherwise specified, the drawings and specifications are intended to include everything obviously requisite and necessary for the proper and entire completion of the work and the job shall be carried out accordingly for the completeness as required.

5.2.4 In the case of variations in drawings and specifications, the decision of the Employer shall be final. In case Contractor in the execution of his work, find discrepancies in the information furnished by Employer, he shall refer such discrepancies to the Employer before proceeding with such work.

5.3 **Fabrication**

5.3.1 **General**

The fabrication work shall be carried out generally in accordance with IS 800 as well as the stipulation contained in these specifications. All materials shall be completely shop fabricated and finished with proper connection materials for ready assembly in the field. All the workmanship and finish shall be of the best quality and shall conform to the best approved method of fabrication. All materials shall be finished straight and shall be machined true and square where so specified. All edges shall be free of burrs, shearing and chipping shall be neatly and accurately done. Material at the shop shall be kept clean and protected from weather, Checklist format, inspection certificate for fabrication and protocol for handing over of structural steel shall be submitted by the Contractor in the form as agreed to by the Employer.

5.3.2 **Straightening**

All material shall be straight and free from bends or twists. If necessary, before being worked, the materials shall be straightened, unless otherwise required/ specified. In case plates are distorted or twisted, straightening or flattening shall be done by methods that will not injure the plates. Long plates shall be straightened by passing through mangle of leveling rolls. Heating or forging shall not be resorted to without the prior approval of Employer in writing.

5.3.3 **Welding**

5.3.3.1 Welding shall be in accordance with IS 816, IS 819, IS 1024, IS 1261, IS 1323, IS 4353 and IS 9595, as appropriate.

5.3.3.2 For welding of any particular type of joint, Contractor shall give evidence

acceptable to the Employer of having satisfactorily completed appropriate tests as described in any of the Indian Standards IS 817, IS 1393, IS 7307 (Part J), as relevant and as per the checklists given in the **Annexure** to this section of the specification.

- 5.3.3.3 The works shall be done as per approved fabrication drawings which would clearly indicate various details of joints to be welded, type of weld, length and size of weld, whether shop or site weld. Symbols for welding on shop drawings shall be according to IS 813. Efforts shall be made to reduce site welding so as to avoid improper welding due to constructional difficulties.
- 5.3.3.4 Welding of Structural Steel shall be done by an electric arc process. The procedure to be followed, materials, plant and equipment to be applied shall be subject to the approval of the Employer and shall conform generally to relevant acceptable standards viz. IS 816, IS 9595, IS 814, and Indian Standard Hand Book for metal arc welding, and other standard codes of practice internationally accepted.
- 5.3.3.5 “Open-Arc-Welding” process employing coated electrodes shall be employed for fabrication of other welded connections and field welding.
- 5.3.3.6 Wherever welding is done for assembling the components of liner, the job shall be so positioned that down hand welding is possible. In cases where such positioning of job is not possible other manual welding positions could be resorted to.
- 5.3.3.7 Any structural joints shall be welded only by those welders who are qualified for all welding procedures and positions required in such joint that is welded. The entire weld of any liner joint shall be made by one welder.
- 5.3.3.8 All welds shall be free from defects like blow holes, slag inclusions, lack of penetration, undercutting, cracks and show uniform Sections, smoothness of Weld metal, feather edge without overlap and freedom from porosity.
- 5.3.3.9 Proper edge preparation shall be made for jointing of materials before welding. Suitable edge preparation shall be done for all processes of welding except for square butt welds. Type of edge preparation shall depend on the thickness of parent materials that are to be joined. The edge forms shall be chosen to suit the design, technology and production conditions and shall be subject to the approval of the Employer. The edge form of weld elements shall be prepared either by machines or by automatic gas cutting with surface rougher of the welding area not exceeding 50 sq.mm. All edge cut by flame shall be ground before they are welded.
- 5.3.3.10 Electrodes used for welding shall be of suitable type and size depending upon specifications of the parent material, the method of welding, the position of

welding and quality of welds desired e.g. normal penetration welds or deep penetration welds.

