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## **SECTION - 1**

### **SCOPE, SPECIFIC TECHNICAL REQUIREMENTS & QUANTITIES**

#### **1.1 SCOPE**

The scope of this specification is to specify all details required by bidder for supplying:

- (i) Type tested tower design and drawings (structure assembly drawings) along with all extension and Auxiliary cross arms,
- (ii) Type test report from accredited Test lab
- (iii) Shop drawings,
- (iv) Bill of material of Tower structure including extension,
- (v) Design and Drawings of foundation for towers for different soil types such as Dry, Wet, Partially Submerged, Fully Submerged etc including Foundation loading data,
- (vi) Drawing for Stubs & Stub setting template,
- (vii) SAG tension calculation,
- (viii) SAG template drawing,
- (ix) Tower Spotting Data.
- (x) Any other data/documents required for execution of transmission line work

The detailed scope of work is submission and approval of above drawing and documents from customer.

The above drawing / documents shall be used by BHEL for the purpose of construction of one no. projects (i.e. single use)

#### **1.2 SPECIFIC TECHNICAL REQUIREMENTS**

**Type test reports should not be more than 7 years old from date of NIT. It will**

- **be responsibility of Bidder to organize approval from the ultimate customer NTPC/RRVUNL.**

The projects wise specific technical requirements shall be as per Section 2.

**SUPPLY OF DESIGN AND DRAWING OF TYPE TESTED TOWERS AND FOUNDATIONS**

**1.3 QUANTITIES**

The quantities indicated are tentative & it may change to any extent during detailed engineering at contract stage.

S.No.	Item description	Unit	Quantity
<b>A</b>	Providing Type tested tower design and drawings (structure assembly drawings) alongwith all extension and Auxiliary cross arms, Type test report from accredited Test lab, Shop drawings, Bill of material, Design and Drawings of foundation for towers for different soil types, Stubs & Stub setting template, SAG tension calculation, SAG template drawing, Tower Spotting Data for following :		
<b>1</b>	Lattice type 400kV D/C Transmission line tower with Twin Moose suitable for wind Zone-4 and as per specification, required for Nabinagar (NPGCL) site -		
<b>a</b>	DA Type	Set	1
<b>b</b>	DD Type	Set	1
<b>2a</b>	Lattice type 33 kV D/C Transmission line tower with Single AAAC (100sqmm) suitable for wind Zone-4 and as per, required for Nabinagar (NPGCL) site		
<b>i)</b>	DA Type	Set	1
<b>ii)</b>	DC Type	Set	1
<b>2b</b>	Lattice type 33 kV S/C Transmission line tower with Single AAAC (100sqmm) suitable for wind Zone-4 and as per specification, required for Nabinagar (NPGCL) site.		
<b>i)</b>	SA Type	Set	1
<b>ii)</b>	SC Type	Set	1
<b>3</b>	Lattice type 11 kV D/C Transmission line tower with Single Zebra suitable for wind Zone-4 and as per specification, required for Suratgarh (RRVUNL) site		
<b>a</b>	DA Type	Set	1
<b>b</b>	DB Type	Set	1
<b>a</b>	DD Type	Set	1

Note :

**01. BIDDER CAN SUBMIT THEIR OFFER FOR ANY ONE OF MORE ITEMS FROM ITEM NO. A1,A2 AND A3 FROM ABOVE. EVALUATION SHALL BE MADE BASED OF TRANSMISSION LINE VOLTAGE RATING WISE.**

**02.RATES QUOTED SHALL BE FOR ONE PROJECT USE BY BHEL.**

**03.THE ABOVE QUOTED PRICE INCLUDES THE APPROVAL FROM CUSTOMER NTPC / RRVUNL AS APPLICABLE AND IF REQUIRED, BIDDER MAY HAVE TO VISIT CUSTOMER/BHEL OFFICE FOR DISCUSSIONS REGARDING APPROVAL. NO SEPARATE PAYMENT SHALL BE MADE FOR SUCH VISITS.**

**04.FOR NABINAGAR 400kV LINE BOTTOM X-ARM HEIGHT SHALL NOT BE LESS THAN 25.97m FOR DA TYPE AND 21.895m FOR DD TYPE TOWER**

**SECTION – 2**

**TECHNICAL DETAILS**

01. Tower design/drg shall be provided with extension of +3M, +6M, +9M for DA , DB, DC and DD towers and +18/25M extension for DD type towers.

**The following Drawings/documents are enclosed for reference:**

<b>Annexure</b>	<b>Document Title</b>	<b>No of pages</b>
<b>SURATGARH</b>		
<b>A-1</b>	--NA--	-
<b>A-2</b>	Design Basis report – 11kv D/C Line	3
<b>A-3</b>	--NA--	-
<b>A-4</b>	--NA	-
<b>NABINAGAR</b>		
<b>B-1</b>	Design basis report - 400kv D/C line (0370-572-PVC-C-620)	5
<b>B-2</b>	Design Basis report – 33kv D/C and S/C Line (0370-572-PVC-C-621)	3
<b>B-3</b>	Typical Drawing for 400kv String hardware (Double tension, Double Suspension, Single Pilot insulator)	4
<b>B-4</b>	Sag tension calculation for 400kv and 33 kv	10 + 8
<b>B-5</b>	NTPC Technical Specification for 33kv Transmission line towers and Foundations	31
<b>B-6</b>	NTPC Technical Specification for 400kv Transmission line towers and foundations	32

## **DATA TO BE SUBMITTED ALONG WITH OFFER**

- A) TECHNICAL PARAMETERS INCLUDING SPAN, DEVIATION ANGLES, MAXIMUM WEIGHT SPAN, MINIMUM WEIGHT SPAN, SUM OF ADJACENT SPAN FOR VARIOUS DEVIATION ANGLE, DESIGN LOAD TENSIONS FOR CONDUCTOR AND GROUND WIRE.
- B) LINE DIAGRAM OF TOWER WITH DIMENSION
- C) COVERING SHEET OF TYPE TEST REPORT WITH STAMP OF TEST AGENCY.
- D) LIST OF PROJECTS WHERE THE PROPOSED DESIGN IS USED. PERFORMANCE CERTIFICATE FROM CUSTOMER IS TO BE ENCLOSED FOR AT LEAST ONE PROJECTS.
- E) DECLARATION FROM THE BIDDER REGARDING HIS SOLE OWNERSHIP OF THE DESIGN/DOCUMENTS AND NO DISPUTE/CLAIM FROM OTHER PARTY.

# ANNEXURE = A-2

BHEL

DBR of 11 KV DC TRANSMISSION LINE AT SURATGARH

Sr. No.	Description	Data		
1	Line kV	11		
2	No. of circuits on tower	2		
3	Tower configuration	Self-supporting Lattice Type Steel Towers with Vertical Configuration		
4	Conductor per phase	Single ACSR 'Zebra'		
5	Earth Wire	Single Galvanised Stranded Steel Wire 7/3.66		
6	Tower coating	Hot-dipped galvanizing (Thickness:- 610 gms/sq.m)		
		Tower Type	Deviation Limit (in Deg)	Typical Usage
7	Tower Types	A	0 - 2	To be used as tangent tower with suspension insulators
		B	2 - 15	To be used as angle tower with tension insulators
		C	15 - 30	To be used as angle tower with tension insulators
		D/DE	30 - 60	To be used as angle tower with tension insulators
			0 - 30	To be used as dead end tower with 0 deg to 30 deg deviation on both line and substation side (slack span) with tension insulators
Note: The above towers can be used for longer span with smaller angle of deviations based on design chart.				
8	Extensions	+0m, +3m body extensions		
9	Design Spans	1) Normal Span	For all tower types	120 m
		2) Slack span (i.e. span between end tower near substation and gantry structure)	for D/DE	100 m
		3) Wind Span	For all tower types	132 m (NC); 80 m (BWC)
		4a) Weight Span (max)	For all tower types	180 m (NC); 110 m (BWC)
		4b) Weight Span (min)	For Tower Type 'A' under Normal Condition (NC)	78 m
			for Tower Types 'B', 'C', 'D/DE'	(-) 78 m
10	Conductor and earth Wire Tensions	1) Between the towers = As per sag tension calculations. 2) For Slack span = 500 kg conductor and 400kg for earthwire		
11	Insulators	Disk Type Porcelain		
	Insulator String type	Pilot	Single Suspension	Single & Double Tension
	Size of disc insulator (mm)	280 x 145	280 x 145	280 x 145
	Min. creepage distance of each disc (mm)	430	430	430
	No of standard discs	1 x 1	1 x 1	1 x 1 (Single Tension) and 2 x 1 (Double Tension)
	Electro-mechanical strength of insulator string (kN)	120	120	1 x 120 (Single Tension) and 2 x 120 (Double Tension)

12	Electrical Clearances	1) The minimum ground clearance from lowest point of power conductor = not to be less than 4750 mm (4600 mm ground clearance + 150 mm sag error) at maximum sag condition i.e. at conductor temperature of 75°C with no wind.		
		2) Minimum mid-span vertical clearance between the conductors & conductor and ground wire in still air, at any temperature for normal design span shall not to be less than 1500 mm.		
		3) The earth wire sag to be at least 10% less than the corresponding sag of power conductor under all temperature loading conditions.		
		4) Shielding angle = 30° maximum For estimating the minimum angle of protection the drop of earth wire suspension clamp alongwith shackle shall be taken as 150mm.		
		5) All other electrical clearances shall be as per the relevant statutory regulations and as per tech spec.		
		6) Minimum clearances from from live conductor to earthed metal parts:		
		<u>Type of Insulator Sting</u>	<u>Swing from Vertical (in Degree)</u>	<u>Minimum Clearance (in mm)</u>
		Jumper	0, 10, 20, 30	330
		Single Suspension String	0, 15, 30, 45, 60	330
		Double Suspension String	30	330
13	Temperatures of Conductors and Earth Wire	<u>Parameter</u>		<u>Value</u>
		Minimum Ambient Temperature		(-) 2.8°C
		Average Ambient Temperature or Every Day Temperature		32°C
		Maximum Temperature for Conductor		75°C
		Maximum Temperature for earth Wire		53°C
14	Wind Loads	Design wind pressure on tower, conductor, earth wires and insulators: considering wind zone 4 with wind speed (Vb) of 47m/sec, reliability level 1 with return of 50 years, risk coefficient "K1" with 1.0 value and terrain category 2 in accordance with IS: 802 (Part 1/Sec 1).		
15	Loading Conditions	As per IS 802 (Part I Sec 1)		
16	Properties of RCC	The cement concrete used for the foundations shall be of grade M25 with 20mm coarse aggregate.		
		Reinforcement shall be Fe 500 D HYSD TMT bars conforming to IS 1786.		
		Unit weight of concrete		
		<u>Type of concrete</u>	<u>Weight in dry region (kg/cum)</u>	<u>Weight in presence of sub-soil water (kg/cum)</u>
		Plain Cement Concrete	2400	1400
17	Design of foundations	Structural design of the foundations shall be done by limit State method.		
		Partial safety factor shall be considered 1.5 for concrete and 1.15 for steel.		
		The overload factor for foundations shall be considered as 1.1.		

BHEL

DBR of 11 kV DC TRANSMISSION LINE AT SURATGARH

Annexure: Wire Properties		
Description	Conductor	Earth Wire
Material /Name	ACSR Zebra	GSW
Stranding (Aluminium)	54/3.18	-
Stranding (Steel)	7/3.18	7/3.66
Diameter (mm)	28.62	10.98
Cross Sectional Area (mm <sup>2</sup> )	484.5	73.61
Ultimate Tensile Strength (Kg)	13284.4	7700
Unit Weight (Kg/m)	0.162	0.574
Modulus of Elasticity (Kg/mm <sup>2</sup> )	7034	19000
Coefficient of Linear Expansion(°C)	1.93E-05	1.15E-05



# Design Basis Report

## 400 kV TRANSMISSION LINE AT NABINAGAR

BHEL

Transmission Line Data				
Sr. No.	Description	Data		
1	Line kV	400		
2	No. of circuits on tower	2 (Double circuit)		
3	Tower configuration	Self-supporting Lattice Type Steel Towers with Vertical Configuration.		
4	Conductor per phase	Twin bundle ACSR Moose (Refer Annexure)		
5	Earth Wire	One Galvanised Stranded Steel Wire 7/3.66 + one OPGW (12 fibres) (Refer Annexure)		
6	Tower coating	Hot-dipped galvanizing (Thickness:- 610 gms/sq.m)		
7	Tower Types	Tower Type	Deviation Limit (in Deg)	Typical Usage
		DA	0 - 2	To be used as tangent tower
		DD	0 - 60	a) Angle tower with tension insulator string. b) Tension tower for uplift forces resulting from an uplift span upto 200m under broken wire condition. c) Also to be designed for unbalanced tension resulting from unequal ruling span of 305m and 150m on each side of the tower. d) Dead end with 0 deg to 15 deg deviation both on line and substation side (slack span).
			0	a) To be used as section tower b) Complete dead end.
			90	To be used near swithyard with reduced design span.
8	Extensions	+3m, +6m & +9m body extensions. For power line crossings, DD towers with maximum +25m body extension shall be provided, DD+25m tower shall be designed such that it can also be used as +18m body extension to normal towers after removal of bottom panels.  DD type towers shall also be designed to cater for 90deg. deviation with auxiliary cross arm and reduced tension/span.		
9	Design Spans	1) Normal Ruling Span	For all tower types	400 m
		2) Slack span (i.e. span between end tower near substation and gantry structure)	Tower Type 'DD'	100 m
		3) Wind Span	For all tower types	400 m (NC); 240 m (BWC)
		4a) Weight Span (max)	For all tower types under Normal Condition (NC)	600 m
		4b) Weight Span (min)	For all tower types under Normal Condition (NC)	(-) 200 m
		5a) Weight Span (max)	For all tower types under Broken Wire Condition (BWC)	360 m
		5b) Weight Span (min)	For all tower types under Broken Wire Condition (BWC)	(-) 200 m

Transmission Line Data

10	Conductor and Earth Wire Tensions	1) Between the towers = As per sag tension calculations. 2) For Slack span = 500 kg per sub-conductor; 400kg for earthwire.		
11	Insulators	Porcelain disc insulators		
	Insulator String type	Single-I suspension	Double suspension	Double tension
	Size of disc insulator (mm)	255/280 x 145	255/280 x 145	255/280 x 170
	Min. creepage distance of each disc (mm)	320	320	320
	No of standard discs	1 x 23	2 x 23	2 x 23
	Electro-mechanical strength of insulator string (kN)	120	2 x 120	2 x 160
		Note: Single suspension (Pilot) string will be used for jumpers of tension DD type towers. It will be similar to single suspension type except the clamp of the conductor.		
12	Electrical Clearances	1) The minimum ground clearance from lowest point of power conductor = not to be less than 8990 mm (=8840 mm ground clearance + 150 mm sag error) at maximum sag condition i.e. at conductor temperature of 75°C with no wind.		
		2) Minimum mid-span vertical clearance between power conductor and ground wire in still air, at any temperature for normal design span shall not to be less than 9000 mm.		
		3) The earth wire sag to be atleast 10% less than that of the corresponding sag of power conductor under all temprature loading conditions.		
		4) Shielding angle = 20° maximum.		
		5) Clearance between conductors i). Vertical clearance : 9000 mm ii). Horizontal clearance : 11000 mm		
		6) All other electrical clearances shall be as per the relevant statutory regulations. Minimum clearance between power line to power line crossing should be 6300mm for 400 kV lines.		
		7) Minimum clearances from live parts to tower body:		
		Type of Insulator Sting	Swing from Vertical (in Degree)	Minimum Clearance (in mm)
		Jumper	0, 20	3050
		Single Suspension String	0, 22	3050
44	1860			
Single/Double Tension String	0	3050		
13	Temperatures of Conductors and Earth Wire	Parameter		Value
		Minimum Ambient Temperature		0°C
		Average Ambient Temperature or Every Day Temperature		32°C
		Maximum Temperature for ACSR Conductor		75°C
		Maximum Temperature for Earth Wire		53°C
14	Wind Loads	Design wind pressure on tower, conductor, shield wire, OPGW and insulators - considering wind zone 4 with wind speed (Vb) of 47m/sec, reliability level 1 with return of 50 years, risk coefficient "K1" with 1.07 value and terrain category 2 in accordance with IS: 802 (Part 1/Sec 1) and IS: 875 (Part 3) Note: Notwithstanding the values of the above mentioned parameters, the design wind pressure so computed at any point shall not be taken less than 1500 N/sqm for all class of structures, ie A, B & C, as defined in IS: 875 (Part 3)		

Transmission Line Data			
15	Design loads	<u>Longitudinal Loads</u>	
		Tower type	Reliability condition
		DA	0
		DB (section tower 0 deg deviation)	MT1
		DB (15 deg deviation)	MT1
		DC (section tower 0 deg deviation)	MT1
		DC (30 deg deviation)	MT1
		DD (60 deg deviation)	MT1
		DD (Dead end with slack span of 100m)	0.7 MT
		DD (complete dead end)	MT
		Security condition	
		0.5 x MT	
		1.0 x MT	
		1.0 x MT x Cos ( $\phi/2$ )	
		1.0 x MT	
		1.0 x MT x Cos ( $\phi/2$ )	
		1.0 x MT x Cos ( $\phi/2$ )	
		1.0 x MT	
		1.0 x MT	
		Note:	
		1. MT is Maximum Tension of Conductor/Earthwire under everyday temperature and full wind condition or Minimum temperature and nil wind condition, whichever is more stringent.	
		2. MT1 is difference in tension for equivalent spans of 400m and 200m.	
		<u>Transverse loads</u>	
		Tower type	Reliability condition
		DA	WC + WI + DY
		Security condition	
		0.6 WC + WI + 0.25 DY for conductors	
		0.6 WC + 0.5 DY for earthwire	
		DB (section tower 0 deg deviation)	WC + WI + DY
		DB (15 deg deviation)	WC + WI + DY
		DC (section tower 0 deg deviation)	WC + WI + DY
		DC (30 deg deviation)	WC + WI + DY
		DD (60 deg deviation)	WC + WI + DY
		DD (Dead end with slack span of 100m)	WC + WI + (0.3MT x Sin 15°)
		DD (complete dead end)	WC + WI
		Notes:	
		1. WC: Wind on conductor/earthwire	
		2. WI: Wind on insulator	
		3. DY: Load due to deviation of tower ( $2 \times MT \times \sin (\phi/2)$ )	
		4. Vertical loads, wind load on towers, safety loads and Anticascade loads shall conform to IS 802.	
		5. Any additional loads apart from the loads mentioned above as required as per IS 802 shall be considered for design purpose.	

Transmission Line Data

16	Soil and Corresponding Foundation Types*	Types of foundations	Locations		
		Foundation for Normal Dry Soil Condition	To be used for locations where normal dry cohesive or non-cohesive soils are met.		
		Foundation for Wet Soil Condition	i) Where sub-soil water is met at 1.5 meters or more below the ground level. ii) Which are in surface water for long periods with water penetration not exceeding one meter below the ground level e.g. the paddy fields.		
		Foundation for Partially Submerged Soil Condition	To be used at locations where sub-soil water table is met between 0.75 meter below the ground level.		
		Foundation for Fully Submerged Soil Condition	To be used at locations where sub-soil water table is met at less than 0.75 meter below the ground level.		
		Foundation for Black Cotton Soil (Wet) Condition	To be used at locations where soil is clayey type, not necessarily black in colour which shrinks when dry and swells when wet, resulting in differential movement extending to a maximum depth of about 3.5 meters below ground level. For designing foundations, for such locations, the soil is to be considered sub-merged in nature.		
		Foundation for Fissured Rock Condition	i) To be used at locations where decomposed or fissured rock, hard gravel kankar, limestone, laterite or any other soil of similar nature is met. Under cut type foundation is to be used for fissured rock locations. ii) To be used at fissured rock locations, where water table is met below ground level.		
		Foundation for Hard Rock Condition	The locations where chiseling, drilling and blasting is required for excavation hard rock type foundations are to be used. For these locations rock anchoring is to be provided to resist uplift forces.		
17	Soil properties*	Weight of soil	Nature of soil	Weight (kg/cum)	
			Dry	1440 kg/cum	
			In presence of surface water	940 kg/cum	
		Submerged fussed rock	In presence of soil water	940 kg/cum	
			Ultimate bearing capacity	62500 kg/sqm	
			Unit weight of earth	1440 kg/cum	
		Hard rock	Angle of repose	20 deg	
			Limit bearing capacity	125000 kg/sqm	
			Ultimate bond between concrete and steel for M15 grade concrete.	10 kg/sqm	
		Properties of soil			
		Type of soil	Limit bearing capacity (kg/sqm)	Angle of repose (deg)	
		Normal dry soil	24000		20
		Wet earth in the presence of sub soil water	12000		10
		Wet earth in the presence of sub surface water	12000		10
		Wet black cotton soil	12000		0

\* The soil parameters and types of foundations shall be finalized as per geotechnical investigations; governing parameters shall be followed.