- 5.3.3.11 Where bare electrodes are used these shall correspond to specification of the parent material. The type of flux wire combination for submerged arc welding shall conform to the requirements of F-60 class of AWSA-5-17-69 and IS 3613 (Latest). The electrodes shall be sorted properly and the flux shall be baked before use in an oven in accordance with the manufacturer's requirements as stipulated.
- 5.3.3.12 Specific approval of the Employer shall be taken by the Contractor for the various electrodes proposed to be used on the work before any welding is started.
- 5.3.3.13 Electrodes larger than 5mm diameter shall not be used for root-runs in butt-welds.
- 5.3.3.14 Welding plant and accessories shall have capacity adequate for the welding procedure laid down and shall satisfy appropriate standards and be of approved make and quality. All the electrical plant in connection with the welding operation shall be properly and adequately earthed and adequate means of measuring the current shall be provided.
- 5.3.3.15 Voltage and current (and polarity if direct current is used) shall be set according to the recommendations of the manufacturer of the electrode being used and suitability to thickness of material, joint form etc.
- 5.3.3.16 Pre-qualified welding procedures recommended by appropriate welding standards and known to provide satisfactory welds shall be followed. For non-standard procedures, qualification tests as prescribed in IS 9595 (latest) shall be made to verify the adequacy of the procedures. A welding procedure shall be prepared by Contractor and submitted to the Employer for approval before start of welding. This shall include all details of welding procedures with references to provisions of IS 9595 and IS 4353. Approval of the welding procedure by Employer shall not relieve Contractor of his responsibility for correct and sound welding without undue distortion in the finished structure.
- 5.3.3.17 No welding shall be done, when the surface of the members is wet, during periods of high wind, unless the welding operator and the work are properly protected.
- 5.3.3.18 In joints connected by fillet welds, the minimum sizes of single run fillet welds for first run and minimum full sizes of fillet welds shall conform to requirements of IS 816.
- 5.3.3.19 **Sequence of Welding**

- i) The sequence of welding shall be carefully chosen to ensure that the

components assembled by welding are free from distortion and large residual stresses are not developed. The distortion should be effectively controlled either by a counter effect of by counter distortion. The direction of welding should be away from the point of restraint and towards the point of maximum freedom.

- ii) Each case shall be carefully studied before finally following a particular sequence of welding.

- 5.3.3.20 Approval of welding sequence and procedure shall not relieve the Contractor of the responsibility for the correct welding and for minimising the distortion in the finished structure which in no case shall exceed that laid down in Indian Standards.
- 5.3.3.21 All welds shall be finished full and made with correct number of runs, the welds being kept free from slag and other inclusions, all adhering slag being removed from exposed faces immediately after such run.
- 5.3.3.22 Current shall be appropriate for the type of electrode used. To ensure complete fusion, the weaving procedure should go proper and rate of arc advancement should not be so rapid so as to leave the edges un-melted.
- 5.3.3.23 Pudding shall be sufficient to enable the gases to escape from the molten metal before it solidifies.
- 5.3.3.24 Non-uniform heating and cooling should be avoided to ensure the excessive stresses are not locked up resulting ultimately in cracks.
- 5.3.3.25 The fusion faces shall be carefully aligned. Angle shrinkage shall be controlled by presenting. Correct gap and alignment shall be maintained during the welding operation.
- 5.3.3.26 All main butt welds shall have complete penetration and except where it is impracticable they shall be welded from both sides, back surface of the weld being gouged out clean before first run of the weld is given from the back.
- 5.3.3.27 Intermittent welds shall not be permitted without the approval of the Employer. These shall be permitted only when specifically approved in the fabrication drawings.
- 5.3.3.28 Inspection of Welds: All Welds shall be inspected for flaws by any of the methods described under Clause "Inspection". The choice of the method adopted shall be determined by Employer.
- 5.3.3.29 The Contractor shall carry out tests which establish soundness of welds. In case

the tests uncover defective work, the Contractor shall correct such defects at his own cost and prove the soundness of rectified work at his own cost.