Transmission Line Data					
18	Properties of RCC	The cement concrete used for the foundations shall be of grade M25 with 20mm coarse aggregate.			
		Reinforcement shall be Fe 500 HYSD TMT bars conforming to IS 1786 and Technical Specification.			
		Unit weight of concrete			
		Type of concrete	Weight of dry region kN/cum (kg/cum)	Weight in presence of sub-soil water kN/cum (kg/cum)	
		Plain Concrete Concrete	21.96 (2240)	12.16 (1240)	
		Reinforced Cement Concrete	23.54 (2400)	13.73 (1400)	
20	Design of foundations	Structural design of the foundations shall be done by limit State method.			
		Partial safety factor shall be considered 1.5 for concrete and 1.15 for steel.			
		The overload factor for foundations shall be considered as 1.1 i.e. the reaction except due to dead loads on foundations shall be increased by 10 per cent.			
Annexure: Wire Properties					
1	Conductor Properties	Code and Standard	IS 398 (Part 5)		Conductor properties are taken from Chapter E12, Clause 2.00.00 of Switchyard Technical Specification.
		Name	ACSR "MOOSE"		
		Overall diameter	31.77 mm		
		Weight	2.004 kg/m		
		Ultimate Tensile Strength	161.2 kN minimum		
		Strands & wire diameter of			
		Aluminium	54/3.53 mm		
		Steel	7/3.53 mm		
		Overall area	597 sq.mm		
2	Earthwire Properties	Number of Strands	7		Earthwire properties are taken from Chapter E12, Clause 7.00.00 of Switchyard Technical Specification.
		Strand diameter	3.66 mm		
		Overall diameter	10.98 mm		
		Weight	583 kg/km		
		Ultimate Tensile Strength	68.4 kN minimum		
		Total cross section area	73.65 sq.mm		
3	OPGW Properties	Ultimate Tensile Strength	7500 kg minimum		OPGW properties are taken from Chapter T4, Clause 7.04.04 of Transmission Technical Specification.
		Outside diameter	14 mm		
		Cross sectional area of conduct	80 sq.mm		
		Modulus of elasticity	10000 kg/sq.mm		
		Coeff. Of linear expansion	1.5 x 10-5		
		Unit Weight	600 kg/km		

## Design Basis Report-

33 kV TRANSMISSION LINE AT NABINAGAR

BHEL

Transmission Line Data				
Sr. No.	Description	Data		
1	Line kV	33		
2	No. of circuits on tower	1 / 2		
3	Tower configuration	Self-supporting Lattice Type Steel Towers with Vertical Configuration		
4	Conductor per phase	Single AAAC 100sq.mm		
5	Earth Wire	Single Galvanised Stranded Steel Wire 7/3.66		
6	Tower coating	Hot-dipped galvanizing (Thickness:- 610 gms/sq.m)		
		Tower Type	Deviation Limit (in Deg)	Typical Usage
7	Tower Types	A	0 - 2	To be used as tangent tower
		C	0 - 60	a) Angle tower with tension insulator string. b) Dead end with 0 deg to 15 deg deviation both on line and substation side (slack span) c) Also to be designed for anti-cascading condition.
			0	a) To be used as section tower b) Complete dead end c) For crossing/ anchoring with longer wind span with 0 deg deviation on crossing span side and 0 deg to 30 deg deviation on other sides.
	Note: The above towers can be used for longer span with smaller angle of deviations			
8	Extensions	+0m, +3m body extensions		
9	Design Spans	1) Normal Span	For all tower types	150 m
		2) Slack span (i.e. span between end tower near substation and gantry structure)	Tower Type 'C'	200 m
		3) Wind Span	For all tower types	200 m (NC); 120 m (BWC)
		4a) Weight Span (max)	For tower type 'A' under Normal Condition (NC)	225 m
			For tower types 'B' and 'C' under Normal Condition (NC)	225 m
		4b) Weight Span (min)	For tower type 'A' under Normal Condition (NC)	120 m
			For tower types 'B' and 'C' under Normal Condition (NC)	160 m
		5a) Weight Span (max)	For tower type 'A' under Broken Wire Condition (BWC)	135 m
			For tower types 'B' and 'C' under Broken Wire Condition (BWC)	135 m
		5b) Weight Span (min)	For tower type 'A' under Broken Wire Condition (BWC)	72 m
			For tower types 'B' and 'C' under Broken Wire Condition (BWC)	(-) 160 m

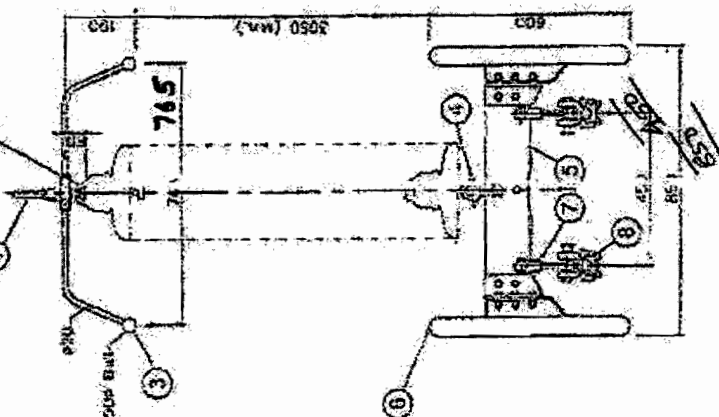
Transmission Line Data																							
10	Conductor and earth Wire Tensions	1) Between the towers = As per sag tension calculations. 2) For Slack span = 400 kg conductor and 300kg for earthwire <b>Shall be as per calculation/ standards</b>																					
11	Insulators	Disk Type																					
12	Electrical Clearances	1) The minimum ground clearance from lowest point of power conductor = not to be less than 5350 mm (5200 mm ground clearance + 150 mm sag error) at maximum sag condition i.e. at conductor temperature of 75°C with no wind. 2) Minimum mid-span vertical clearance between power conductor and ground wire in still air, at any temperature for normal design span shall not to be less than 1500 mm. 3) The earth wire sag to be at least 10% less than the corresponding sag of power conductor under all temperature loading conditions. 4) Shielding angle = 30° maximum For estimating the minimum angle of protection the drop of earth wire suspension clamp alongwith shackle shall be taken as 150mm. 5) All other electrical clearances shall be as per the relevant statutory regulations and as per tech spec. 6) Minimum clearances from live parts to tower body: <table><tr><th>Type of Insulator Sting</th><th>Swing from Vertical (in Degree)</th><th>Minimum Clearance (in mm)</th></tr><tr><td>Jumper</td><td>10, 20, 30</td><td>330</td></tr><tr><td>Single Suspension String</td><td>0, 15, 30, 45, 60</td><td>330</td></tr><tr><td>Double Suspension String</td><td>30</td><td>330</td></tr><tr><td>Single Tension String</td><td>0</td><td>330</td></tr><tr><td>Double Tension String</td><td>0</td><td>330</td></tr><tr><td>Pin Insulator String</td><td>0</td><td>330</td></tr></table>	Type of Insulator Sting	Swing from Vertical (in Degree)	Minimum Clearance (in mm)	Jumper	10, 20, 30	330	Single Suspension String	0, 15, 30, 45, 60	330	Double Suspension String	30	330	Single Tension String	0	330	Double Tension String	0	330	Pin Insulator String	0	330
Type of Insulator Sting	Swing from Vertical (in Degree)	Minimum Clearance (in mm)																					
Jumper	10, 20, 30	330																					
Single Suspension String	0, 15, 30, 45, 60	330																					
Double Suspension String	30	330																					
Single Tension String	0	330																					
Double Tension String	0	330																					
Pin Insulator String	0	330																					
13	Temperatures of Conductors and Earth Wire	<table><tr><th>Parameter</th><th>Value</th></tr><tr><td>Minimum Ambient Temperature</td><td>0°C</td></tr><tr><td>Average Ambient Temperature or Every Day Temperature</td><td>32°C</td></tr><tr><td>Maximum Temperature for Conductor</td><td>75°C</td></tr><tr><td>Maximum Temperature for earth Wire</td><td>53°C</td></tr></table>	Parameter	Value	Minimum Ambient Temperature	0°C	Average Ambient Temperature or Every Day Temperature	32°C	Maximum Temperature for Conductor	75°C	Maximum Temperature for earth Wire	53°C											
Parameter	Value																						
Minimum Ambient Temperature	0°C																						
Average Ambient Temperature or Every Day Temperature	32°C																						
Maximum Temperature for Conductor	75°C																						
Maximum Temperature for earth Wire	53°C																						
14	Wind Loads	Design wind pressure on tower, conductor, earth wires and insulators - considering wind zone 4 with wind speed (Vb) of 47m/sec, reliability level 1 with return of 50 years, risk coefficient "K1" with 1.07 value and terrain category 2 in accordance with IS: 802 (Part 1/Sec 1) and IS: 875 (Part 3) Note: Notwithstanding the values of the above mentioned parameters, the design wind pressure so computed at any point shall not be taken less than 1500 N/sqm for all class of structures, ie A, B & C, as defined in IS: 875 (Part 3)																					
15	Broken Wire Condition (Security Condition)	All tower under this condition shall be designed for maximum wind condition.																					
16	Soil and Corresponding Foundation Types*	<table><tr><th>Types of foundations</th><th>Locations</th></tr><tr><td>Foundation for Normal Dry Soil Condition</td><td>To be used for locations where normal dry cohesive or non-cohesive soils are met.</td></tr><tr><td>Foundation for Wet Soil Condition</td><td>i) Where sub-soil water is met at 1.5 meters or more below the ground level. ii) Which are in surface water for long periods with water penetration not exceeding one meter below the ground level e.g. the paddy fields.</td></tr><tr><td>Foundation for Partially Submerged Soil Condition</td><td>To be used at locations where sub-soil water table is met between 0.75 meter below the ground level.</td></tr><tr><td>Foundation for Fully Submerged Soil Condition</td><td>To be used at locations where sub-soil water table is met at less than 0.75 meter below the ground level.</td></tr></table>	Types of foundations	Locations	Foundation for Normal Dry Soil Condition	To be used for locations where normal dry cohesive or non-cohesive soils are met.	Foundation for Wet Soil Condition	i) Where sub-soil water is met at 1.5 meters or more below the ground level. ii) Which are in surface water for long periods with water penetration not exceeding one meter below the ground level e.g. the paddy fields.	Foundation for Partially Submerged Soil Condition	To be used at locations where sub-soil water table is met between 0.75 meter below the ground level.	Foundation for Fully Submerged Soil Condition	To be used at locations where sub-soil water table is met at less than 0.75 meter below the ground level.											
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Foundation for Fully Submerged Soil Condition	To be used at locations where sub-soil water table is met at less than 0.75 meter below the ground level.																						

33 kV TRANSMISSION LINE AT NABINAGAR

BHEL

Transmission Line Data				
		Foundation for Black Cotton Soil (Wet) Condition	To be used at locations where soil is clayey type, not necessarily black in colour which shrinks when dry and swells when wet, resulting in differential movement extending to a maximum depth of about 3.5 meters below ground level. For designing foundations, for such locations, the soil is to be considered sub-merged in nature.	
		Foundation for Fissured Rock Condition	i) To be used at locations where decomposed or fissured rock, hard gravel kankar, limestone, laterite or any other soil of similar nature is met. Under cut type foundation is to be used for fissured rock locations. ii) To be used at fissured rock locations, where water table is met below ground level.	
		Foundation for Hard Rock Condition	The locations where chiseling, drilling and blasting is required for excavation hard rock type foundations are to be used. For these locations rock anchoring is to be provided to resist uplift forces.	
		Other type of foundations	i) Intermediate conditions under the above classifications to effect more economy. ii) For locations where special foundations (well type or piles) are necessitated.	
17	Soil properties*	Weight of soil	Nature of soil	Weight (kg/cum)
			Dry	1440 kg/cum
			In presence of surface water	940 kg/cum
			In presence of soil water	940 kg/cum
		Soft rock	Ultimate bearing capacity	62500 kg/sqm
			Unit weight of earth	1440 kg/cum
			Angle of repose	20 deg
		Hard rock	Limit bearing capacity	125000 kg/sqm
			Ultimate bond between concrete and steel for M15 grade concrete	10 kg/sqm
		Properties of soil		
		Type of soil	Limit bearing capacity (kg/sqm)	Angle of repose (deg)
		Normal dry soil	24000	20
		Wet earth in the presence of sub soil water	12000	10
		Wet earth in the presence of sub surface water	12000	10
Wet black cotton soil	12000	0		
* The soil parameters and types of foundations shall be finalized as per geotechnical investigations; governing parameters shall be followed.				
18	Properties of RCC	The cement concrete used for the foundations shall be of grade M20 with 20mm coarse aggregate.		
		Reinforcement shall be Fe 500 HYSD TMT bars conforming to IS 1786 and Technical Specification.		
		Unit weight of concrete		
		Type of concrete	Weight of dry region kN/cum (kg/cum)	Weight in presence of sub-soil water kN/cum (kg/cum)
		Concrete	21.96 (2240)	12.16 (1240)
		Reinforced	23.54 (2400)	13.73 (1400)
19	Design of foundations	Structural design of the foundations shall be done by limit State method.		
		Partial safety factor shall be considered: 1.5 for concrete and 1.15 for steel.		
		The overload factor for foundations shall be considered as 1.1 i.e. the reaction except due to dead loads on foundations shall be increased by 10 per cent.		





All Dimensions are in mm

General Tolerance  $\pm 0.15$  unless otherwise specified

Reference to length of hardware fitting

Fasteners Parts are hot dip galvanized as per IS 1299

Bolt & socket designation 20mm as per IS 2488

Ultimate Tensile Strength of assembly 1.0 kN

Slip strength of clamp 20 to 28 kN

Clamp is suitable for ACBR lacquer data 1.77

Spring washer are electro galvanized

Flat washers are hot dip galvanized

Min. zero one extraction voltage (250 V (R. )

RV at 500 kV (rms) (Vtg) busbar 1000 across

Magnetic power loss of 600 Amp. cond. bar at 1000

1000 than 8 Watt per suspension system

Accessories Weight = 27.318 Kg

✓  
To be approved  
with WSI  
Cody

Sl.	Description	Material	Cat. No.	Qty.	UTS(N)
3	Suspension Clamp	Aluminium Alloy as per IS-817 (A-B)	N-13	2	70
7	Close Eye	Forged Steel as per IS-2004 (CL-IV)	J-124F	2	70
6	Carcing Central Ring	Aluminium G-1108/8063 & Mild Steel IS-2062	MOS-4M	1 pair	-
5	Yoke Plate	Mild Steel as per IS-2062 Fe-410	1-24SL	1	120
4	Socket Clamp	Forged Steel as per IS-2004 (CL-IV)	Q-24	1	120
3	Arching Burn	Mild Steel as per IS-2062	N-104SR1	1	-
2	Ball Eyes (horn holder)	Forged Steel as per IS-2004 (CL-IV)	Q-54S	1	120
1	Anchor Shackle	Forged Steel as per IS-2004 (CL-IV)	Q-5	1	120
St.	Description	Material	Cat. No.	Qty.	UTS(N)

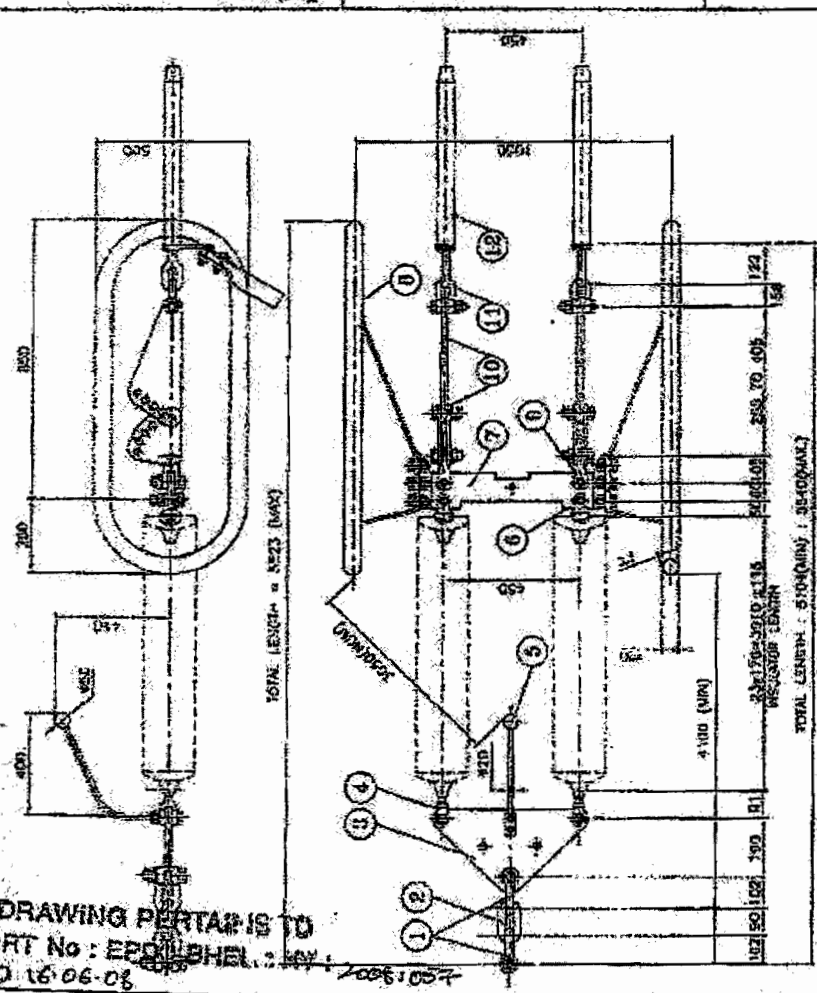
REPORT No: EPD BHEL BY: 2011:003  
DATED 08/01/2011

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THIS DRAWING PERTAINS TO  
REPORT No : EPC/SHEL : 14  
DATED 16/06/08



- TECHNICAL DETAILS:
- 1) ALL DIMENSIONS ARE IN mm.
  - 2) SURFING SURFING OF CLAMP 1012 KN (225 LB).
  - 3) BALL & SOCKET JOINT 20 TON (45000 LBS).
  - 4) ALL HARDWARE PARTS ARE NOT TO BE GALVANIZED AS PER POWER GRID SPECIFICATION.
  - 5) METAL TO METAL CONTACT.
  - 6) ALL DIMENSIONS ARE AFTER GALVANIZING EXCEPT DRILLED HOLES.
  - 7) TOLERANCE ON TOTAL LENGTH OF HARDWARE PARTS:  $\pm 2\%$ .
  - 8) TOLERANCE ON INSULATOR DISC:  $\pm 5\%$ .
  - 9) MIN. CORONA PROTECTION VOLTAGE (DBV) 300 KV (RMS).
  - 10) EHV AT 305 KV (RMS) (DBV) 300 KV (RMS).
  - 11) VENTUS ARE INDICATIVE NOT MANDATORY.



**EMI TRANSMISSION LIMITED**  
KOLSHET ROAD, THANE  
(MUMBAI, INDIA)

**TITLE:- 400 KV DOUBLE TENSION INSULATOR STRING  
FOR TWIN ACSR MOOSE CONDUCTOR.**

**CUSTOMER : POWERGRID CORPORATION OF INDIA LTD**

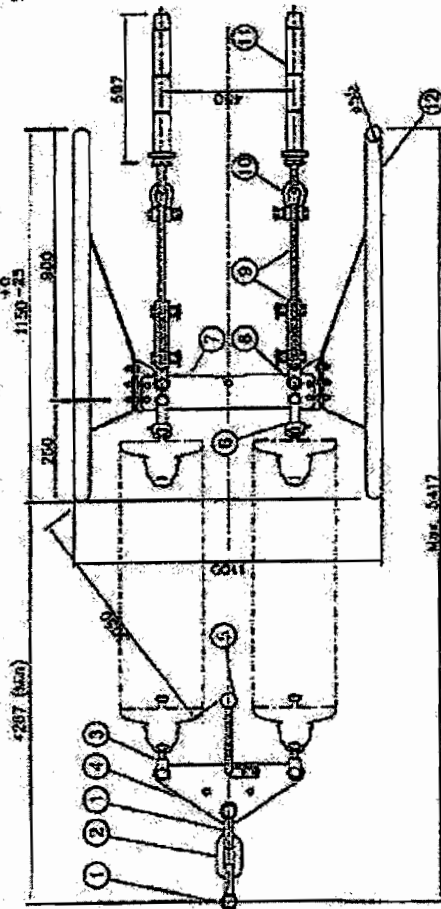
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ORG NO : EMI/400 KV : 16/DTA-DEA-31.77 AF 1A1

REV.