- 5.3.3.30 The correction of defective welds shall be carried out as directed by Employer without damaging the parent metal. When a crack in the weld is removed, magnetic particles inspection or any other equally positive means as prescribed by Employer shall be used to ensure that the hole of the crack and material up to 25 mm beyond each end of the crack has been removed. Cost of all such test and operations incidental to correction shall be to Contractor's account.

5.3.3.31 Inspection and Rectification

5.3.3.31.1 Visual Inspection

100 percent of the welds shall be inspected visually for external defects. Dimensions of welds shall be checked. The length and size of weld shall be as per approved fabrication drawing. It may be slightly over sized but should not be under sized. The profile of weld is affected by the position of the joint but it should be uniform. In case of butt and corner welds the profile shall be convey and in case of submerged are fillet weld, it shall be slightly concave. The welds should have regular height and width of beads. The height and spacing or ripples shall be uniform. The joints in the weld run where welding has been recommended shall as far as possible be smooth and should not show any humps or craters in the weld surface. Welds shall be free from the unfilled craters on the surface under cuts slag on the surface visible cracks. Such inspection shall be done after clearing the welds surface with steel wire brushes and chisel to remove the sputter metal, scales, slag, etc. If external defects mentioned above are noticed the work shall be dismantled and redone duly replacing the defective materials including the base members.

5.3.3.31.2 Rectification of Defective Welding Work

Wherever defects like improper penetration, extensive presence of blow holes, undercuts cracking, slag inclusion etc. are noticed by visual inspection/other tests, the welds at such locations shall be removed by gouging process. The joints shall be prepared again by cleaning the burrs and residual matters with wire brushes and grinding, if necessary and re-welded. The gouging as far as possible be done using gouging electrodes. Flame gouging shall be resorted to only in special cases with specific permission of the Employer.

5.3.3.31.3 Acceptance of the Welded Structures

The acceptance of the welded work shall depend upon correct dimensions and alignment, absence of distortion in the structure, satisfactory results from the examination and testing of the joints and the test specimens as per IS soundness

of the welds and upon general workmanship being good.

Random die penetration tests shall be conducted after welding of MS liner plates.

5.4 Erection Marks

5.4.1 Before any steel work leaves the Contractor's fabrication shop, it shall be suitably marked in accordance with the approved fabrication drawing and according to an approved marking plan. Copies of all drawing showing such erection marks on the various steel works to be furnished to the Employer well in advance of the erection.

5.4.2 The erection marks assigned to various components of the structural steel work shall also contain an erection sequence number indicating the sequence in which the various components are to be erected.

5.4.3 Erection marks shall be clearly painted on the work, each piece being marked in at least two places. Each piece shall also have its weight marked thereon. In order to help identification, each piece shall bear the erection marks and erection sequence number. Erection marks shall be painted on the structures, during the process of fabrication to facilitate their identification during inspection. Where a number of components are identical and bear the same erection marks, these components shall be further identified by assigning numerals in addition to the common erection mark.

5.5 Errors

Any error in shop work which prevents proper assembling and fitting of parts in the field, moderate use of drift pins or moderate amount of reaming will be classified by Employer as defective workmanship. All charges incurred by Employer either directly or indirectly because of workmanship will be deducted from the amount due to Contractor, before payment is made. The amount of such deduction will consist of the sum total of the costs of labour direct or indirect, material, plants, transportation, equipment, rental and overhead expense. In case Employer chooses to reject the material because of poor workmanship the cost of all handling and returning the material to Contractor, if he so desires, shall entirely be to Contractor's account and in such cases, the cost of handling, transport and delivery to site shall be borne by Contractor.