**COMPONENT DETAILS**

ITEM NO.	DESCRIPTION	QUANTITY	UNIT	REMARKS
1	COMPRESSION RING	1	PC	ALUMINUM ALLOY 1050/1050 B731
2	INSULATOR STRING	1	PC	1050/1050 B731
3	INSULATOR PLATE	1	PC	1050/1050 B731
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Notes:

- All Dimensions are in mm
- Tolerance on length of hardware fitting  $\pm 2\%$
- General Tolerance  $\pm 1\%$  unless otherwise specified
- Ferrule Parts are hot dip galvanized on per IS:1620
- Bolt & socket designation 20mm on per IS:2486
- Stainless Steel R clip shall be provided with socket fittings
- Ultimate Tensile Strength of assembly 320 kN
- Slip strength of clamp 95% of UTS of Conductor = 163.14 kN
- Arcing gap 305mm min.
- Clamp is suitable for ACSR Moose (dia. 31.77 mm)
- Spring weather are electro galvanized
- Fuel weather are hot dip galvanized
- Electrical resistance Max. 25% of equivalent length of conductor
- Min. Arcing Extinction Voltage Dry 320 kV (R.M.S)
- Qty of 305 KV (9448) Dry below 1000 microamp
- Approximate Weight = 66.070 Kg

Sl.	Description	Material	Cal. No.	Qty.	UTS(kN)
12	Octagon Control Ring & Brackets	Extruded Aluminium & Mild Steel HDG	MGT-AH	1 pair	-
11	Dead End Clamp	Extruded Aluminium & Forged Steel	MMCP-517A	2	95%
10	Anchor Shackle	Forged Steel as per IS: 2004 (CL-IV)	Q-5A	2	180
9	Sag Adjustment Plates	Mild Steel as per IS: 2062	SAP-6B	2 pairs	180
8	Clavis Eye	Forged Steel as per IS: 2004 (CL-IV)	J-124T	2	160
7	Yoke Plate (line side)	Mild Steel as per IS: 2062	L-481T	1	320
6	Socket Clavis	Forged Steel as per IS: 2004 (CL-IV)	D-24T	2	160
5	Arising Horn	Forged Mild Steel as per IS: 2062	M-514R2	1	-
4	Yoke Plate (tower side)	Mild Steel as per IS: 2062	L-451T	1	320
3	Ball Clavis	Forged Steel as per IS: 2004 (CL-IV)	E-24T	2	160
2	Chain Link	Forged Steel as per IS: 2004 (CL-IV)	P-3	1	320
1	Anchor Shackle	Forged Steel as per IS: 2004 (CL-IV)	Q-6	2	320

THIS DRAWING PERTAINS TO  
REPORT No. EFD EDEL 144 2011:005  
DATED 08/01/2011

**Contents**

Sl. No.	Document Title	Document No.	No. of Sheets
1.	SAG TENSION CALCULATION FOR 400 kV D/C TRANSMISSION LINE	TCE-721B-765-CALC-01	9

**NTPC DOC. NO.:** 0370-572-PVC-U-505, Rev-02

**DOC. TITLE:** Design document for Transmission line tower and line (Sag and swing calculation and tower design)

NABINAGAR POWER GENERATION CO. PVT. LTD.  
(A JV OF NTPC LTD. & BIHAR STATE POWER (HOLDING) CO. LTD.)

400/132 kV SWITCHYARD AT NABINAGR STPP (3X660MW)  
& 400 KV SWITCHYARD EXTENSION AT NABINAGAR TPP(BRBCL)  
NOA Number :CS-0370-572-2-FC-NOA-0009 DATED 12-02-2013



BHARAT HEAVY ELECTRICALS LTD.  
TRANSMISSION PROJECTS DIVISION  
NEW DELHI

W.O. Number : 81004



**TATA CONSULTING ENGINEERS LIMITED**

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## **400kV & 33kV TRANSMISSION LINES AT NABINAGAR, BIHAR**

### **SAG TENSION CALCULATION FOR 400kV DC TRANSMISSION LINE**

**NTPC DRG. NO: 0370-572-PVE-U-501**

**TCE DRG. NO: TCE-7219B-765-CALC-01**

**BHARAT HEAVY ELECTRICALS LIMITED  
NEW DELHI**

**MAY 2014**

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**CONTENT SHEET**

<b>Sr. No.</b>	<b>Description</b>
1	WIND PRESSURE CALCULATION
2	SAG TENSION FOR 400m SPAN
3	SAG TENSION FOR 305m SPAN
4	SAG TENSION FOR 150m SPAN
5	LINE DIAGRAM FOR TOWER TYPE "DA"
6	LINE DIAGRAM FOR TOWER TYPE "DD"

Project :	400kV DC TRANSMISSION LINE AT NABINAGAR, BIHAR		
Title :	Wind Pressure Calculation		
<b>WIND PRESSURE CALCULATIONS</b>			
Wind Zone to be considered for Design	=	4	47.00 m/sec
Design Wind Speed (Vr)	=	47/1.375	
	=	34.182	m/sec
The Basic Span	=	400	m
Reliability Level	=	1	
Terrain Category	=	2	
Factor K1	=	1.07	
Factor K2	=	1	
Design Wind Speed (Vd)	=	Vr x K1 x K2	
	=	34.182 x 1.07 x 1	
	=	36.575	m/sec
Design Wind Pressure (Pd)	=	0.6 x (Vd) <sup>2</sup>	
	=	0.6 x (36.575) <sup>2</sup>	
	=	803	N/m <sup>2</sup>
	=	81.9	Kg/m <sup>2</sup>
(i) Wind Pressure on Conductor (Pc) = Pd x Cd x Gc			
Average Height of Conductor considered for Wind Pressure Calculation (h)			42.451 m
Sag at Minimum Temperature & Nil Wind (m) =			9.666 m
	Suspension	Tension tower	
Minimum Ground Clearance	8.840	8.840	
Maximum Sag of Conductor	12.864	12.864	
Allowance of Sag Error	0.150	0.150	
Bottom Conductor to Top Conductor	18.000	18.000	
Hanger / BM (for Top Conductor)	0.151	0.041	
Maximum Body Extension	9.000	9.000	
Height of top conductor attachment point considering +9m body extension for tower (Refer Tower line diagram)	48.854	48.895	
Less 2/3rd Sag at Minimum Temperature (2/3 x 9.666)	-6.444	-6.444	
Average Height of Conductor in m	42.410	42.451 (Governing)	
Where, Pd =	Design Wind Pressure		
Cd =	Drag Coefficient	1	
Gc =	Gust Response Factor	2.221	
(Refer Table - 7 of IS 802-1995/Sec-1)			
		= 81.9 x 1 x 2.221	
Wind Pressure on Conductor (Pc)		= 181.90 say 182	Kg/m <sup>2</sup>



Project :	400KV DC TRANSMISSION LINE AT NABINAGAR, BIHAR	
Title :	Wind Pressure Calculation	
(III) Wind Pressure on Earthwire/OPGW ( $P_e$ ) = $P_d \times C_d \times G_e$		
Average Height of Earthwire/OPGW considered for Wind Pressure Calculation (h)		51.246 m
Sag At Minimum Temperature & Nil Wind (m) =		8.699 m
	Suspension	Tension tower
Minimum Ground Clearance	8.840	8.840
Maximum Sag of Conductor	12.864	12.864
Allowance of Sag Error or Creep	0.150	0.150
Insulator Length	3.965	—
Bottom Conductor to Top Conductor	18.000	18.000
Hanger / BM (for Top Conductor)	0.151	0.041
Height of G.W. Peak	4.300	8.150
Maximum Body Extension	9.000	9.000
Less Hanger for Earthwire	-0.250	—
Height of Earthwire/OPGW attachment point considering +9m body extension for tower (Refer Tower line diagram)	57.020	57.045
Less 2/3rd Sag at Minimum Temperature (2/3 x 8.699)	-5.799	-5.799
Average Height of Earthwire in m	51.221	51.246 (Governing)
<p> <math>C_d</math> = Drag Coefficient 1.2  <math>G_e</math> = Gust Response Factor 2.296          (Refer Table - 7 of IS 802-1995/Sec-1)  <math>= 81.9 \times 1.2 \times 2.296</math>  <b>Wind Pressure on Earthwire (<math>P_e</math>)</b> = 225.65 say 226 <math>\text{Kg/m}^2</math> </p>		
(III) Wind Pressure on Insulator ( $P_i$ ) = $P_d \times C_d \times G_i$		
Average Height of Insulator considered for Wind Pressure Calculation (h)		50.837 m
	Suspension	Tension
Height of Insulator attachment mid point considering +9m body extension for tower (Refer Tower line diagram)		
Minimum Ground Clearance	8.840	8.840
Maximum Sag of Conductor	12.864	12.864
Allowance of Sag Error or Creep	0.150	0.150
Bottom Conductor to Top Conductor	18.000	18.000
Hanger / BM (for Top Conductor)	—	0.041
Maximum Body Extension	9.000	9.000
	48.854	48.895
Centre of Insulator (Insulator Length / 2) (3.965/2)	1.983	—
Average Height of Insulator in m	50.837 (Governing)	48.895
<p>         Where, <math>P_d</math> = Design Wind Pressure  <math>C_d</math> = Drag Coefficient 1.2  <math>G_i</math> = Gust Response Factor 2.486          (Refer Table - 6 of IS 802-1995/Sec-1)  <math>= 81.9 \times 1.2 \times 2.486</math>  <b>Wind Pressure on Insulator (<math>P_i</math>)</b> = 244.32 say 245 <math>\text{Kg/m}^2</math> </p>		

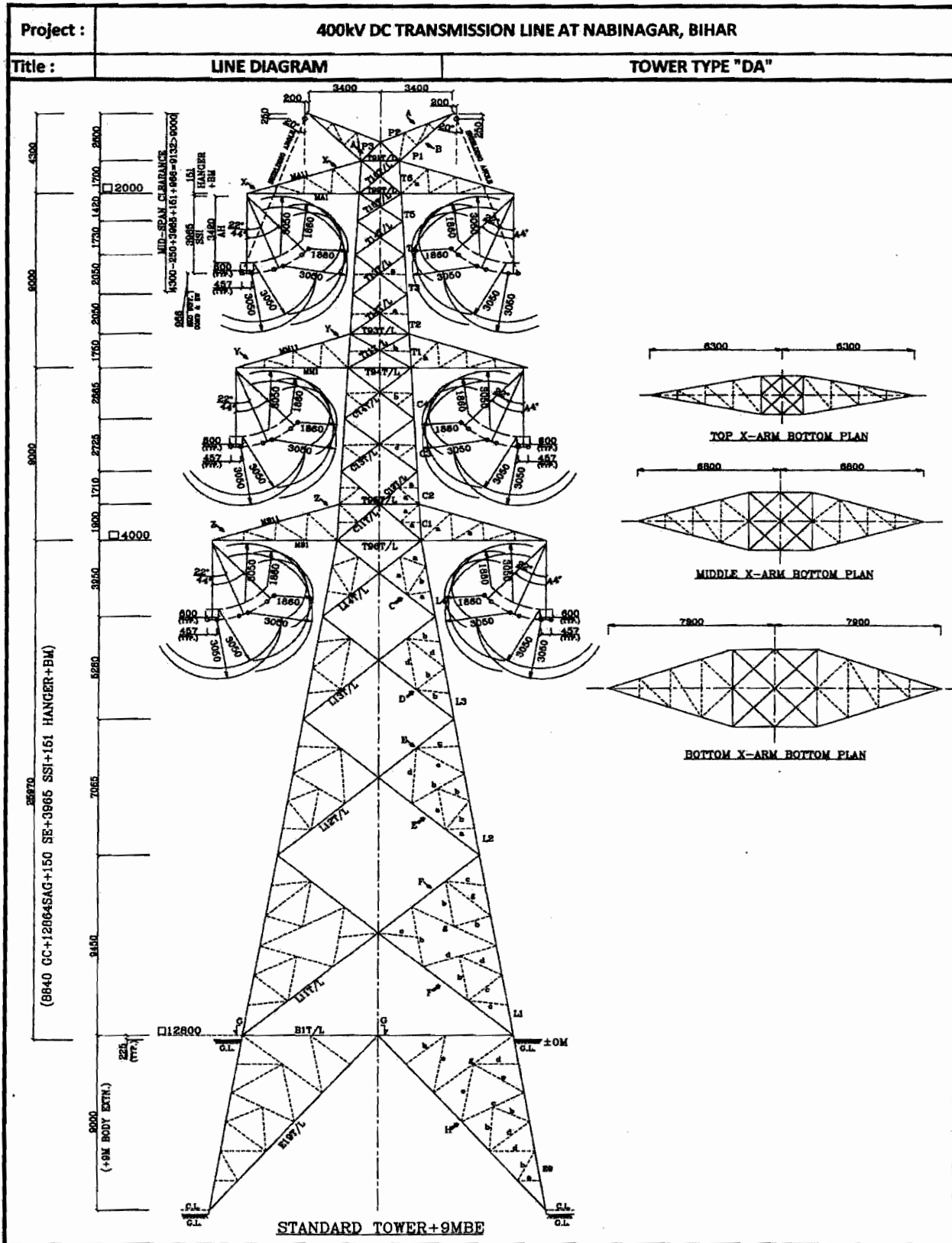
**TATA CONSULTING ENGINEERS LIMITED**

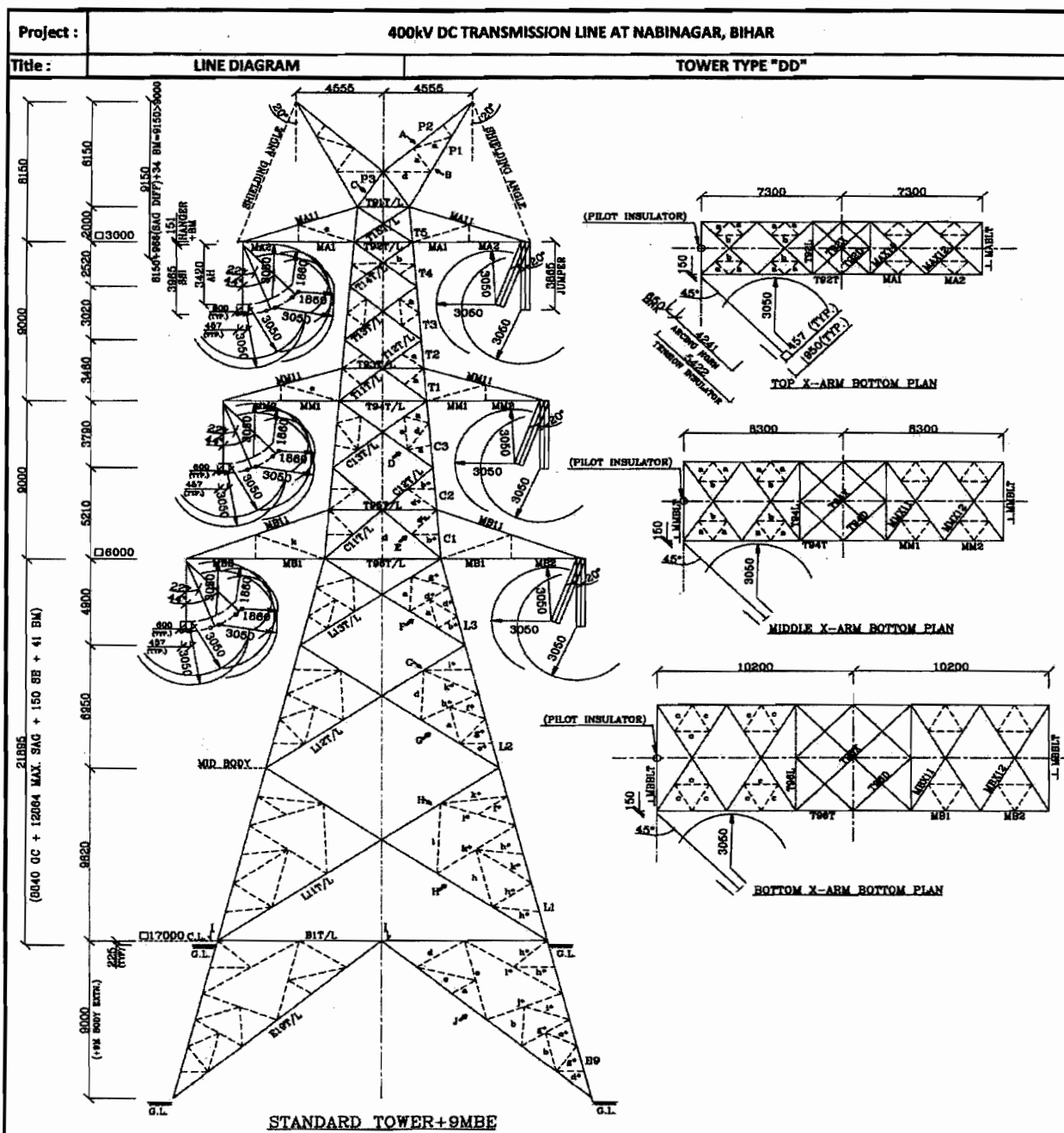
Project :		400kV DC TRANSMISSION LINE AT NABINAGAR, BIHAR						
Title :		SAG TENSION FOR 400M SPAN						
Normal Span (m):		400		Equation : Parabolic				
Material Properties :								
Description		Conductor		Earth Wire 1		Earth Wire 2		
Material		ACSR		GSW		OPGW		
Mane		Moose		7/3.66		-		
Stranding (Aluminium)		54/3.53				-		
Stranding (Steel)		7/3.54		7/3.66		-		
Stranding (Optical Fibre)		-		-		-		
Diameter (mm)		31.77		10.98		14		
Cross Sectional Area (mm <sup>2</sup> )		597		73.65		81.66		
Ultimate Tensile Strength (Kg)		16432.21		6972.48		7500		
Unit Weight (Kg/m)		2.004		0.583		0.6		
Modulus of Elasticity (Kg/mm <sup>2</sup> )		7034		19361		10000		
Coefficient of Linear Expansion (°C)		1.93E-05		1.15E-05		1.40E-05		
Climatic Conditions & Corrospounding Sag & Tension Values for Conductor								
S.No.	Temp (°C)	Wind Pressure (Kg/m <sup>2</sup> )	Ice Thk (mm)	Ice Density (Kg/m <sup>3</sup> )	Tension (Kg)	FOS (Reqd)	FOS (Actual)	Vert. Sag (m)
1	32	0	0	0	3615	4.545	4.545	11.086
2 (Initial Cond.)	32	182	0	0	8740	1.429	1.880	4.586
3	32	137	0	0	7248	1.429	2.268	5.53
4	0	66	0	0	5472	1.429	3.003	7.324
5	0	0	0	0	4147	1.429	3.968	9.666
6	75	0	0	0	3115	1.429	5.263	12.866
7	53	0	0	0	3347	1.429	4.910	11.974
Keeping the sag of earthwire 10% less than that of power conductor at 0°C No wind condition, the sag of earthwire will be 9.666*0.9 = 8.699m								
This condition is treated as initial condition for earthwire and sag tension values at other conditions have been worked out to check their satisfying the reuired limits.								
Climatic Conditions & Corrospounding Sag & Tension Values for Earth Wire 1 (GSW)								
S.No.	Temp (°C)	Wind Pressure (Kg/m <sup>2</sup> )	Ice Thk (mm)	Ice Density (Kg/m <sup>3</sup> )	Tension (Kg)	FOS (Reqd)	FOS (Actual)	Vert. Sag (m)
1	32	0	0	0	1213	5.000	5.748	9.612
2	32	226	0	0	3651	1.429	1.910	3.194
3	32	170	0	0	3017	1.429	2.311	3.865
4	0	81	0	0	2064	1.429	3.378	5.648
5 (Initial Cond.)	0	0	0	0	1340	1.429	5.203	8.699
6	53	0	0	0	1144	1.429	6.095	10.196
Climatic Conditions & Corrospounding Sag & Tension Values for Earth Wire 2 (OPGW)								
S.No.	Temp (°C)	Wind Pressure (Kg/m <sup>2</sup> )	Ice Thk (mm)	Ice Density (Kg/m <sup>3</sup> )	Tension (Kg)	FOS (Reqd)	FOS (Actual)	Vert. Sag (m)
1	32	0	0	0	1246	5.000	6.024	9.631
2	32	226	0	0	3831	1.429	1.957	3.132
3	32	170	0	0	3197	1.429	2.347	3.754
4	0	81	0	0	2200	1.429	3.413	5.454
5 (Initial Cond.)	0	0	0	0	1379	1.429	5.435	8.699
6	53	0	0	0	1172	1.429	14.021	10.243