5.6 Protection against Damage in Transit

All steel work shall be efficiently and sufficiently protected against damage in transit to site from any cause whatsoever to prevent damage or distortion during transit. Should there be any distortion of fabricated members the Contractor shall

immediately report the matter to the Employer. Distorted steel shall not be used in fabrication unless the distortion is minor which in the opinion of the Employer can be removed by acceptable methods. These distortions shall be rectified by the Contractor by cold-bending. If heating is necessary to rectify the defects the details of the procedure shall be intimated to the Employer whose approval shall be taken before such rectification. The temperature of heat treatment shall not exceed the limits beyond which the original properties of steel are likely to be impaired.

5.7 Anti-Corrosive Treatment for Mild Steel Liners

5.7.1 After inspection and issue of test and acceptance certificate, all steel surfaces shall be coated with a coat of rust primer/ metal primer and thereafter these shall be provided with a final coat of minimum 250 microns of high built epoxy coal tar. The primer and paint shall be of reputed companies like Asian Paints/ Berger/ Nerolac/ Shalimar etc. The fabricated mild steel liners to be used for the piling work shall be cleaned from grease or any other contaminant, by mechanical/ manual cleaning. The primer shall be applied with a brush or spray to develop a dry film thickness or minimum 25 microns. The final coat shall consist of high built epoxy coal tar with a thickness of minimum 250 microns. The physical properties of primer and top coat shall be as per IS 20174 (Latest revision) .

5.8 Shop Connections

5.8.1 Surfaces to be permanently in contact shall receive a priming coat immediately at the works except where jointed by welding.

6.0 List of Indian Standards

The construction work of pile foundation shall conform to the following Indian Standards, which shall mean latest revisions, amendments/ changes adopted and published, unless otherwise specified hereinbefore. Some of the important relevant applicable codes for this section are as follows:

1	IS 432	Specification for mild steel and high tensile steel bars and hard drawn steel wire for concrete reinforcement
2	IS 456	Code of practice for plain and reinforcement concrete
3	IS 516	Methods of test for strength of concrete
4	IS 800	Code of Practice for General Construction in Steel
5	IS 813	Scheme of symbols for Welding
6	IS 814	Specification for Covered Electrodes for Metal Arc

		Welding of Structural Steels
7	IS 816	Code of Practice for use of Metal Arc Welding for General Construction in Mild Steel
8	IS 817	Code of Practice for Liquid Penetrant Flaw Detection
9	IS 1199	Methods of sampling and analysis of concrete
10	IS 1200 (Part-I)	Method of measurement of Building and civil Engineering work-earthwork
11	IS 1200 (Part-23)	Method of measurement of Building and civil Engineering Work-Piling
12	IS 1786	Cold worked steel high strength deformed bars for concrete reinforcement
13	IS 1838	Performed fillers for expansion joints in concrete non-extruding and resilient type (bitumen impregnated filler).
14	IS 2062	Weld able structural steel
15	IS 2074	Ready Mixed Paint, air drying, Red Oxide Zinc Chrome, Priming
16	IS 2386 (Part-III)	Specific gravity, density, voids absorption and bulking
17	IS 2502	Code of Practice for bending and fixing of bars for concrete reinforcement
16	IS 2505	General requirements for concrete vibrators immersion type
19	IS 2506	Screed board concrete vibrators
20	IS 2514	Concrete vibrating tables
21	IS 2911 (Part 1/ Section 2)	Code of practice for design and construction of pile foundation-Bored cast-in-situ concrete piles
22	IS 3025	Methods of sampling and test (Physical and chemical) for water used in Industry
23	IS 3350	Methods of tests for routine control for water used in Industry
24	IS 3370	Code of Practice for concrete structure for the storage of liquids
25	IS 3613	Acceptance Tests for Wire Flux Combinations for submerged Arc welding of structural steels

26	IS 3658	Recommended Practice for Radiographic Examination of Fusion Welded Butt Joints in Steel Plates
27	IS 3764	Safety codes for Excavation work
28	IS 4353	Recommendations for Submerged Arc Welding of Mild Steel and Low Alloy Steels
29	IS 4656	Form vibrators for concrete
30	IS 4701	Code of practice for earth work on canals
31	IS 8500	Specification for weldable structural steel (medium and high strength qualities)
32	IS 9103	Admixtures for concrete
33	IS 10262	Recommended guidelines for concrete mix design