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Project :	400kV DC TRANSMISSION LINE AT NABINAGAR, BIHAR							
Title :	SAG TENSION FOR 305M SPAN							
Normal Span (m):		305	Equation : Parabolic					
Material Properties :								
Description	Conductor		Earth Wire 1		Earth Wire 2			
Material	ACSR		GSW		OPGW			
Mane	Moose		7/3.66		-			
Stranding (Aluminium)	54/3.53				-			
Stranding (Steel)	7/3.54		7/3.66		-			
Stranding (Optical Fibre)	-		-		-			
Diameter (mm)	31.77		10.98		14			
Cross Sectional Area (mm <sup>2</sup> )	597		73.65		81.66			
Ultimate Tensile Strength (Kg)	16432.21		6972.48		7500			
Unit Weight (Kg/m)	2.004		0.583		0.6			
Modulus of Elasticity (Kg/mm <sup>2</sup> )	7034		19361		10000			
Coefficient of Linear Expansion (1/°C)	1.93E-05		1.15E-05		1.40E-05			
Climatic Conditions & Corrospounding Sag & Tension Values for Conductor								
S.No.	Temp (°C)	Wind Pressure (Kg/m <sup>2</sup> )	Ice Thk (mm)	Ice Density (Kg/m <sup>3</sup> )	Tension (Kg)	FOS (Reqd)	FOS (Actual)	Vert. Sag (m)
1	32	0	0	0	3615	4.545	4.546	6.445
2 (Initial Cond.)	32	182	0	0	8041	1.429	2.044	2.898
3	32	137	0	0	6769	1.429	2.428	3.442
4	0	66	0	0	5590	1.429	2.940	4.169
5	0	0	0	0	4474	1.429	3.673	5.209
6	75	0	0	0	2900	1.429	5.666	8.034
7	53	0	0	0	3219	1.429	5.105	7.238
Keeping the sag of earthwire 10% less than that of power conductor at 0°C No wind condition, the sag of earthwire will be 5.209*0.9 = 4.688m								
This condition is treated as initial condition for earthwire and sag tension values at other conditions have been worked out to check their satisfying the reuired limits.								
Climatic Conditions & Corrospounding Sag & Tension Values for Earth Wire 1 (GSW)								
S.No.	Temp (°C)	Wind Pressure (Kg/m <sup>2</sup> )	Ice Thk (mm)	Ice Density (Kg/m <sup>3</sup> )	Tension (Kg)	FOS (Reqd)	FOS (Actual)	Vert. Sag (m)
1	32	0	0	0	1242	5.000	5.614	5.460
2	32	226	0	0	3307	1.429	2.108	2.050
3	32	170	0	0	2774	1.429	2.514	2.444
4	0	81	0	0	2044	1.429	3.411	3.317
5 (Initial Cond.)	0	0	0	0	1446	1.429	4.822	4.688
6	53	0	0	0	1135	1.429	6.143	5.970
Climatic Conditions & Corrospounding Sag & Tension Values for Earth Wire 2 (OPGW)								
S.No.	Temp (°C)	Wind Pressure (Kg/m <sup>2</sup> )	Ice Thk (mm)	Ice Density (Kg/m <sup>3</sup> )	Tension (Kg)	FOS (Reqd)	FOS (Actual)	Vert. Sag (m)
1	32	0	0	0	1291	5.000	5.806	5.403
2	32	226	0	0	3418	1.429	2.194	2.041
3	32	170	0	0	2891	1.429	2.594	2.413
4	0	81	0	0	2126	1.429	3.527	3.282
5 (Initial Cond.)	0	0	0	0	1488	1.429	5.038	4.688
6	53	0	0	0	1183	1.429	13.890	5.900

Project :	400kV DC TRANSMISSION LINE AT NABINAGAR, BIHAR							
Title :	SAG TENSION FOR 150M SPAN							
Normal Span (m):		150		Equation : Parabolic				
Material Properties :								
Description	Conductor			Earth Wire 1		Earth Wire 2		
Material	ACSR			GSW		OPGW		
Mane	Moose			7/3.66		-		
Stranding (Aluminium)	54/3.53					-		
Stranding (Steel)	7/3.54			7/3.66		-		
Stranding (Optical Fibre)	-			-		-		
Diameter (mm)	31.77			10.98		14		
Cross Sectional Area (mm <sup>2</sup> )	597			73.65		81.66		
Ultimate Tensile Strength (Kg)	16432.21			6972.48		7500		
Unit Weight (Kg/m)	2.004			0.583		0.6		
Modulus of Elasticity (Kg/mm <sup>2</sup> )	7034			19361		10000		
Coefficient of Linear Expansion (°C)	1.93E-05			1.15E-05		1.40E-05		
Climatic Conditions & Corrospounding Sag & Tension Values for Conductor								
S.No.	Temp (°C)	Wind Pressure (Kg/m <sup>2</sup> )	Ice Thk (mm)	Ice Density (Kg/m <sup>3</sup> )	Tension (Kg)	FOS (Reqd)	FOS (Actual)	Vert. Sag (m)
1	32	0	0	0	3615	4.545	4.546	1.559
2 (Initial Cond.)	32	182	0	0	6218	1.429	2.643	0.906
3	32	137	0	0	5449	1.429	3.016	1.034
4	0	66	0	0	5939	1.429	2.767	0.949
5	0	0	0	0	5519	1.429	2.977	1.021
6	75	0	0	0	2197	1.429	7.479	2.566
7	53	0	0	0	2768	1.429	5.936	2.036
Keeping the sag of earthwire 10% less than that of power conductor at 0°C No wind condition, the sag of earthwire will be 1.021*0.9 =0.919m								
This condition is treated as initial condition for earthwire and sag tension values at other conditions have been worked out to check their satisfying the reuired limits.								
Climatic Conditions & Corrospounding Sag & Tension Values for Earth Wire 1 (GSW)								
S.No.	Temp (°C)	Wind Pressure (Kg/m <sup>2</sup> )	Ice Thk (mm)	Ice Density (Kg/m <sup>3</sup> )	Tension (Kg)	FOS (Reqd)	FOS (Actual)	Vert. Sag (m)
1	32	0	0	0	1362	5.000	5.122	1.204
2	32	226	0	0	2503	1.429	2.787	0.655
3	32	170	0	0	2187	1.429	3.190	0.750
4	0	81	0	0	2014	1.429	3.463	0.814
5 (Initial Cond.)	0	0	0	0	1785	1.429	3.909	0.919
6	53	0	0	0	1129	1.429	14.555	1.452
Climatic Conditions & Corrospounding Sag & Tension Values for Earth Wire 2 (OPGW)								
S.No.	Temp (°C)	Wind Pressure (Kg/m <sup>2</sup> )	Ice Thk (mm)	Ice Density (Kg/m <sup>3</sup> )	Tension (Kg)	FOS (Reqd)	FOS (Actual)	Vert. Sag (m)
1	32	0	0	0	1510	5.000	4.968	1.118
2	32	226	0	0	2581	1.429	2.906	0.654
3	32	170	0	0	2278	1.429	3.293	0.741
4	0	81	0	0	2054	1.429	3.653	0.822
5 (Initial Cond.)	0	0	0	0	1836	1.429	4.084	0.919
6	53	0	0	0	1310	1.429	12.544	1.289





### Contents

Sl. No.	Document Title	Document No.	No. of Sheets
1.	SAG TENSION CALCULATION FOR 33kV SC&DC TRANSMISSION LINES	TCE-7219B-765-CALC-101	7

**NTPC DOC. NO.:** 0370-572-PVE-U-630, Rev-00

**DOC. TITLE:** SAG TENSION CALCULATION FOR 33kV SC&DC TRANSMISSION LINES

NABINAGAR POWER GENERATION CO. PVT. LTD.  
(A JV OF NTPC LTD. & BIHAR STATE POWER (HOLDING) CO. LTD.)

400/132 kV SWITCHYARD AT NABINAGR STPP (3X660MW)  
& 400 KV SWITCHYARD EXTENSION AT NABINAGAR TPP(BRBCL)  
NOA Number :CS-0370-572-2-FC-NOA-0009 DATED 12-02-2013



BHARAT HEAVY ELECTRICALS LTD.  
TRANSMISSION PROJECTS DIVISION

W.O. Number : 81004

NEW DELHI  
Digitally signed by Kalash

*Kalash*

Date: 2014.08.19  
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Location:  
NTPCEOC

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**BHARAT HEAVY ELECTRICALS LIMITED**  
**NEW DELHI**

**400kV & 33kV TRANSMISSION LINES AT  
NABINAGAR, BIHAR**

**33kV SC&DC TRANSMISSION LINES  
SAG TENSION CALCULATION**

**NTPC DRG. NO: 0370-572-PVC-U-  
TCE DRG. NO: TCE-7219B-765-CALC-101**



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**JULY 2014**

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Pl refer CI No. 3.04.00 of Chapter-T1 (33kV) of tech spec

**CONTENT SHEET**

Sr. No.	Description
1	WIND PRESSURE CALCULATION
2	SAG TENSION FOR 150m SPAN 200
3	LINE DIAGRAM FOR TOWER TYPE "DA"
4	LINE DIAGRAM FOR TOWER TYPE "DC"

<b>Project :</b>	<b>33kV SC &amp; DC TRANSMISSION LINES AT NABINAGAR, BIHAR</b>		
<b>Title :</b>	<b>Wind Pressure Calculation</b>		
<b><u>WIND PRESSURE CALCULATIONS</u></b>			
Wind Zone to be considered for Design	=	4	47.00 m/sec
Design Wind Speed (Vr)	=	47/1.375	
	=	34.182	m/sec
The Basic Span	=	150	m
Reliability Level	=	1	
Terrain Category	=	2	
Factor K1	=	1.07	
Factor K2	=	1	
Design Wind Speed (Vd)	=	Vr x K1 x K2	
	=	34.182 x 1.07 x 1	
	=	36.575	m/sec
Design Wind Pressure (Pd)	=	0.6 x (Vd) <sup>2</sup>	
	=	0.6 x (36.575) <sup>2</sup>	
	=	803	N/m <sup>2</sup>
	=	81.9	Kg/m <sup>2</sup>
<b><u>(I) Wind Pressure on Conductor (Pc) = Pd x Cd x Gc</u></b>			
Average Height of Conductor considered for Wind Pressure Calculation (h) =		13.845	m
Sag At Minimum Temperature & Nil Wind (m) =		1.00	m
	Suspension	Tension tower	
Minimum Ground Clearance	5.200	5.200	
Maximum Sag of Conductor	2.962	2.962	
Allowance of Sag Error or Creep	0.150	0.150	
Bottom Conductor to Top Conductor	3.200	3.200	
Maximum Body Extension	3.000	3.000	
Height of top conductor attachment point considering +3m body extension for tower (Refer Tower line diagram)	14.512	14.512	
Less 2/3rd Sag at Minimum Temperature (2/3 x 1.00)	-0.667	-0.667	
Average Height of Conductor in m	13.845	13.845	
Where, Pd =	Design Wind Pressure		
Cd =	Drag Coefficient	1	
Gc =	Gust Response Factor	1.9415	
(Refer Table - 7 of IS 802-1995/Sec-1)			
	=	81.9 x 1 x 1.9415	
<b><u>Wind Pressure on Conductor (Pc)</u></b>	=	159.0	Kg/m <sup>2</sup>

Project :	33kV SC & DC TRANSMISSION LINES AT NABINAGAR, BIHAR	
Title :	Wind Pressure Calculation	
<b>(II) Wind Pressure on Earthwire (Pe) = Pd x Cd x Ge</b>		
Average Height of Earthwire considered for Wind Pressure Calculation (h) =	17.149	m
Sag At Minimum Temperature & Nil Wind (m) =	0.90	m
	Suspension	Tension tower
Minimum Ground Clearance	5.200	5.200
Maximum Sag of Conductor	2.962	2.962
Allowance of Sag Error or Creep	0.150	0.150
Insulator Length	0.905	-
Bottom Conductor to Top Conductor	3.200	3.200
Hanger / BM (For Top Conductor)	0.152	0.037
Height of G.W. Peak	1.885	3.200
Maximum Body Extension	3.000	3.000
Less Hanger for Earthwire	-0.150	-
Height of Earthwire attachment point considering +3m body extension for tower (Refer Tower line diagram)	17.304	17.749
Less 2/3rd Sag at Minimum Temperature (2/3 x 0.90)	-0.600	-0.600
Average Height of Earthwire in m	16.704	17.149 (Governing)
Where, Pd = Design Wind Pressure Cd = Drag Coefficient 1.2 Gc = Gust Response Factor 2.037 (Refer Table - 7 of IS 802-1995/Sec-1) $= 81.9 \times 1.2 \times 2.037$		
<b>Wind Pressure on Earthwire (Pe)</b>	= 200.2	Kg/m <sup>2</sup>
<b>(III) Wind Pressure on Insulator (Pi) = Pd x Cd x Gc</b>		
Average Height of Insulator considered for Wind Pressure Calculation (h)	14.965	m
	Suspension	Tension
Height of Insulator attachment mid point considering +9m body extension for tower (Refer Tower line diagram)		
Minimum Ground Clearance	5.200	5.200
Maximum Sag of Conductor	2.962	2.962
Allowance of Sag Error or Creep	0.150	0.150
Bottom Conductor to Top Conductor	3.200	3.200
Hanger / BM (for Top Conductor)	-	0.037
Maximum Body Extension	3.000	3.000
	14.512	14.549
Centre of Insulator (Insulator Length / 2) (0.905/2)	0.453	-
Average Height of Insulator in m	14.965 (Governing)	14.549
Where, Pd = Design Wind Pressure Cd = Drag Coefficient 1.2 Gc = Gust Response Factor 2.059 (Refer Table - 6 of IS 802-1995/Sec-1) $= 81.9 \times 1.2 \times 2.059$		
<b>Wind Pressure on Insulator (Pi)</b>	= 202.4	Kg/m <sup>2</sup>

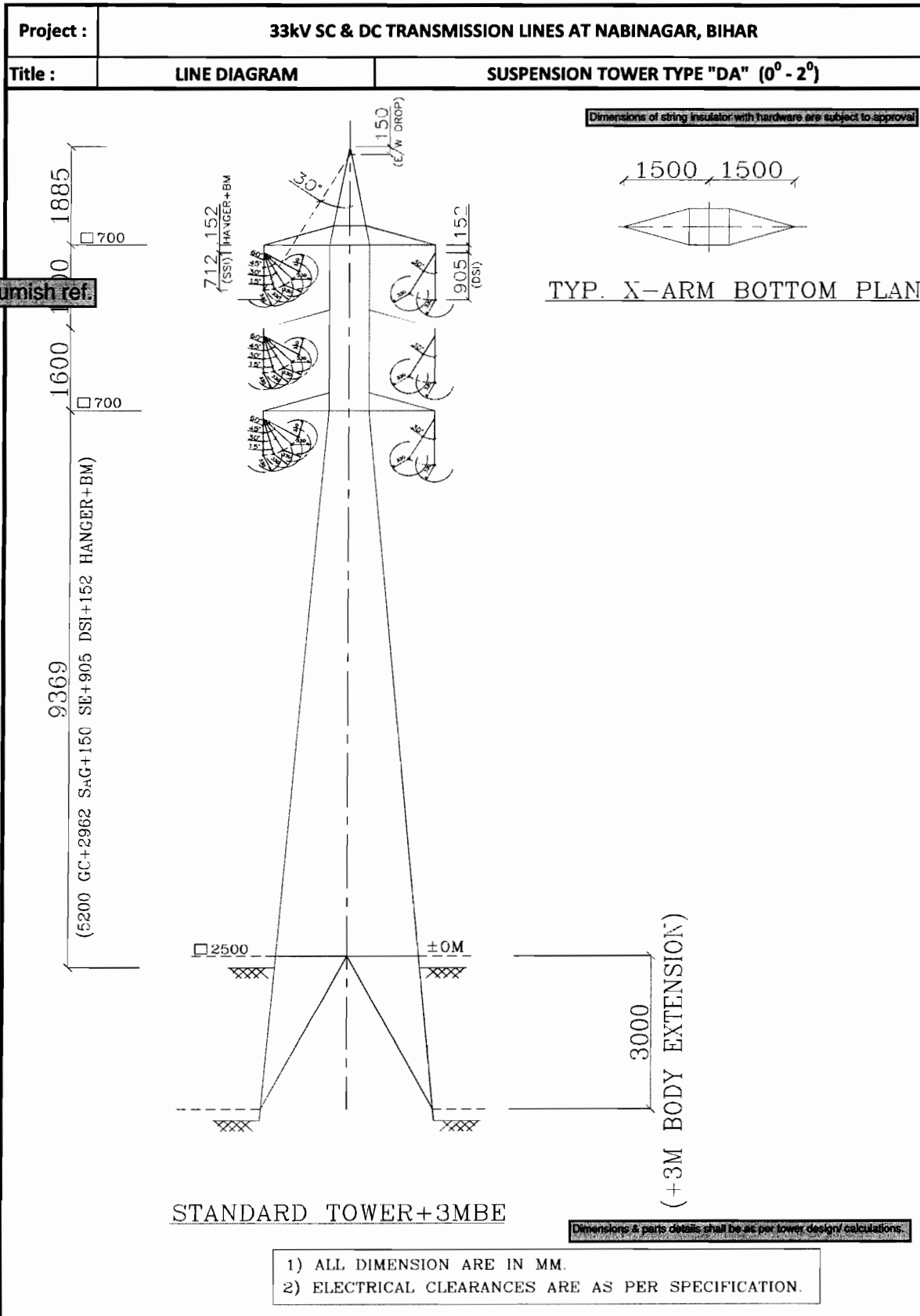
Project :	33kV SC & DC TRANSMISSION LINES AT NABINAGAR, BIHAR							
Title :	SAG TENSION FOR 150M SPAN							
Normal Span (m):		150		Equation : Parabolic				
Material Properties :								
Description	Conductor		Earth Wire					
Material	AAAC		GSW					
Name	100 sq mm		7/3.66					
Stranding (Aluminium)	7/4.26							
Stranding (Steel)	-		7/3.66					
Diameter (mm)	12.78		10.98					
Cross Sectional Area (mm <sup>2</sup> )	100		73.65					
Ultimate Tensile Strength (Kg)	2926		6975					
Unit Weight (Kg/m)	0.27286		0.583					
Modulus of Elasticity (Kg/mm <sup>2</sup> )	6324		19361					
Coefficient of Linear Expansion (/°C)	2.30E-05		1.15E-05					
Climatic Conditions & Corresponding Sag & Tension Values for Conductor								
S.No.	Temp (°C)	Wind Pressure (Kg/m <sup>2</sup> )	Ice Thk (mm)	Ice Density (Kg/m <sup>3</sup> )	Tension (Kg)	FOS (Reqd)	FOS (Actual)	Sag (m)
1	32	0	0	0	447	4.545 (22% of UTS)	6.546	1.715
2 (Initial condition)	32	159.0	0	0	1436	1.4285 (70% of UTS)	2.038	0.534
3	32	119.3	0	0	1205	1.4285 (70% of UTS)	2.428	0.637
4	0	57.2	0	0	1037	1.4285 (70% of UTS)	2.822	0.740
5	0	0	0	0	767	1.4285 (70% of UTS)	3.815	1.000
6	75	0	0	0	259	1.4285 (70% of UTS)	11.297	2.962
7	53	0	0	0	329	1.4285 (70% of UTS)	8.894	2.332
<p>Keeping the sag of earthwire 10% less than that of power conductor at 0°C No wind condition, the sag of earthwire will be <math>1.000 \times 0.9 = 0.900\text{m}</math></p> <p>This condition is treated as initial condition for earthwire and sag tension values at other conditions have been worked out to check their satisfying the required limits.</p>								
Climatic Conditions & Corresponding Sag & Tension Values for Earth Wire								
S.No.	Temp (°C)	Wind Pressure (Kg/m <sup>2</sup> )	Ice Thk (mm)	Ice Density (Kg/m <sup>3</sup> )	Tension (Kg)	FOS (Reqd)	FOS (Actual)	Sag (m)
1	32	0	0	0	1394	5.000 (25% of UTS)	5.004	1.176
2	32	200.2	0	0	2381	1.4285 (70% of UTS)	2.929	0.689
3	32	150.2	0	0	2093	1.4285 (70% of UTS)	3.333	0.784
4	0	72.1	0	0	2006	1.4285 (70% of UTS)	3.477	0.817
5 (Initial condition)	0	0	0	0	1822	1.4285 (70% of UTS)	3.828	0.900
6	53	0	0	0	1156	1.4285 (70% of UTS)	6.034	1.418
<p>Pl refer cl no. 3.05.00 &amp; 3.00.00 of Chapter T1 (33kV) of tech spec w.r.t. loading conditions.</p>								

M/s BHEL to ensure the typical data w.r.t conductor/ earthwire data/ spec.

29.26kN =  $29.26 \times 1000 / 9.81 = 2982.671 \text{ Kg}$

Pl check w.r.t. Cl. No. 2.01.00 of Chapter-12 of tech spec.

Pl check w.r.t. Cl. No. 2.04.08 of Chapter T1 (33kV) of tech spec.





**PART- III**

**TECHNICAL SPECIFICATION**

**CHAPTER – T1**

**TRANSMISSION LINES TOWERS**

**(33 kv)**

# **PART- III**

## **TECHNICAL SPECIFICATION CHAPTER – T1**

### **TRANSMISSION LINES TOWERS**

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5.00.00	Tower Materials	T1-6
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**CHAPTER – T1 : TRANSMISSION LINE TOWERS**

1.00.00

**GENERAL DESCRIPTION OF TOWERS**

1.01.00

The double circuit towers are self supporting lattice steel type and square, designed to carry the line conductors with necessary insulators, earthwires and all fittings under all loading conditions. The tower shall be fully galvanised structure. The types and grade of steel shall conform to latest applicable standards. However, the Bidders are permitted to opt for not more than two grades of steel.

1.02.00

**Types of Towers**

<u>Type of Tower</u>	<u>Deviation Limit</u>	<u>Typical Use</u>
A	0 deg. – 2 deg.	To be used as tangent tower
B	0 deg. – 30 deg.	a) Angle towers with tension insulator string b) Also to be designed for anti-cascading condition.
B	0 deg.	To be used as section tower
C	30 deg. – 60 deg.	a) Angle towers with tension insulator string b) Dead end with 0 deg. to 15 deg. deviation both on line and substation side (slack span)
C	0 deg.	a) Complete dead end d) For crossing/anchoring with longer wind span with 0 deg. deviation on crossing span side and 0 deg. to 30 deg. deviation on other sides.

Note: The above towers can be used for longer span with smaller angle of deviations.

1.03.00

**Extensions**

The single circuit towers shall be designed so as to be suitable for adding 3m, 6m, 9m and 12m body extensions for maintaining adequate ground clearance without reducing the specified factor of safety in any manner. All above extension provisions to normal tower shall be treated as part of normal tower body.

2.00.00

**SPANS AND CLEARANCES**

2.01.00

**Normal Span**

The normal ruling span of the line shall be 150 meters.

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2.02.00	Wind Span	The wind span is the sum of the two half spans adjacent to the support under consideration. For normal horizontal spans this equals to normal span.																					
2.03.00	Weight Span	The weight span is the horizontal distance between lowest point of the conductors on the two spans adjacent to the tower. For design of structures, the span limits given below shall prevail.																					
		<table> <tr> <th rowspan="2">Tower type</th><th colspan="2">Normal Condition</th><th colspan="2">Broken Wire Condition</th></tr> <tr> <th>Max. (m)</th><th>Min. (m)</th><th>Max. (m)</th><th>Min. (m)</th></tr> <tr> <td>A</td><td>225</td><td>120</td><td>135</td><td>72</td></tr> <tr> <td>B &amp; C</td><td>225</td><td>160</td><td>135</td><td>-160</td></tr> </table>			Tower type	Normal Condition		Broken Wire Condition		Max. (m)	Min. (m)	Max. (m)	Min. (m)	A	225	120	135	72	B & C	225	160	135	-160
Tower type	Normal Condition		Broken Wire Condition																				
	Max. (m)	Min. (m)	Max. (m)	Min. (m)																			
A	225	120	135	72																			
B & C	225	160	135	-160																			
2.04.00	Electrical Clearance																						
2.04.01	Ground clearance	<p>The minimum ground clearance from the bottom conductor shall not be less than 5.2 meters at the maximum sag conditions i.e. at maximum temperature and still air. However, to achieve the above clearance the height of tower shall be increased in the following manner:</p> <ol style="list-style-type: none"> <li>Allowance of 150 mm shall be provided to account for errors in stringing.</li> <li>Conductor creep shall be compensated by over tensioning the conductor at a temperature lower than the ambient temperature. The creep correction temperature along with calculations shall be furnished by the Contractor.</li> </ol>																					
2.04.02	Rail Crossing	<p>In case of rail crossing the min. height above rail level of the lowest portion of any conductor under condition of max. sag, in accordance with the regulations for Electrical Crossing of Railway tracks as prevailing at the time of construction of line shall be applicable. However, as per present regulations (revised in 1987) the minimum clearance is stipulated as 14.1 meters.</p>																					
2.04.03	Power Line Crossing	<ol style="list-style-type: none"> <li>Minimum clearance between power line to power line crossing should be 4580 mm for 220 kV and 6300mm for 400 kV lines.</li> <li>For power line crossing, suitable gantries/Rail Pole structures may be used.</li> </ol>																					
2.04.04	Live Metal Clearance	<p>The minimum live metal clearance to be provided between the live parts and steel work of super-structure shall conform to IS-5613 (Part-2/Sec-1) - 1985.</p>																					

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	<u>Type of Insulator String</u>	<u>Swing in Degrees</u>	<u>Min. Clearance (mm)</u>
a)	Pin Insulator	NIL	330
b)	Tension string (Single/Double)	NIL	330
c)	Jumper	10°	330
		20°	330
		30°	330
d)	Single suspension string	Nil	330
		15°	330
		30°	330
		45°	330
		60°	330
e)	Double suspension string	30°	330
2.04.05	Bidder shall adopt same cross arm design where jumper is projecting outside of cross-arm for 'C' type tower to be used as dead end and angle tower.		
2.04.06	The design of the tower shall be such that it should satisfy all the above conditions when clearances are measured from any live point of the strings.		
2.04.07	<p><b>Angle of Shielding</b></p> <p>The angle of shielding is defined as the angle formed by the line joining the center lines of the earthwire and outer power conductor, in still air, at tower supports, to the vertical line through the center line of the earthwire. Bidders shall design the tower in such a way that the angle of shielding does not exceed 30 deg for double circuit towers. The drop of the earthwire clamp, which is in the scope of contractor supplied items, should be considered while calculating the minimum angle of protection. For estimating the minimum angle of protection the drop of earth wire suspension clamp alongwith shackle shall be taken as 150mm.</p>		
2.04.08	<p><b>Mid Span Clearance</b></p> <p>The minimum vertical mid span clearance between the earthwire and the nearest power conductor shall not be less than 1.5 meters, which shall mean the vertical clearance between earthwire and the nearest conductor under all temperatures and still air condition in the normal ruling span. Further, the tensions of the earthwires and power conductors, shall be so co-ordinated that the sag of earthwires shall be at least 10% less than that of power conductors under all temperature loading conditions.</p>		
3.00.00	<b>LOADING CONDITIONS</b>		
3.01.00	<p><b>Loads at Conductor And Earthwire Points</b></p> <p>Owner has calculated the ultimate external loadings at conductor and earthwire points and enclosed alongwith the Specification. The Contractor shall develop the tower designs considering loadings given by the Owner. These loads have been computed based on IS 802/Part - I, 1996 and towers are to be designed to cater for the following</p>		

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	loads:
	<ul style="list-style-type: none"> <li>a) Reliability Loads (Normal condition)</li> <li>b) Security Loads (Broken wire condition)</li> <li>c) Safety Loads (Construction &amp; Maintenance loads)</li> </ul>
3.02.00	<p>Wind Loads on Tower Body</p> <p>The wind load on tower body shall be calculated by the Contractor as per IS: 802, Part-I, 1996.</p>
3.03.00	<p>Maximum Tension</p> <p>Maximum tension shall be based on either of the following (whichever is more stringent):</p> <ul style="list-style-type: none"> <li>a) at 0 deg C with 36% full wind pressure., or</li> <li>b) at 32 deg C with full wind pressure</li> </ul>
3.04.00	Sag tension calculation for design purpose shall be calculated considering normal span of 200 meter.
3.05.00	The initial conductor and earthwire tension at 32 degree C and without wind shall be 22% of the ultimate tensile strength of the conductor and 20% of the ultimate tensile strength of the Earthwire.
3.06.00	<p>Limiting Tensions of conductor &amp; Earthwire</p> <p>The ultimate tension of conductor and ground wire shall not exceed 70 per cent of the ultimate tensile strengths.</p>
3.07.00	<p>Broken Wire condition(Security Condition)</p> <p>All tower under this condition shall be designed for maximum wind condition</p>
3.07.01	<p>Suspension Tower Type A</p> <p>Any one phase or earthwire broken: whichever is more stringent for a particular member. The design longitudinal load under this conditions shall be 100% of maximum tension for earthwire and 50% of maximum tension for conductors.</p>
3.07.02	<p>Tension Tower Type B</p> <p>Any two phases broken on the same side and same span or any one phase and ground wire broken : whichever is more stringent for a particular member.</p>
3.07.03	<p>Tension tower type C</p> <p>Any three phases broken on the same side and same span or groundwire and any two phases on the same span and same side broken whichever is more stringent for a particular member.</p>

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4.00.00	<b>DESIGN OF TOWERS</b>																
4.01.00	<b>Design Criteria</b>  Towers shall be designed based on spans and clearances, and loading conditions as detailed above.																
4.02.00	<b>Design Temperatures</b>  The following temperature range for the conductors and ground wires shall be adopted for line design:  <table><tr><td>a)</td><td>Minimum temperature</td><td>:</td><td>0 deg.C</td></tr><tr><td>b)</td><td>Everyday temperature of conductor</td><td>:</td><td>32 deg.C</td></tr><tr><td>c)</td><td>Max. temperature of Conductor</td><td>:</td><td>75 deg.C</td></tr><tr><td>d)</td><td>Max. temperature of Earthwire exposed to sun</td><td>:</td><td>53 deg.C</td></tr></table>	a)	Minimum temperature	:	0 deg.C	b)	Everyday temperature of conductor	:	32 deg.C	c)	Max. temperature of Conductor	:	75 deg.C	d)	Max. temperature of Earthwire exposed to sun	:	53 deg.C
a)	Minimum temperature	:	0 deg.C														
b)	Everyday temperature of conductor	:	32 deg.C														
c)	Max. temperature of Conductor	:	75 deg.C														
d)	Max. temperature of Earthwire exposed to sun	:	53 deg.C														
4.03.00	<b>Redundant Design</b>  All redundants in the towers are to be triangulated. Redundants, having an angle of 15 deg or less with horizontal are to be designed for a concentric vertical ultimate load of 1.5 KN acting at center of the unsupported length. The Contractor has to furnish the calculation for the same. The redundants shall also be designed for 2.5% of max. axial load of connecting members (i.e. leg members, bracing members etc.).																
4.04.00	<b>Steel Sections</b>  For designing of towers, preferably rationalised steel sections shall be used. During execution of the project, if any particular section is not available same shall be substituted by higher section at no extra cost to Owner and the same shall be borne by the Contractor. However, design approval for such substitution shall be obtained from the Owner before any substitution.																
4.05.00	<b>Thickness of Members</b>  The minimum thickness of angle sections used in the design of tower, unless otherwise specified elsewhere in this Specification, shall be kept not less than the following values:  <table><tr><td>a)</td><td>Main corner leg members including the groundwire peak and main cross arm</td><td>: 5 mm</td></tr><tr><td>b)</td><td>For all other members</td><td>: 4 mm</td></tr></table>	a)	Main corner leg members including the groundwire peak and main cross arm	: 5 mm	b)	For all other members	: 4 mm										
a)	Main corner leg members including the groundwire peak and main cross arm	: 5 mm															
b)	For all other members	: 4 mm															
4.06.00	<b>Bolts &amp; Nuts</b>																
4.06.01	The minimum bolt spacing and rolled edge distance and sheared edge distance from the centers of the bolt holes to be maintained are given below:  <table><tr><td>a)</td><td>Diameter of bolts</td><td>16 mm</td></tr><tr><td>b)</td><td>Hole diameter</td><td>17.5 mm</td></tr><tr><td>c)</td><td>Min. bolt spacing</td><td>40 mm</td></tr><tr><td>d)</td><td>Min. rolled distance</td><td>20 mm</td></tr><tr><td>e)</td><td>Min. sheared edge distance</td><td>23 mm</td></tr></table>	a)	Diameter of bolts	16 mm	b)	Hole diameter	17.5 mm	c)	Min. bolt spacing	40 mm	d)	Min. rolled distance	20 mm	e)	Min. sheared edge distance	23 mm	
a)	Diameter of bolts	16 mm															
b)	Hole diameter	17.5 mm															
c)	Min. bolt spacing	40 mm															
d)	Min. rolled distance	20 mm															
e)	Min. sheared edge distance	23 mm															

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4.06.02	Bolts sizes mentioned above shall only be used. The minimum width of the flanges without bolt holes shall be 30mm.
4.06.03	For the purpose of calculating shearing stress and bearing stress for bolts, IS:802-Part-II-1973 may be referred.
4.07.00	Slenderness Ratio
4.07.01	Slenderness ratio for members shall be computed in accordance with IS:802, Part-II, 1993. Slenderness ratio for compression and tension members shall not exceed the values specified therein.
4.07.02	The following maximum limit of the slenderness ratio i.e. the ratio of unsupported length of the section in any plane to the appropriate radius of gyration will be adopted: <ul style="list-style-type: none"> <li>a) For main corner leg members including the corner members of earthwire peak and the lower corner members of the cross-arms 120</li> <li>b) For other members having calculated stresses 200</li> <li>c) For redundant members 250</li> <li>d) For members having tensile stress only 375</li> </ul>
4.08.00	The bracing pattern, including that of secondary bracings (redundants) shall be identical on transverse and longitudinal faces of the tower, i.e. staggering of primary and secondary bracings are not permitted. Primary bracings and redundants shall be properly triangulated, i.e. the overall pattern of bracing on tower body and cross arms shall be triangular only.
4.09.00	Erection Stress <p>Where erection stress combined with other permissible co-existent stresses could produce a working stress in any member appreciably above the specified working stress, such other provisions are to be made as may be necessary to bring the working stress within the specified limit.</p>
5.00.00	<b>TOWER MATERIALS</b>
5.01.00	Tower Steel Sections <p>IS steel sections of tested quality in conformity with IS:226-1975 or IS:2062-1980 are to be used in towers, extensions and stub setting templates. No individual member shall be longer than 6000mm. The Bidder can also use most efficient grades of structural steel angle sections and plates conforming to latest international standards. However, the Bidders are permitted to opt for not more than two (2) grades of steel for any particular package.</p>
5.02.00	Fasteners : Bolts, Nuts and Washers
5.02.01	All bolts and nuts shall conform to IS:6639-1972. All bolts and nuts shall be galvanised and shall have hexagonal head and nuts, the heads being forged out of the solid, truly concentric, and square with the shank, which must be perfectly straight.

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5.02.02	The bolt shall be of 16 mm dia and of property class 5.6 as specified in IS:1367 (Part-III) 1979 and matching nut of property class as specified in IS:1367 (Part-VI) 1980.
5.02.03	Bolts upto M16 and having length upto 10 times the diameter of the bolt should be manufactured by cold forging and thread rolling process to obtain good and reliable mechanical properties and effective dimensional control. The shear strength of bolts for 5.6 grade should be 310 MP a minimum as per IS:12427. Bolts should be provided with washer face in accordance with IS:1363 Part-I to ensure proper bearing.
5.02.04	To ensure uniformity of galvanizing, bolts and nuts should be galvanised by high temperature hot-dip galvanizing, at a minimum temperature of 530 deg.C . The temperature should be recorded continuously in the form of a continuous chart. The galvanised coating should be uniform and its value should be between 50 micron to 115 micron to be checked on random sampling basis, on the threaded portion as well. The facility to check the galvanised coating should be by metallographic method.
5.02.05	Nuts should be double chamfered as per the requirement of IS:1363 Part-III, 1984. It should be ensured by the manufacturer that nuts should not be overtapped beyond 0.4 MM oversize on effective diameter for size upto M16.
5.02.06	Fully threaded bolts shall not be used. The length of bolts shall be such that the threaded portion will not extend into the place of contact of the members.
5.02.07	All bolts shall be threaded to take the full depth of the nuts and threaded enough to permit firm gripping of the members, but not further. It shall be ensured that the threaded portion of each bolt protrudes not less than 3 mm and not more than 8mm when fully tightened. All nuts shall fit and tight to the point where the shank of the bolt connects to the head.
5.02.08	Flat and tapered washers shall be provided wherever necessary. Spring washers shall be provided for insertion under all nuts. These washers shall be of steel electro-galvanised, positive lock type and 3.5mm in thickness for 16mm dia.
5.02.09	The Bidder shall furnish bolt schedules giving thickness of members connected, the nut and the washer and the length of shank and the threaded portion bolts and sizes of holes and any other special details of this nature.
5.02.10	To obviate bending stress in bolts or to reduce to minimum, no bolt shall connect aggregate thickness of more than three (3) times its diameter.
5.02.11	The bolt positions in assembled towers shall be as per IS:5613 (Part-II/Section-2)-1976.
5.02.12	Bolts at the joints shall be so staggered that nuts may be tightened with spanners without fouling.
5.03.00	Tower Accessories
5.03.01	Step Bolts & ladders  Each tower shall be provided with step bolts of not less than 16mm diameter and 175 mm long, spaced not more than 450mm apart and extending from about 3.5 meters above the ground level to the top of the tower. Step bolt shall be provided with two nuts on one end to fasten the bolt securely to the tower and button head at the other end to

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	prevent the feet from slipping away. The step bolts shall be capable of withstanding a vertical load not less than 1.5 KN. For special structures, where the height of the super structure exceeds 50 meters, ladders along with protection rings as per the Owner approved design shall be provided in continuation of the step bolts on one face of the tower from 30 meters above ground level to the top of the special structure. From 3.5 m to 30 m height of super structure step bolts shall be provided. Suitable railing for access from step bolts to the ladder and from the ladder to each crossarm tip and the groundwire support shall be fixed on tower by using Countersunk bolts.
5.03.02	<p><b>Insulator Strings and Earthwire Clamps Attachments</b></p> <p>a) For the attachment of suspension insulator string a suitable dimensioned swinging hanger on the tower shall be provided so as to obtain requisite clearance under extreme swinging conditionings and free from swinging of the string. The hanger shall be designed to withstand an UTS equivalent to that of insulators. The supply of design &amp; supply of hanger is in the scope of the Contractor.</p> <p>b) At tension towers strain plates of suitable dimensions on the underside of each cross-arm tip and at the top of earthwire peak, suitable plate should be provided for taking the hooks or D-Shackle of the tension insulator strings or earthwire tension clamps, as the case may be. Full details of the attachments shall be submitted by the bidder for Owner's approval before starting the mass fabrication.</p>
5.03.03	Earthwire peaks/crossarms are to be suitably designed to accommodate the shackle of the suspension clamp/tension clamps.
5.03.04	<p><b>Anti-climbing Device</b></p> <p>Barbed wire type anti-climbing device, as per enclosed drawing shall be provided and installed by the Contractor for all towers. The height of the anti-climbing device should be provided approximately 3m above ground level. The barbed wire shall conform to IS-278-1978. The barbed wires shall be given chromating dip as per procedure laid down in IS:1340-1959.</p>
5.03.05	<p><b>Danger plate, Number plates, Circuit Plate, Phase plate &amp; Bird Guards.</b></p> <p>Danger, Number Plates, Phase Plates &amp; Bird Guards shall be provided and installed by the Contractor:</p> <p>a) Each tower shall be fitted with a number plate, and danger plate. Each tension tower shall be provided with a set of phase plates also. The arrangement for fixing these accessories shall not be more than 4.5m above the ground level.</p> <p>b) The letters, figures and the conventional skull and bones of data plates shall conform to IS:2551-1963 and shall be in a single red on the front of the plate.</p> <p>c) The corners of the number and danger plate shall be rounded off to remove sharp edges.</p> <p>d) To prevent birds from perching immediately above the suspension insulator strings and thus fouling it with droppings suitable birdguards shall be provided at cross arm tips of all suspension towers. The arrangement shall conform to IS:5613 part-2/Sec.I.</p>
6.00.00	<b>TOWER FABRICATION</b>
6.01.00	Except where hereinafter modified, details of fabrication shall conform to IS:802 (Part-II) 1993 or the relevant international standards.


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6.02.00	Butt splices shall be used and the inside Angle and outside plate shall be designed to transmit the load and inside cleat angle, shall not be less than half the thickness of the heavier member connected plus 2mm. Lap splice may be used for connecting members of unequal size and the inside angle of lap splice shall be rounded at the heel to fit the fillet of the outside angle. All splices shall develop full stress in the member connected through bolts. Butt as well as lap splice shall be made as above and as close to the main panel point as possible.
6.03.00	Joints shall be so designed as to avoid eccentricity as far as possible. The use of gusset plates for joining tower members shall be avoided as far as possible. However, where the connections are such that the elimination of the gusset plates would result in eccentric joints, gussets plates and spacer plates may be used in conformity with modern practices. The thickness of the gusset plates required to transmit stress shall not be less than that of members connected.
6.04.00	The use of filler in connection shall be avoided as far as possible. The diagonal web members in tension may be connected entirely to the gusset plate wherever necessary to avoid the use of filler and it shall be connected at the point of intersection by one or more bolts.
6.05.00	The tower structures shall be accurately fabricated to connect together easily at site without any undue strain on the bolts.
6.06.00	No angle member shall have the two leg flanges brought together by closing angle.
6.07.00	The diameter of the hole shall be equal to the diameter of bolt plus 1.5mm.
6.08.00	The structure shall be designed so that all parts shall be accessible for inspection and cleaning. Drain holes shall be provided at all points where pockets depression are likely to hold water.
6.09.00	All similar parts shall be made strictly inter-changeable. All steel sections before any work is done on them, shall be carefully leveled, straightened and made true to detailed drawings by methods which will not injure the materials so that when assembled, the adjacent matching surfaces are in close contact through out. No rough edges shall be permitted in the entire structure.
6.10.00	Drilling and Punching
6.10.01	Before any cutting work is started all steel sections shall be carefully straightened and trued by pressure and not by hammering. They shall again be trued after being punched and drilled.
6.10.02	Holes for bolts shall be drilled on punched with a jig but drilled holes shall be preferred. The following maximum tolerance of accuracy of punched holes is permissible. <ul style="list-style-type: none"> <li>a) Holes must be perfectly circular and no tolerance in this respect permissible.</li> <li>b) The max. allowable difference in diameter of the holes on the two sides of plates or angle is 0.8mm. i.e. the allowable taper in a punched holes should not exceed 0.8mm on diameter.</li> <li>c) Holes must be square with the plates or angles and have their walls parallel.</li> </ul>

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6.10.03	All burrs left by drills or punch shall be removed completely. When the tower members are in position the holes shall be truly opposite to each other. Drilling or reaming to enlarge holes shall not be permitted.
6.11.00	Erection mark
6.11.01	Each individual member shall have erection mark conforming to the component number given to it in the fabrication drawings. This mark shall be marked with marking dies of 16mm size before galvanising and shall be legible after galvanising.
6.11.02	Erection Mark shall be "A - BB- CC – DDD", where A = Owner's code assigned to the Contractor Alphabet. BB = Contractor's Mark-Numerical CC = Tower Type-Alphabet DDD = Number mark to be assigned by Contractor.
6.12.00	Quantities and Weights
6.12.01	The provisional quantities required are mentioned in the respective Schedule of Prices. Final quantities shall be determined after completion and approval of the detailed route survey. The final quantities of tower shall be confirmed by the Owner based on the requirement of quantities of various towers furnished by the Contractor after completion of detailed survey. Hence it will be responsibility of the Contractor to intimate the exact requirements of all towers and various line materials required for line immediately after the survey. The Owner reserves the right to order the final quantities (including spare towers) for which the rates quoted in the Bid shall be valid.
6.12.02	The Owner shall/may purchase few towers as spare which shall be supplied at the rate quoted in the bid.
6.12.03	The estimated unit weight of each type of tower, stubs and extensions shall be furnished by the bidder. The weight of tower shall mean the weight of tower calculated by using the black sectional (i.e. un-galvanised) weight of steel members of the size indicated in the approved fabrication drawings and bills of materials, without taking into consideration the reduction in weights, holes, notches and bevel cuts etc, but taking into consideration the weight of the fasteners, anti-climbing devices etc.
6.13.00	Galvanising  Fully galvanised towers and stub shall be used for the line. Galvanising of the member of the towers shall conform to IS:2629-1985 and IS:4759-1968. All galvanised shall conform to IS:5358-1969. The galvanising shall be done after all fabrication work is completed, except that the nuts may be tapped or re-run after galvanising. Threads of bolts and nuts shall have a neat fit and shall be such that they can be turned with finger throughout the length of the threads of bolts and they shall be capable of developing full strength of the bolts. Spring washers shall be electro-galvanised as per Grade 4 of IS:1573-1970.
7.00.00	<b>TOWER EARTHING</b>  The footing resistance of all towers shall be measured by the Contractor in dry weather after tower erection but before the stringing of earthwire. All the tower are to be

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	earthed. In no case tower footing resistance shall exceed 10 ohms. Pipe type earthing and counterpoise type earthing wherever required shall be provided in accordance with the stipulations made in IS:3043-1987 and IS:5613 (part-II/Section-2) 1985. The details for pipe and counterpoise type earthing are given in drawing enclosed with the specification.
8.00.00	<b>INSPECTION AND TESTS</b>
8.01.00	All standard tests, including quality control tests, in accordance with appropriate Indian/International standard, shall be carried out unless otherwise specified herein.
8.02.00	Inspection  In addition to the provisions contained in Vol. I of tenders documents, the following shall also apply:
8.02.01	The Contractor shall keep the Owner informed in advance about the time of starting and the progress of manufacture and fabrication of various tower parts at various stages, so that arrangements could be made for inspection.
8.02.02	The acceptance of any part of items shall in no way relieve the Contractor of any part of his responsibility for meeting all the requirements of the Specification.
8.02.03	The Owner or his representative shall have free access at all reasonable times to those parts of the Contractor's works which are concerned with the fabrication of the Owner's material for satisfying himself that the fabrication is being done in accordance with the provisions of the specifications.
8.02.04	Unless specified otherwise inspection shall be made at the place of manufacture prior to dispatch and shall be conducted so as not to interfere unnecessarily with the operation of the work.
8.02.05	Should any member of the structure be found not to comply with the approved design, it shall be liable to rejection. No member once rejected shall be resubmitted for inspection, except in cases where the Owner or his authorised representative considers that the defects can be rectified.
8.02.06	Defect which may appear during fabrication shall be made good with the consent of, and according to the procedure proposed by the Contractor and approved by the Owner.
8.02.07	All gauges and templates necessary to satisfy the Owner shall be supplied by the manufacturer.
8.02.08	The correct grade and quality of steel shall be used by the Contractor. To ascertain the quality of steel used the inspector may at his discretion get the material tested at an approved laboratory.
8.03.00	<b>Tower Load Tests</b>
8.03.01	<b>Testing of Tower</b>  Galvanised tower of each type complete with 6M extension shall be subjected to design and destruction tests by first applying test loads applied in a manner approved by the

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	<p>Owner. The tower shall withstand these tests without showing any sign of failure or permanent distortion in any part. Thereafter the tower shall be subjected to destruction by increasing the loads further in an approved manner till it fails. The tower shall be tested for all the conditions considered for the design of tower. The contractor shall submit to the Owner for approval, the detailed programme and proposal for testing the towers showing the methods of carrying out the tests and manner of applying the loads. After the Owner has approved the test procedures and programmes the Contractor will intimate the Owner about carrying out the tests at least 30 days in advance of the scheduled date of tests during which the Owner will arrange to depute his representative to be present at the time of carrying out the tests. Six copies of the test reports shall be submitted.</p>
8.03.02	The Contractor shall submit one set of shop drawings alongwith the bill of materials at the time of prototype tower testing for checking the tower material. Further, at the time of submitting test report, the Contractor has to submit the final tracings of shop drawings and Bill of materials for Owner's reference and record. The type testing charges shall be released only after approval of test report, shop drawings, bill of material and structural drawings of tower.
8.03.03	In case of premature failure the tower shall be re-tested and steel already used in the earlier test shall not be used again. However, in case of minor failures, the Contractor can replace the members with higher section and carry out the testing. The Contractor shall provide facilities to the Owner or their representatives for inspection of materials during manufacturing stage and also during testing of the same.
8.03.04	In case of any premature failure even during waiting period, the tower is to be re-tested with rectified members. However, if the failures are major in nature and considerable portion of tower is to be re-erected, in such cases all the tests which has been carried out earlier are required to be conducted again in compliance with Specification.
8.03.05	No part of any tower subject to test shall be allowed to be used on the line. The price will be quoted after allowing rebate for the scrap value of the tower material which shall be retained by the Contractor.
8.03.06	The Contractor shall ensure that the specification of materials and workmanship of all towers actually supplied conform strictly to the towers which have successfully undergone the tests. In case any deviation is detected, the Contractor shall replace such defective towers free of cost to the Owner. All expenditure incurred in erection, to and fro transportation and any other expenditure or losses incurred by the Owner on this account shall be fully borne by the Contractor. No extension in delivery time shall be allowed on this account.
8.03.07	Each type of tower to be tested shall be a full scale prototype galvanised tower and shall be erected vertically on rigid foundation of the stub protruding above ground level as provided in the design/drawing between ground level and concrete level. This portion of the stub shall be kept unbraced while testing. The tower erected on test bed shall not be out of plumb by more than 1 in 360.
8.03.08	All the measuring instruments shall be calibrated in systematic/approved manner with the help of standard weight/device. Calibration shall be done before commencing the test of each tower upto the maximum anticipated loads to be applied during testing.
8.03.09	The sequence of testing shall be decided by the Owner at the time of approving the

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	rigging chart/test data sheet.
8.03.10	The Owner may decide to carry out the tensile test, bend test etc. as per relevant IS on few members of the test tower after completion of the test or in case of any premature failure. The Contractor shall make suitable arrangement for the same without any extra cost of the Owner.
8.03.11	Prefix 'T' shall be marked on all members of test tower in addition to the mark number already provided.
8.04.00	Method of Load Application
8.04.01	Loads shall be applied according to the approved rigging arrangement through normal wire attachments angles on bent plates.
8.04.02	The various types of loads, transverse, vertical and longitudinal shall be applied in such a way that there is no impact loading on the tower due to jerks from the winches.
8.04.03	All the loads shall be measured through a suitable arrangement of strain devices or by using weights. Positioning of the strain devices shall be such that the effect of pulley friction is eliminated. In case the pulley friction cannot be avoided, the same will be measured by means of standard weights and accounted for in the test loads.
8.05.00	Tower Testing Procedure  The procedure for conducting the tower test shall be as follows:
8.05.01	Bolt Slip Test <ul style="list-style-type: none"> <li>a) In the bolt slip test, the test loads shall be gradually applied up to the 50% of design loads under normal condition and held for two (2) minutes at that loads and then released gradually.</li> <li>b) The initial and final readings on the scales (for measurement of defection) before application and after the release of Loads respectively shall be taken with the help of theodolite. The difference between these readings gives the values of the bolt slip.</li> </ul>
8.05.02	Normal/Broken Wire Load Tests  All the loads, for a particular load-combination test shall be applied gradually upto the full design loads in the following steps and shall also be released in the similar manner: <ul style="list-style-type: none"> <li>25 percent</li> <li>50 percent</li> <li>75 percent</li> <li>90 percent</li> <li>95 percent</li> <li>100 percent</li> </ul>
8.05.03	Observation Periods <ul style="list-style-type: none"> <li>a) Under normal and broken wire load tests, the tower shall be kept under observation for sign of any failure for two minutes (excluding the time for adjustment of loads) for all</li> </ul>

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	intermediate steps of loading upto and including 95 per cent of full design loads.					
b)	For normal, as well as broken wire tests, the tower shall be kept under observation for five (5) minutes (excluding the time for adjustment of loads) after it is loaded upto 100 percent of full design loads.					
c)	While the loading operation are in progress, the tower shall be constantly watched, and if it shows any tendency of failure anywhere, the loading shall be immediately stopped, released and then entire tower shall be inspected. The reloading shall be started only after the corrective measures are taken.					
d)	The structure shall be considered to be satisfactory, if it is able to support the specified full design loads for five (5) minutes, with no visible local deformation after unloading (such as bowing, buckling etc.) and no breakage of elements or constituent parts.					
e)	Ovalization of holes and permanent deformation of bolts shall not be considered as failure.					
8.05.04	<b>Recording</b>  The deflection of the tower shall be recorded at each intermediate and final stage of normal load and broken wire load tests by means of a theodolite and graduated scale. The scale shall be of about one meter long with marking upto 5 mm accuracy.					
8.05.05	<b>Destruction Test</b>  a) The destruction test shall be carried out under normal condition or broken wire condition. The Owner at the time of approval of rigging chart/test data sheet shall intimate the contractor. Under which load condition the destruction test is to be carried out.  b) The procedure for application of load for normal/broken wire test shall also be applicable for destruction test. However, the load shall be increased in steps of five (5) percent after the full design loads have been reached.					
9.00.00	<b>PACKING</b>					
9.01.00	Angle section shall be wire bundled.					
9.02.00	Cleat angles, gusset plates, brackets, fillet plate, hanger and similar loose pieces shall be tested and bolted together in multiples or securely wired through holes.					
9.03.00	Bolts, nuts, washers and other attachments shall be packed in double gunny bags accurately tagged in accordance with the contents.					
9.04.00	The packings shall be properly done to avoid losses/damages during transit. Each bundle or package shall be appropriately marked.					
10.00.00	<b>DESIGN CALCULATION AND DRAWINGS</b>					
10.01.00	The following design calculation and drawings are required to be furnished alongwith					
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	the bid.
	<ul style="list-style-type: none"> <li>a) Computation of wind load</li> <li>b) Sag-tension calculation</li> <li>c) Tower loading</li> <li>d) Single line diagram of towers showing electrical clearances and steel sections.</li> <li>e) Sketches of foundation showing dimensions.</li> </ul>
10.02.00	After the award the Contractor shall submit detailed design of tower & extension alongwith stress diagram/computer output together with sample calculations for few critical members etc.. stub templates and loading/rigging arrangement of tower testing to enable the Owner to make a preliminary check regarding structural stability of tower (before) tests.
10.03.00	<p>After successful testing of tower and subsequent approval of design, drawing and bill of materials, the Contractor shall furnish the following in to the Owner.</p> <ul style="list-style-type: none"> <li>a) Detailed design calculation and drawing for towers and foundations.</li> <li>b) Detailed structural drawings indicating section size, length of members sizes of plate along with hole to hole distance, joint details etc.</li> <li>c) Bill of materials, indicating cutting and bending details against each member.</li> <li>d) Shop drawings showing all details relevant to fabrication.</li> <li>e) All the drawings for the tower accessories.</li> </ul>

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**PART- III**

**TECHNICAL SPECIFICATION**

**CHAPTER – T2**

**TOWER FOUNDATIONS**

(33 KV)



# **PART- III**

## **TECHNICAL SPECIFICATION CHAPTER – T2**

### **TOWER FOUNDATIONS**

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<b>CHAPTER – T2 : TOWER FOUNDATIONS</b>	
1.00.00	<b>TYPES OF FOUNDATION</b>
1.01.00	General
1.01.01	Cement concrete/Reinforced concrete footing shall be used for all type of normal tower in conformity with the present day practice followed in the country and the specifications laid herein. All the four footings of the tower and their extension shall be similar, irrespective of down thrust and uplift.
1.01.02	Foundation includes supply of materials such as cement, sand, coarse aggregates etc. and also reinforcement steel, if required. Rates quoted for foundations in appropriate schedules shall include all items of work related to supply and installation of foundations such as form work, excavation and backfilling, stub setting, providing reinforcement (if required) etc.
1.02.00	Classifications of Foundations  The foundation designs shall depend upon the type of soil, sub-soil water level and the presence of surface water which have been classified as follows:
1.02.01	Normal Dry  To be used for locations where normal dry cohesive or non-cohesive soils are met.
1.02.02	Wet  To be used for locations:  a) Where sub-soil water is met at 1.5 meters or more below the ground level. b) Which are in surface water for long periods with water penetration not exceeding one meter below the ground level e.g. the paddy fields.
1.02.03	Partially submerged  To be used at locations where sub-soil water table is met between 0.75 meter below the ground level.
1.02.04	Fully submerged  To be used at locations where sub-soil water table is met at less than 0.75 meter below the ground level.
1.02.05	Black Cotton Soil (Wet)  To be used at locations where soil is clayey type, not necessarily black in colour which shrinks when dry and swells when wet, resulting in differential movement extending to a maximum depth of about 3.5 meters below ground level. For designing foundations, for such locations, the soil is to be considered sub-merged in nature.

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1.02.06	Fissured Rock
a)	To be used at locations where decomposed or fissured rock, hard gravel kankar, limestone, laterite or any other soil of similar nature is met. Under cut type foundation is to be used for fissured rock locations.
b)	To be used at fissured rock locations, where water table is met below ground level.
1.02.07	Hard Rock
	The locations where chiseling, drilling and blasting is required for excavation hard rock type foundations are to be used. For these locations rock anchoring is to be provided to resist uplift forces.
1.02.08	In addition to the above, depending on the site conditions other types of foundations shall also be provided by the Contractor suitable for :
a)	Intermediate conditions under the above classifications to effect more economy, or
b)	For locations where special foundations (well type or piles) are necessitated.
1.03.00	The proposal for these types of foundations shall be submitted by the Contractor based on the detailed soil investigation and approval for the same shall be obtained from the Owner.
2.00.00	<b>SOIL INVESTIGATION</b>
2.01.00	The transmission tower foundations shall be classified based on the soil conditions. Optimisation of foundation design and their safety mainly depends on correctness of soil data and their analysis.
2.02.00	The Contractor shall be required to carry out detailed soil investigation at various tower locations such as angle points, crossings, etc. where soil strata is different from the other locations investigated. In addition the soil investigation may be required to be carried at other locations at the discretion of the Engineer.
2.03.00	This specification covers all the work required for detailed soil investigation and preparation of a detailed report. It shall include mobilization of necessary equipment, providing necessary engineering supervision and technical personnel, carrying out field investigation and tests, laboratory tests, analysis and interpretation of data and results, collecting data regarding change of course of rivers from local sources, velocity, scour, etc., giving flood details of the area (past history), preparations for the type of foundations and the safe bearing capacity for different sizes of foundations, different founding strata for the various locations along the transmission lines.
2.04.00	Soil Classification
2.04.01	The type of soils normally encountered in construction of transmission lines can be broadly classified into the following four types of soils.
a)	Sand
b)	Mixed Soils
c)	Clay soils

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d)	Rocky Soils
2.04.02	The soil at any location shall be classified only after completion of the following field work and tests: <ul style="list-style-type: none"> <li>a) One bore hole of 150 mm id shall be drilled at the center point of tower.</li> <li>b) Standard penetration test (S.P.T) shall be carried out at 1.5 m interval or change of strata upto a depth of 7.0 meters below ground level or to refusal whichever occurs earlier. (By refusal it shall mean that a standard penetration below count (N) of 100 is a recorded for 30 cm penetration.</li> <li>c) Bore details shall be furnished upto 7.0 meters below ground level or refusal whichever occurs earlier.</li> <li>d) Details of water table upto 7.0 meters below ground level shall be furnished.</li> </ul>
2.04.03	Based on the above SPT and other details collected the type of soil shall be classified as per clause 2.04.01 and the same shall be got approved by Engineer-in-Charge.
2.04.04	If the soil is classified as 'same' the bearing capacity and angle of repose shall be furnished alongwith calculations and justification.
2.04.05	If the soils is classified as 'mixed soil' or 'clay soil' the following tests shall be carried out. The samples required for the following tests shall be collected at the time of preliminary investigation carried: <ul style="list-style-type: none"> <li>a) Detailed bore log with the IS classification of soil and its properties such as specific gravity, bulk unit weight, moisture content etc.</li> <li>b) Collecting undisturbed samples of 100/75mm diameter, 450 mm long from the bore holes at 1.5 m intervals of change of strata, starting from 3 meter and upto 7 meter below ground level.</li> <li>c) To find out the following soil properties laboratory tests shall be carried out on the above undisturbed samples: <ol style="list-style-type: none"> <li>1) Type of soil and gradation (As per IS classification)</li> <li>2) Atterberg limit (Liquid and plastic limit only)</li> <li>3) Triaxial tests to determine shear parameters such as cohesion (c) and angle of internal friction.</li> <li>4) Natural moisture content, specific gravity and bulk unit weight.</li> <li>5) Consolidation test.</li> <li>6) Unconfined compression test.</li> <li>7) Unconsolidated undrained test.</li> <li>8) Chemical tests on soil and water to determine the carbonates, sulphates, nitrates and organic matter and any other chemical harmful to the concrete foundations.</li> <li>9) The bearing capacity of soil at different levels starting from 3.0 meter and upto 7.0 meter below ground levels. The above shall be calculated based on above determined soil data and considering a base width of foundation as 2.0 meters.</li> </ol> </li> </ul>
2.04.06	While carrying out the SPT test if the blow count of 100 is recorded for 30 cm of penetration, the soil shall be classified as rocky soil. In case of rock the bore drilling

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	shall be continued 3.0 meters further to ascertain its sufficient thickness. Core recovery and crushing strength of the rock shall also be reported.
2.05.00	The laboratory tests shall be carried out progressively during the field work after sufficient number of samples have reached the laboratory in order that the test results of the initial boreholes can be made use of in planning the later stages of the field investigation and quantum of laboratory tests. All samples brought from field, whether disturbed or undisturbed shall be extracted/prepared and examined by competent technical personnel and the tests shall be carried out as per the procedures laid out in the latest editions of the relevant IS codes.
2.06.00	Test report for soil investigation shall be furnished for approval. The report shall include, but not limited to the following: <ul style="list-style-type: none"> <li>a) Borelogs : Bore logs of each bore hole clearly identifying the satisfaction and the type of soil stratum with depth upto the refusal. The location of water table shall be identified in the borelog. The value of SPT at the depths where the tests were conducted from samples collected at various depths shall be clearly shown against the particular stratum.</li> <li>b) Test results of field and laboratory tests shall be summarised stratawise as well in combined tabular form with all relevant graphs, charts, tables, diagrams and photographs, if any, shall be submitted alongwith the report.</li> <li>c) Recommendations : The report should contain specific recommendations for the type of foundation. The Contractor shall acquaint himself about the type of structures and their functions from the Engineer-in-charge. The observation/recommendations, shall include but not limited to the following : <ul style="list-style-type: none"> <li>i) Geological information of the area, past observations or historical data, if available, for the area and for the structures in the nearby area, fluctuations of water table etc.</li> <li>ii) Limit bearing pressure on the soil at various depths for different sizes of the foundations based on shear strength and settlements characteristics of soil with supporting calculations for the recommendations.</li> <li>iii) Comments on the chemical nature of soil and ground water with due regard to deleterious effects of the same on concrete and steel and recommendations for protective measures.</li> <li>iv) Recommendations for additional investigation, beyond the scope of the present work, if contractor feels that such investigation is necessary.</li> </ul> </li> </ul>
3.00.00	<b>SOIL PROPERTIES</b>
3.01.00	For design of foundations, the following properties of soil shall be considered:
3.01.01	Weight of soil <ul style="list-style-type: none"> <li>a) Dry 1440 Kg/m<sup>3</sup></li> <li>b) In presence of surface water 1440 Kg/m<sup>3</sup></li> <li>c) In presence of soil water 940 Kg/m<sup>3</sup></li> </ul>

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3.01.02	Soft Rock		
a)	Ultimate Bearing Capacity	62,500 Kg/M <sup>2</sup>	
b)	Weight of Earth	1440 Kg/M <sup>3</sup>	
c)	Angle of Repose Degrees	20 degrees	
3.01.03	Hard Rock		
a)	Limit Bearing Capacity	12,50,00 Kg/M <sup>2</sup>	
b)	Ultimate Bond Between Steel and Concrete (M15)	10 Kg/M <sup>2</sup>	
3.01.04	Properties of Soil		
	Type of soil	Limit Bearing Capacity	Angle of Repose (Degrees)
a)	Normal Dry Soil	24,000	20°
b)	Wet earth in the presence of sub soil water	12,000	10°
c)	Wet earth due to presence of sub surface water	12,000	10°
d)	Wet Black Cotton Soil	12,000	0°
4.00.00	<b>LOADS ON FOUNDATIONS</b>		
4.01.00	The foundations shall be designed to withstand the specific loads of the superstructure and for the full footings reactions obtained from the structural stress analysis in conformity with the relevant over load factors. The over load factor for foundation design shall be 1.10 for all loads except dead loads.		
4.02.00	The reactions on the footings shall be composed of the following type of loads for which these shall be required to be checked :		
a)	Max. tension or uplift along the leg slope.		
b)	Max. compression or down-thrust along the leg slope.		
c)	Max. horizontal shear or side thrust.		
4.03.00	The base slab of the foundation shall be designed for additional moments developing due to eccentricity of the loads.		
4.04.00	The additional weight of concrete in the footing below ground level over the earth weight and the full weight of concrete above the ground level in the footing and embedded steel parts will also be taken into account adding to the down thrust.		
5.00.00	<b>STABILITY ANALYSIS</b>		
5.01.00	In addition to the strength design, stability analysis of the foundation shall be done to check the possibility of failure by over-turning, uprooting, sliding and tilting of the foundation.		
5.02.00	The following primary type of soil resistance shall be assumed to act in resisting the loads imposed on the footing in earth:		

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5.02.01	Resistance against uplift	The uplift loads will be assumed to be resisted by the weight of earth in an inverted frustum of a conical pyramid of earth as per formula detailed in Annexure-A of this Section on the footing pad whose sides make an angle equal to the angle of repose of the earth with the vertical, in average soil. The weight of concrete embedded in earth and that above the ground will also be considered for resisting the uplift. In case where the frustum of earth pyramids of two adjoining legs super-impose each other, the earth frustum will be assumed truncated by a vertical plane passing through the center line of the tower base.	
5.02.02	Resistance against down thrust	The down-thrust load combined with the additional weight of concrete above earth will be resisted by bearing strength of the soil assumed to be acting on the total area of the bottom of the footings.	
5.02.03	Resistance against side-thrust	The chimney portion of the foundation shall be designed as per limit load method described at clause 38.6 of IS-456-1978, or as per any other international standard, considering the chimney as a column subjected to axial loads (down thrust loads) and biaxial bending moments resulting from side thrust forces. The passive earth pressure (as per Rankine's formula) shall be considered for the design of chimney against side thrust. If uplift and down thrust are computed in vertical direction for the foundation design, full resultant horizontal shear shall be taken at footing tip for design of the footing to resist side thrust.	
6.00.00	PROPERTIES OF CONCRETE		
6.01.00	The cement concrete used for the foundations shall be of grade M-150 corresponding to 1:2:4 nominal mix ratio with 20mm coarse aggregate for chimney portion and 40mm coarse aggregate for pyramid or slab portion.		
6.02.00	All the properties of concrete regarding its strength under compression tension, shear, punching and bend etc. as well as workmanship will conform to IS:456-1978.		
6.03.00	The weight of concrete to be considered for design of foundations below		
	Type of concrete	Weight of dry region KN/m <sup>3</sup> (Kg/m <sup>3</sup> )	Weight in presence of sub-soil water KN/M <sup>3</sup> (KG/m <sup>3</sup> )
	Concrete	21.96 (2240)	12.16 (1240)
	Reinforced	23.54 (2400)	13.73 (1400)
6.04.00	The Portland Cement used in concrete shall conform to IS:269-1967.		
6.05.00	The Puzzelena cement used in concrete shall conform to IS:1489-1976. The curing time of Puzzolena cement will be decided at the time of execution of the contract.		
6.06.00	Concrete aggregates shall conform to IS:383-1970.		

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6.07.00	The water used for mixing concrete shall be fresh, clean and free from oil, acids and alkalies, organic materials or other deleterious substances. Portable water is generally preferred.
6.08.00	Reinforcement shall conform to IS:432-1966 for MS bars and hard drawn steel wires and to IS:1139-1966 and IS:1786-1966 for deformed and cold twisted bars respectively. All reinforcement shall be clean and free from loose mill scales, dust, loose rust, and coats of paint, oil or other coating, which may destroy or reduce bond. Contractor shall supply, fabricate and place reinforcement to shapes and dimensions as indicated or as required to carry out the intent of drawings and specifications.
7.00.00	<b>DESIGN OF FOUNDATIONS</b>
7.01.00	Structural design of the foundations shall be done by limit State method.
7.02.00	Partial safety factor shall be considered 1.5 for concrete and 1.15 for steel.
7.03.00	The physical properties of soil under various conditions as furnished in clause 3.00.00 are to be considered for the design of various types foundations.
7.04.00	The composite rates quoted in schedule of prices shall be payable for foundations designed based on above soil properties and classified as per clause 1.00.00 above. The composite rate shall be paid to the Contractor for above foundations irrespective of change in approved design volumes in comparison to estimated volume. No extra payment shall be payable/recoverable on account of increase/decrease in concrete volumes, excavation volume, etc. Further, once the foundations are classified based on the preponderant soil, the payment shall be made based on composite rate and extra claim is not admissible for excavation in different kinds of soil encountered inside the pit. However, it may be noted that the soil properties furnished above are tentative in nature. After soil investigations, if it is found that the foundations listed in schedule of prices cannot be used at that location, new foundation design shall be developed based on properties furnished in soil report. The payment for these foundations shall be made based on unit rate quoted for excavation, concrete and reinforcement.
7.05.00	Particulars of the foundations, along with the estimated volumes of concrete and excavation volumes for the various types of towers shall be given in the bid. The foundation shall be designed such as to satisfy the following conditions:
7.06.00	The thickness of concrete in the chimney portion of the tower footing would be such that it provides minimum cover of not less than 100mm from any part of the stub angle to the nearest outer surface of the concrete in respect of all dry locations limiting the minimum section of chimney to 300mm square. In respect of all wet location, the chimney should have all around clearance of 150mm from any part of stub angle limiting to 450mm sq. minimum.
7.07.00	The chimney top or muffing must be at least 225 mm above ground level and also the coping shall be extended upto lower most joint level between the bottom lattices and the main corner legs of the tower.
7.08.00	The spread of concrete pyramid or slabs for both P.C.C. type foundations shall be limited to 45 degree with respect to the vertical. The centroidal axis of the slab shall

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	coincide with the axis of the chimney and pass through the center of foundation base. The design of the foundations (base slab and its reinforcement) shall take into account the additional stresses in the foundation resulting from the eccentricity introduced due to non-compliance of this requirement.
7.09.00	At least 50mm thick pad of size equal to the base of pyramid with its sides vertical will be provided below the pyramid to account for the unevenness of soils and impurities likely to be mixed in concrete due to direct contact of wet concrete with earth and also for allowing stone aggregate reaching upto corner edges. This pad will also be provided in cases where pyramids are provided over concrete slabs.
7.10.00	In case of fully submerged type foundation, at least one base slab of not less than 200 mm thick shall be provided. In case of reinforced concrete slab, the slab thickness should not be less than 300 mm.
7.11.00	The minimum distance between the lowest edge of the stub angle and the bottom surface of concrete footing shall not be less than 100mm or more than 150 mm in case of dry locations and not less than 150 mm or more than 200mm in case of wet locations.
7.12.00	The total depth of foundations below the ground level shall not be less than 1.5 meters and more than 3.0 meters. To maintain the interchangeability of stubs for all types of foundations, for each type of tower, the same depths of foundations shall be used for different types of foundations.
7.13.00	The portion of the stub in the pyramid (or slab) shall be designed to take full down-thrust or uplift loads by the cleats combined with the bond between stub angles and pyramid concrete. The Contractor shall furnish the calculation for uprooting of stub along with the foundation design.
7.14.00	In case of foundation having steel reinforcement in pyramid or base slab, at least 50mm thick pad of lean concrete corresponding to 1:3:6 nominal mix shall be provided to avoid the possibility of reinforcement rod being exposed due to unevenness of the bottom of the excavated pit.
7.15.00	Over Load Factor  The overload factor for foundations shall be considered as 1.1 i.e. the reaction except due to dead loads on foundations shall be increased by 10 per cent.
7.16.00	Unit Rates and Measurements  The Bidders are required to furnish unit rates in the Bid proposal sheets.
7.17.00	The excavation volumes for each tower footing shall be estimated assuming the faces of surrounding earth as vertical keeping a distance of 150mm clearance from the extreme edge of the base slab of footing.
7.18.00	The concrete volume and dimensions of the foundation shall be determined from the drawings approved. Measurement of concrete volume shall be in cubic meters and shall be worked out to the second place of decimal. The rate of foundation per tower shall include excavation, stub setting, concreting, reinforcement, if any, shoring, shuttering, de-watering, stock-piling, dressing, curing, back filling the foundation after concreting with excavated/borrowed earth (irrespective of leads) and consolidation of earth,

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	carriage of surplus earth to the suitable point of proposal as required by the Owner or any other activities related to completion of foundation works.
7.19.00	The steel required for reinforcement of special foundation shall be provided by the Contractor. Measurement will be based on the calculated weights of steel actually used in tonnes corrected to third place of decimal, no allowance being made for wastage. No payments will be made for wire required for binding the reinforcement chairs, bolsters and spacers, as the cost of these is deemed to be included in the unit rate quoted for the item of reinforcement.
8.00.00	<b>CONSTRUCTION OF TOWER FOUNDATION</b>
8.01.00	Excavation
8.01.01	Excavation work must not be started until the tower schedule and profile has been approved by the Owner.
8.01.02	Except as specifically otherwise provided, all excavation for footing shall be made to the lines and grades of the foundation. The excavation wall shall be vertical and the pit dimensions shall be such as to allow a clearance of 150mm on all sides from the foundation pad. The Contractor should ensure clearance of 150 mm from the foundation pad for quality work. All excavation shall be protected so as to maintain a clean subgrade, until the footing is placed, using timbering/shuttering, shoring etc., if necessary. Any sand, mud, silt or other undesirable materials which may accumulate in the excavated pit shall be removed by the Contractor before placing concrete.
8.01.03	The soil to be excavated for tower foundations shall be classified as under: <ul style="list-style-type: none"> <li>a) Normal Soil : Soil removable by means of an ordinary pick axe, spade and shovel.</li> <li>b) Wet Soil : Where the subsoil water table is encountered within the range of foundation depth or/and where pumping or bailing out of water is required due to presence of surface water will be treated as wet soil.</li> <li>c) Rocky Soil : hard conglomerate or other soft or fissured rock which can be quarried or split with crow bars, wedges or pickaxes. However, if required, light blasting may be resorted to for loosening the material, but this will not in any way entitle the material to be classified as hard rock.</li> <li>d) Hard Rock : Any rock excavation other than specified under fissured rock above for which blasting, drilling, chiseling are required. The unit rate quoted for hard rock excavation shall be inclusive of all costs for such drilling, chiseling and blasting etc.</li> </ul>
8.01.04	Where soil is of composite nature, classification of foundation shall be made accordingly.
8.01.05	No extra charge shall be admissible for the removal of the fallen earth in the pit, when once excavated. Shoring and timbering/shuttering as approved by authorized representative of the Owner shall be provided by the Contractor when the soil condition is so bad that there is likelihood of accident due to the falling of earth.
8.01.06	Where rock is encountered, the holes for tower footings, shall preferably be drilled, but

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	<p>where blasting is to be resorted to as an economy measure, it shall be done with the utmost care to minimise the use of concrete for filling the blasted area. All cases where unnecessarily large quantities are excavated/blasted, resulting in placement of large volumes of concrete, payment of concrete shall be limited to approved design, the balance cost of concrete being to the Contractor's account. In case where drilling is done, the stubs may be shortened suitably with the approval of the Owner or his authorised representatives.</p>
8.01.07	The Contractor shall supply requisite blasting materials and be responsible for the purpose of the storage and use of this material.
8.02.00	Setting of Stubs
8.02.01	The stubs shall be set correctly in accordance with approved method at the exact location and alignment and precisely at correct levels with the help of stub setting templates and leveling instrument. Stubs shall be set in the presence of Owner's representative available at site where required and for which adequate advance intimation shall be given to the Owner by the Contractor.
8.02.02	Setting of stub at each location shall be approved by the Owner's representative.
8.02.03	<p>Stub setting templates shall be designed and arranged by the Contractor at his own cost for all types of towers with or without extension and also for leg extension. Stub templates for standard towers and towers with extension upto 6M shall be of adjustable type. The stub templates shall be painted. Generally for each transmission line tower package, following numbers of stub setting templates shall be deployed by the Contractor:</p> <p>For each A type tower : 3 Nos. For each of B and C type : 2 Nos.</p> <p>However, if Owner feels that more number of templates are required for timely completion of a particular line the Contractor shall have to deploy the same without any extra cost to Owner.</p>
8.02.04	One set of each type of stub setting template as applicable, shall be supplied to the Owner, on completion of the project at no extra cost to Owner.
8.03.00	Mixing, Placing and Compacting of Concrete
8.03.01	The concrete shall be mixed in a mechanical mixer. However, in case of difficult terrain hand mixing may be permitted at the discretion of Owner. The water for mixing concrete shall be fresh, clean and free from oil, acids and alkalies. Saltish or blackish water shall not be used.
8.03.02	Mixing shall be continued until there is uniform distribution of material and the mix is uniform in colour and consistency, but in no case the mixing be done for less than two minutes. Normally mixing shall be done close to the foundation, but in case it is not possible the concrete may be mixed at the nearest convenient place. The concrete shall be transported from the place of mixing to the place of final deposit as rapidly as practicable by methods which shall prevent the segregation or loss of any ingredient. The concrete shall be placed and compacted before setting commences.

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8.03.03	Form boxes shall be used for casting all type of foundations. The concrete shall be laid down in 150mm layers and consolidated well, so that the cement cream works up to the top and no honey-combing is left in the concrete. The mechanical vibrator shall be employed for compaction of the concrete. However, in case of difficult terrain, manual compaction may be permitted at the discretion of Owner. After concreting the chimney portion to the required height, the top surface should be finished smooth with a slight slope towards the outer edge, to drain off any rain water falling on the coping.
8.03.04	In wet locations, the site must be kept complete de-watered, both during the placing of the concrete and for 24 hours thereafter. There should be no disturbance of concrete by water during this period.
8.03.05	After the form-work has been removed if the concrete surface is found to be defective, the damage shall be repaired with rich cement and sand mortar to the satisfaction of the Owner's representative before the foundation pits are backfilled.
8.04.00	Back-Filling and Removal of Stub Template.
8.04.01	After opening of form-work and removal of shoring and timbering, if any, backfilling shall be started, after repairs, if any, to the foundation concrete. Backfilling shall normally be done with excavated soil, unless it consists of large boulders/stones, in which case the boulders shall be broken to a maximum size of 80 mm. At such locations where borrowed earth is required for backfilling, shall be done by the Contractor at his own cost, irrespective of lead.
8.04.02	The backfilling materials should be clean and free from organic or other foreign materials. The earth shall be deposited in maximum 200 mm layers, leveled and wetted and tempered properly before another layer is deposited. Care shall be taken that the backfilling is started from the foundation ends of the pits, towards the outer ends. After the pits have been backfilled to full depth, the stub template may be removed.
8.04.03	The backfilling and grading shall be carried to an elevation of about 75 mm above the finished ground level to drain out water. After backfilling 50 mm high earthen embankment (bandh) will be made along the sides of excavation pits and sufficient water will be poured in the backfilled earth for atleast 24 hours.
8.05.00	Curing  The concrete after setting for 24 hours shall be cured by keeping the concrete wet continuously for a period of 10 days after laying. The pit may be back filled with selected earth sprinkled with necessary amount of water and well consolidated in layers not exceeding 200 mm of consolidated thickness after a minimum period of 24 hours and thereafter both the backfilled earth and exposed chimney top shall be kept wet for the remainder of the prescribed time of 10 days. The uncovered concrete chimney above the backfilled earth shall be kept wet by providing empty cement bags dipped in water fully wrapped around the concrete chimney for curing and ensuring that the bags are kept wet by the frequent pouring of water on them.
8.06.00	Benching  When the line passes through hilly/undulated terrain, for a few tower locations it may be required to level the ground for casting of tower footings on same elevation. All the activities related to make the required area of ground in same elevation for casting of

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	<p>foundation, shall be termed as benching work. Benching work shall include cutting of excess earth and removing the same to a suitable point of disposal as required by the Owner. Benching shall be resorted to only after getting specific approval from the Owner. Volume of the earth to be cut shall be measured before cutting and got approved from the Owner. This volume of earth shall be considered for the purpose of payment against the head of benching work. The earth removed for setting of stub template or for casting of foundation with difference of elevations of 1M between the tower legs shall not be entitled for payment.</p>
8.07.00	Protection of Tower Footing
8.07.01	The work shall include all necessary stone revetments, concreting and earth filling above ground level and the clearance from stacking on the site of all surplus excavated soil, special measures for protection of foundation close to or in nallahs, river bed hilly/undulated terrain etc, by providing suitable revetments or galvanised wire netting and meshing packed with boulders. The top seal cover of the stone revetments shall be done with M-150 concrete (1:2:4:mix). The Contractor shall furnish recommendations for providing protection at these locations wherever required.
8.07.02	The quantity of excavated earth obtained from a particular location shall generally be utilised in back-filling work in protection of tower footing of same locations, unless it is unsuitable for such purpose. In the latter case, the back-filling shall be done with borrowed earth of suitable quality irrespective of lead as per the rate provided in the letter of award. The consolidation of earth shall however be done after backfilling free of cost.

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**PART- III**

**TECHNICAL SPECIFICATION**

**CHAPTER – T1**

**TRANSMISSION LINES TOWERS**

(400 KV)

# **PART- III**


## **TECHNICAL SPECIFICATION CHAPTER – T1**


### **TRANSMISSION LINES TOWERS**


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	<div>SECTION – T1: TRANSMISSION LINE TOWERS</div> <div>1.00.00 GENERAL DESCRIPTION OF TOWERS</div> <div>1.01.00 Types of Towers</div> <div>1.01.01 400 KV Towers</div> <div>The towers shall be of self supporting lattice steel type, designed to carry the line conductors with necessary insulators, earth wires and all fittings under all loading conditions.</div> <div>1.01.02 The tower shall be of a fully galvanised structure, using structural mild steel sections for members. Bolts and nuts with spring washers shall be used for connections.</div> <div>1.01.03 Bidders can also use high tensile steel and cold formed steel for fabrication of towers provided they furnish the justification for use of such steel with reference to national or international standards. However, the factors of safety, limitation on member length, requirement of fasteners and galvanisation shall be as specified in this specification.</div> <div>The towers shall be classified as given in Table 1-1</div> <div>Table T1-1</div> <table><thead><tr><th>Type of Tower</th><th>Deviation limit</th><th>Typical use</th></tr></thead><tbody><tr><td>DA</td><td>0 to 2</td><td>To be used as tangent tower</td></tr><tr><td>DB</td><td>0 to 15</td><td>a) Angle towers with tension insulator string b) Tension tower for uplift forces resulting from an uplift span upto 200 metres under broken wire conditon. c) Also to be designed for unblanced tension resulting from unequal ruling span of 305 m and 150 m on each side of the tower.</td></tr><tr><td>DB</td><td>0</td><td>d) to be used as section tower</td></tr><tr><td>DC</td><td>15 to 30 degree.</td><td>a) Angle tower with tension insulator string b) Tension tower for uplift forces resulting from</td></tr></tbody></table>	Type of Tower	Deviation limit	Typical use	DA	0 to 2	To be used as tangent tower	DB	0 to 15	a) Angle towers with tension insulator string b) Tension tower for uplift forces resulting from an uplift span upto 200 metres under broken wire conditon. c) Also to be designed for unblanced tension resulting from unequal ruling span of 305 m and 150 m on each side of the tower.	DB	0	d) to be used as section tower	DC	15 to 30 degree.	a) Angle tower with tension insulator string b) Tension tower for uplift forces resulting from
Type of Tower	Deviation limit	Typical use														
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1.03.00	D* and DD	30 deg. To 60 deg.	<p>an uplift span upto 200 meters under broken wire condition.</p> <p>c) Also to be designed for unbalanced tension resulting from unequal ruling span of 305 m and 150 m on each side of the tower.</p> <p>a) Angle tower with tension insulator string.</p> <p>b) Tension tower for uplift forces resulting from an uplift span upto 200 metres under broken wire condition.</p> <p>c) Also to be designed for the unbalanced tension resulting from unequal ruling span of 305m (*400 m) 150 m (*200 m) on each side of the tower (* For 400 KV towers)</p> <p>d) Dead end with 0 deg. to 15 deg deviation both on line and sub- station side (slack span).</p>		
	D* and DD	0deg.	e) complete dead end.		
	D* and DD	90deg.	f) to be used near switchyard with Reduced design and span		
	<p>NOTE: The above towers may also be used for longer span with smaller angle of deviation.</p> <p>* Indicates Single circuit tower.</p>				
	<p><b>Extension</b></p> <p>The single and double circuit tower shall be designed so as to be suitable for adding 3M, 6M and 9M body extension for maintaining adequate ground clearance without reducing the specified factor of safety in any manner.</p> <p>For power line crossing 25 metre extensions with DD type towers are required. Bidders shall state in relevant clause of volume II-A the maximum reduced span for which type tower with 25 metre extension can be used with the stipulated factor of safety.</p> <p>The 25 metre extension should be designed in such a manner the same can also be used as 18.0 metre extension to normal tower after removal of bottom panels.</p> <p>For under line crossing of EHV transmission lines the bidder shall have to design minus-three metres and minus six metre extensions to D type tower.</p> <p>D/DD type towers shall be designed to cater for 90deg. deviation with auxiliary cross arm and reduced tension/span.</p>				
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1.04.00	<b>Stub Setting templates.</b>  Stub templates shall be designed and arranged by the contractor at his own cost for all types of tower with or without extension and also for leg extension. Stub templates for standard towers and tower with extension shall be of adjustable type. The stub templates shall be painted. The number of such templates of each type proposed to be supplied shall be stated by the Bidder. One set of each type of stub setting template for single and double circuit tower shall be supplied to the Owner, on completion of the project, at no extra cost.															
2.00.00	<b>SPANS AND CLEARANCES</b>															
2.01.00	<b>Normal Span</b>  The normal ruling span of the line shall be 400 meters for 400 KV towers..															
2.02.00	<b>Wind Span</b>  The wind span is the sum of the two half spans adjacent to the support under consideration. For normal horizontal spans this equals to normal span.															
2.03.00	<b>Weight Span</b>  The weight span is the horizontal distance between lowest point of the conductors on the two spans adjacent to the tower. For design of structures, the span limits given below shall prevail.															
	<table><tr><th rowspan="2">Tower type</th><th colspan="2">Normal Condition</th><th colspan="2">Broken Wire Condition</th></tr><tr><th>Max. (m)</th><th>Min. (m)</th><th>Max. (m)</th><th>Min. (m)</th></tr><tr><td>DA, DB, DC &amp; DD (400 KV)</td><td>600</td><td>-200</td><td>360</td><td>-200</td></tr></table>	Tower type	Normal Condition		Broken Wire Condition		Max. (m)	Min. (m)	Max. (m)	Min. (m)	DA, DB, DC & DD (400 KV)	600	-200	360	-200	
Tower type	Normal Condition		Broken Wire Condition													
	Max. (m)	Min. (m)	Max. (m)	Min. (m)												
DA, DB, DC & DD (400 KV)	600	-200	360	-200												
2.04.00	<b>Electrical Clearance</b>															
2.04.01	<b>Ground clearance</b>  The minimum ground clearance from the bottom conductor shall not be less than 8.84 meters for 400 KV lines at the maximum sag conditions i.e. at maximum temperature and still air. However, to achieve the above clearance the height of tower shall be increased in the following manner:  a) Allowance of 150 mm shall be provided to account for errors in stringing.  b) Conductor creep shall be compensated by over tensioning the conductor at a temperature lower than the ambient temperature. The creep correction temperature along with calculations shall be furnished by the Contractor.  c) Minimum spacing The minimum electrical clearance between conductors shall be as follows: Vertical : 9.0 mtr. Horizontal : 11.0 mtr.															
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Clause No.	TECHNICAL REQUIREMENTS																					
2.04.02	<b>Rail Crossing</b>  In case of rail crossing the min. height above rail level of the lowest portion of any conductor under condition of max. sag, in accordance with the regulations for Electrical Crossing of Railway tracks as prevailing at the time of construction of line shall be applicable. However, as per present regulations (revised in 1987) the minimum clearance is stipulated as 18.6 meters for 400 KV towers.																					
2.04.03	<b>Power Line Crossing</b>  Minimum clearance between power line to power line crossing should be 4580 mm for 220 kV and 6300mm for 400 kV lines.																					
2.04.04	<b>Live Metal Clearance</b>  The minimum live metal clearance to be provided between the live parts and steel work of super-structure shall conform to IS-5613- 1985/ IS- 5613 Part as follows : <table><tr><th>Type of Insulator String</th><th>Swing in Degrees</th><th>Min. Clearance (mm)</th></tr><tr><td rowspan="3">a) Single suspension string</td><td>NIL</td><td>3050</td></tr><tr><td>22</td><td>3050</td></tr><tr><td>44</td><td>1860</td></tr><tr><td>b) Tension string (Single/Double)</td><td>NIL</td><td>3050</td></tr><tr><td rowspan="2">c) Jumper</td><td>NIL</td><td>3050</td></tr><tr><td>20</td><td>3050</td></tr></table> <p>d) Bidder shall adopt same cross arm design where jumper is projecting outside of cross-arm for 'DD' type tower to be used as dead end and angle tower.</p> <p>The design of the tower shall be such that it should satisfy all the above conditions when clearances are measured from any live point of the strings.</p>				Type of Insulator String	Swing in Degrees	Min. Clearance (mm)	a) Single suspension string	NIL	3050	22	3050	44	1860	b) Tension string (Single/Double)	NIL	3050	c) Jumper	NIL	3050	20	3050
Type of Insulator String	Swing in Degrees	Min. Clearance (mm)																				
a) Single suspension string	NIL	3050																				
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b) Tension string (Single/Double)	NIL	3050																				
c) Jumper	NIL	3050																				
	20	3050																				
2.04.05	<b>Angle of Shielding</b>																					
2.04.06	The angle of shielding is defined as the angle formed by the line joining the center lines of the earthwire and outer power conductor, in still air, at tower supports, to the vertical line through the center line of the earthwire. Bidders shall design the tower in such a way that the angle of shielding does not exceed 20 deg for 400 KV towers. The drop of the earthwire clamp, which is in the scope of contractor supplied items, should be considered while calculating the minimum angle of protection. For estimating the minimum angle of protection the drop of earth wire suspension clamp alongwith shackle shall be taken as 150mm.																					
2.04.07	<b>Mid Span Clearance</b>																					
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Clause No.	TECHNICAL REQUIREMENTS			
	<p>The minimum vertical mid span clearance between the earthwire and the nearest power conductor shall not be less than 6.1 meters, which shall mean the vertical clearance between earthwire and the nearest conductor under all temperatures and still air condition in the normal ruling span. Further, the tensions of the earthwires and power conductors, shall be so co-ordinated that the sag of earthwires shall be at least 10% less than that of power conductors under all temperature loading conditions.</p>			
3.00.00	<b>LOADING CONDITIONS</b>			
3.01.00	<b>Loads at Conductor And Earthwire Points</b>			
	<p>Owner has calculated the ultimate external loadings at conductor and earthwire points and enclosed alongwith the Specification. The Contractor shall develop the tower designs considering loadings given by the Owner. These loads have been computed based on IS 802/Part - I, 1995and towers are to be designed to cater for the following loads:</p>			
	<ul style="list-style-type: none"><li>a) Reliability Loads (Normal condition)</li><li>b) Security Loads (Broken wire condition)</li><li>c) Safety Loads (Construction &amp; Maintenance loads)</li></ul>			
	<b>Suspension towers shall be designed for full wind load under security condition</b>			
3.02.00	<b>Wind Loads on Tower Body</b>			
	<p>The wind load on tower body shall be calculated by the Contractor as per IS:802, Part-I, 1995.</p>			
3.03.00	<b>Maximum Tension</b>			
	<p>Maximum tension shall be based on either of the following (whichever is more stringent):</p>			
	<ul style="list-style-type: none"><li>a) at 0 deg C with 36% full wind pressure., or</li><li>b) at 32 deg C with full wind pressure</li></ul>			
	<p>The value of drag co-efficient (Cd) shall be 1.2 for conductor/earthwire if the diameter of the conductor/earth is 15mm or less.</p>			
3.04.00	<p>Sag tension calculation for design purpose shall be calculated considering normal span of 400 meter.</p>			
3.04.05	<p>The initial conductor and earthwire tension at 32 degree C and without wind shall be 22% of the ultimate tensile strength of the conductor and 20% of the ultimate tensile strength of the Earthwire.</p>			
3.06.00	<p>Limiting Tensions of conductor &amp; Earthwire</p>			
	<p>The ultimate tension of conductor and ground wire shall not exceed 70 per cent of the ultimate tensile strengths.</p>			
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Clause No.	TECHNICAL REQUIREMENTS	
3.07.00	<b>Broken Wire Condition</b>	
3.07.01	<b>Suspension Tower Type DA</b> Breaking of conductor in one phase only, resulting in instantaneous unbalanced tension of maximum working conductor tension or breaking of one earthwire resulting in an unbalance tension equal to the maximum tension of the earthwire whichever is more stringent is to be considered.	
3.07.02	<b>Tower Type DB&amp; DC</b> Breaking conductor is any two phase only or breaking of earthwire and any one phase on the same side and same span resulting is instantaneous unbalanced tension on the tower is to be considered. The unbalanced tension shall be taken as the maximum tension.	
3.07.03	<b>Tower Type DD</b> Breakage of all the three phases on the same side and on the same span or breakage of two phases and any one earthwire on the same side and one he same span, whichever combination is more stringent for a particular member.	
3.08.00	<b>Design Loads</b>	
3.08.01	Owner's requirement for most stringent design longitudinal and transverse loads is summerized in Table T1-2.	
3.08.02	The Bidder shall furnish the details of design loads proposed to be adopted in the tower design in accordance with this specification. The same design load data be filled in the Data Requirement Sheet.	
4.00.00	<b>DESIGN OF TOWERS</b>	
4.01.00	<b>Design Criteria</b> Towers shall be designed based on spans and clearances, and loading conditions as detailed above.	
4.02.00	<b>Design Temperatures</b> The following temperature range for the conductors and ground wires shall be adopted for line design:  a) Minimum temperature : 0 deg.C b) Everyday temperature of conductor : 32 deg.C c) Max. temperature of Conductor : 75 deg.C d) Max. temperature of Earthwire exposed to sun : 53 deg.C	
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Clause No.	TECHNICAL REQUIREMENTS	
4.03.00	<b>Redundant Design</b>  All redundants in the towers are to be triangulated. Redundants, having an angle of 15 deg or less with horizontal are to be designed for a concentric vertical ultimate load of 1.5 KN acting at center of the unsupported length. The Contractor has to furnish the calculation for the same. The redundants shall also be designed for 2.5% of max. axial load of connecting members (i.e. leg members, bracing members etc.).	
4.04.00	<b>Steel Sections</b>  For designing of towers, preferably rationalised steel sections shall be used. During execution of the project, if any particular section is not available same shall be substituted by higher section at no extra cost to Owner and the same shall be borne by the Contractor. However, design approval for such substitution shall be obtained from the Owner before any substitution.	
4.05.00	<b>Thickness of Members</b>  The minimum thickness of angle sections used in the design of tower, unless otherwise specified elsewhere in this Specification, shall be kept not less than the following values:  a) Main corner leg members including the groundwire peak and main cross arm : 5 mm b) For all other members : 4 mm	
4.06.01	<b>Bolts &amp; Nuts</b>	
4.06.02	The minimum bolt spacing and rolled edge distance and sheared edge distance from the centers of the bolt holes to be maintained are given below:  a) Diameter of bolts 16 mm b) Hole diameter 17.5 mm c) Min. bolt spacing 40 mm d) Min. rolled distance 20 mm e) Min. sheared edge distance 23 mm	
4.07.00	Bolts sizes mentioned above shall only be used. The minimum width of the flanges without bolt holes shall be 30mm.	
4.07.01	For the purpose of calculating shearing stress and bearing stress for bolts, IS:802-Part-II-1993 may be referred.	
4.07.02	<b>Slenderness Ratio</b>	
4.08.00	Slenderness ratio for members shall be computed in accordance with IS:802, Part-II, 1993. Slenderness ratio for compression and tension members shall not exceed the values specified therein.	
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Clause No.	TECHNICAL REQUIREMENTS									
4.09.00	<p>The following maximum limit of the slenderness ratio i.e. the ratio of unsupported length of the section in any plane to the appropriate radius of gyration will be adopted:</p> <table><tr><td>a) For main corner leg members including the corner members of earthwire peak and the lower corner members of the cross-arms</td><td>120</td></tr><tr><td>b) For other members having calculated stresses</td><td>200</td></tr><tr><td>c) For redundant members</td><td>250</td></tr><tr><td>d) For members having tensile stress only</td><td>375</td></tr></table>	a) For main corner leg members including the corner members of earthwire peak and the lower corner members of the cross-arms	120	b) For other members having calculated stresses	200	c) For redundant members	250	d) For members having tensile stress only	375	
a) For main corner leg members including the corner members of earthwire peak and the lower corner members of the cross-arms	120									
b) For other members having calculated stresses	200									
c) For redundant members	250									
d) For members having tensile stress only	375									
4.10.00	<p>The bracing pattern, including that of secondary bracings (redundants) shall be identical on transverse and longitudinal faces of the tower, i.e. staggering of primary and secondary bracings are not permitted. Primary bracings and redundants shall be properly triangulated, i.e. the overall pattern of bracing on tower body and cross arms shall be triangular only.</p>									
4.11.00	<p><b>Erection Stress</b></p> <p>Where erection stress combined with other permissible co-existent stresses could produce a working stress in any member appreciably above the specified working stress, such other provisions are to be made as may be necessary to bring the working stress within the specified limit.</p>									
5.00.00	<p><b>TOWER MATERIALS</b></p>									
5.01.00	<p><b>Tower Steel Sections</b></p> <p>IS steel sections of tested quality in conformity with IS:226-1975 or IS:2062-1980 are to be used in towers, extensions and stub setting templates. No individual member shall be longer than 6000mm. The Bidder can also use most efficient grades of structural steel angle sections and plates conforming to latest international standards. However, the Bidders are permitted to opt for not more than two (2) grades of steel for any particular package.</p>									
5.02.00	<p><b>Fasteners : Bolts, Nuts and Washers</b></p>									
5.02.01	<p>All bolts and nuts shall conform to IS:6639-1972. All bolts and nuts shall be galvanised and shall have hexagonal head and nuts, the heads being forged out of the solid, truly concentric, and square with the shank, which must be perfectly straight.</p>									
5.02.02	<p>The bolt shall be of 16 mm dia and of property class 5.6 as specified in IS:1367 (Part-III) 1979 and matching nut of property class as specified in IS:1367 (Part-VI) 1980.</p>									
5.02.03	<p>Bolts upto M16 and having length upto 10 times the diameter of the bolt should be manufactured by cold forging and thread rolling process to obtain good and reliable mechanical properties and effective dimensional control. The shear strength of bolts for 5.6 grade should be 310 MP a minimum as per IS:12427. Bolts should be provided with washer face in accordance with IS:1363 Part-I to ensure proper bearing.</p>									
<table><tr><td>NABINAGAR STPP (3X660MW) 400/132kV SWITCHYARD PACKAGE</td><td>Bid Doc. No.: CS-0370-