Annexure-A

REQUIREMENTS OF DRILLING MUD (BENTONITE)

REQUIREMENTS The bentonite powder and bentonite suspension used for piling work shall satisfy the following requirements:

a) The liquid limit of bentonite when tested in accordance with IS 2720 (Part 5) shall be 400 percent or more.

b) The bentonite suspension shall be made by mixing it with fresh water using a pump for circulation. The density of the freshly prepared bentonite suspension shall be between 1.03 and 1.10 g/ml depending upon the pile dimensions and the type of soil in which the pile is to be bored. The density of bentonite after contamination with deleterious material in the bore hole may rise up to 1.25 g/ml. This should be brought down to at least 1.12 g/ml by flushing before concreting. A higher density of bentonite slurry (up to **1.12 g/ml**) may be allowed in situations where:

The soils are highly unstable, coarse, or loose.

There is high groundwater pressure or water-sensitive soils.

Slurry performance needs to be enhanced for better stabilization

c) The marsh viscosity of bentonite suspension when tested by a marsh cone shall be between 30 to 90 stok.

d) The pH value of the bentonite suspension shall be between 9 and 11.5.

Annexure-B

Pile Data Sheet

1	Reference No. Location (Co-ordinates)	
2	Sequence of Piling	
3	Pile diameter & Type	
4	Working level (Platform level)	
5	Cut off level (COL)	
6	Actual length below COL	
7	Pile termination level	
8	Top of finished concrete level	
9	Date and time of start and completion of boring	
10	Depth of Ground water table in the vicinity	
11	Type of strata at pile tip	
12	Method of boring operation	
13	Details of drilling mud as used:	
	i) Freshly supplied mud:	
	a) liquid limit	
	b) sand content	
	c) density	
	d) marsh viscosity	
	e) Swelling index	
	f) pH value	
	ii) Contaminated mud:	
	a) Density	
	b) sand content	
14(a)	SPT, N values in soil (from the nearest bore hole) / UCS value in rock (from the nearest bore hole)	
15	Chiseling if any,	from.....m to.....m
16(a)	Date and time of start of concreting	
16(b)	Date and time of completion of concreting	
17	Method of placing concrete	
18	Concrete quantity:	
	a) Actual	
	b) Theoretical	
19	Ref. Number of test cubes	
20	Grade and slump of concrete	

21	Results of test cubes	
22	Reinforcement details:	
i)	Main Reinforcement	
a)	Type	
b)	No.	
c)	Dia	
d)	Depth	
ii)	Stirrups:	
a)	Type	
b)	No.	
c)	Dia	
d)	spacing	
23	Any other information regarding constructions, delay and other interruption to the sequence of work.	

Note: The above details are required to be furnished by the Contractor before starting the installation work.

Inspection & Testing for Structural Steel Works

1.0 General

Contractor shall carry out a comprehensive inspections and testing programme during fabrication and erection. An indicative programme of inspection/testing envisaged by Employer is given below. This is however not intended to form a comprehensive programme as it is the Contractor's responsibility to draw up and carry out such a programme duly approved by the Employer. Such approval shall not relieve the Contractor of the responsibility about the correctness and adequacy of workmanship, materials etc.

1.1 Raw Materials Inspection

1.1.1 Steel

i) Specifications

Check the specification of steel and availability of the relevant Test Certificates.

ii) Physical Conditions

- a) Steel shall not be pitted and should be free from scales and rust.
- b) If the plates are bent or distorted, bent to distortion shall normally be removed by the cold treatment etc.
- c) Straightening under hot stage shall be resorted to only under specific permission from the Employer.
- d) If any rolling defect viz, laminations, cracks etc. are found in the steel during processing it shall be rejected.

iii) Storage

- a) Steel plates of different specifications shall be stacked separately.
- b) Steel of IS 2062 quality shall be given a distinctive identification mark.
- c) Steel sections shall be stacked over spacers supported on posts of about 50 cm height above ground. Passage and space between the stacks shall be sufficient for rigging operations.

1.1.2 Electrodes

- i) Electrodes for manual metal arc welding shall be procured envisaged in the welding procedure sheet predetermined before actual welding operation starts.
- ii) Electrodes shall be properly stored dry as required by the IS Code or by the manufacturer.
- iii) Electrodes shall bear the I.S.I or equivalent Certification mark.
- iv) The approval for all the consumables for welding shall be specifically obtained beforehand.

1.1.3 Paints/ Primers

- i) The relevant IS or equivalent mark on sealed tins shall be checked.
- ii) A few tins shall be opened at random to check the condition of the paints. Paint from old stock and showing signs of solidification shall not be accepted.

1.2 Welding Procedure Qualification

As per ASME section (ix) or equivalent Indian Standards, Welding procedures, Specification shall be submitted by the Contractor for review and approval of Employer.

1.3 Welders Qualification Test

As per ASME section (ix) or equivalent Indian Standard.

1.4 Inspection for Tack Assembly set up for:

- i) Level
- ii) Gap
- iii) Offsetting
- iv) Shrinkage allowance
- v) Fitment sequence
- vi) Principal overall size.

1.5 Inspection of Main welds

- a) Fillet welds for
 - i) Size
 - ii) Dye Check
 - iii) Visual examination
 - iv) Dye penetration test/MPI shall be carried out.

- b) Butt welds for
 - i) Dye check for root after back gauging shall be carried out.
 - ii) Mechanical testing of welds (Destructive Tests) Minimum on joint per liner length/piece.
 - iii) Non-destructive-as per FCL:SS:4-100% visual examination.

B. FABRICATION CHECK LIST (STANDARD)

Title: **Welding Tests on welds and Weld Defects**

Mechanical testing of welds (Destructive test) Butt welds having one or more of the following defects are not acceptable.

- i) Bend test: No crack on root/ face on being bent through 180 deg. with mandrel of 4t where t is the thickness of plate.
- ii) Tensile test: Weld strength not to be less than part metal's strength.

VISUAL EXAMINATION

Following defects are not allowed:

- 1) Unsatisfactory appearance
- 2) Incomplete weld
- 3) Molten metal flow
- 4) Pits
- 5) Surface crack, lack of penetration
- 6) Insufficient length
- 7) Surface defects exceeding 5% of weld seam area

DYE PENETRATION TEST

All surfaces to be examined shall be free from:

- a) Relevant linear indications
- b) Four or more rounded defects in a line separated by 1/16" or less (edge to edge) except where the specification for the material establishes requirements for acceptance so far as defects are concerned.

C. TYPICAL WELDING PROCEDURE DATA SHEET

Contractor.....Address.....
..

Quality of weld metal.....Specification.....
Inspection and Test ScheduleSpecification.....
Material Specification.....Thickness.....Batch/Cast No.....
Joint Preparation (Fig.).....Gap.....
Location of Specimens.....
Weather Conditions.....Time of day.....Wind brake used.....
Electrode Group No..... Make.....Specimen.....
Pre and Post Heating.....
Welding position.....
Size of Reinforcement.....Whether removed.....
Welding Sequence.....
Backing Strip use.....Type.....
Welding Process.....
Current Conditions-Polarity.....
Size of Electrode.....
Amperage and Voltage.....
Number of Electrodes used per run.....
Cleaning method.....
Remarks.....

Signature

Engineer-in-Charge
Employer
(Inspecting Authority)

For and on behalf of Contractor
Date:

D. **FABRICATION CHECK LIST: ACCEPTANCE PROFORMA**

No.: _____

Dt.: _____

Project: _____

Work: _____

Sub-Assy

Sl. No.	Characteristic	As per DRG/FCL	Actual	Accept/ reject	Remarks

Engineer-in-Charge
Employer
(Inspecting Authority)

Signature

For and on behalf of Contractor
Date: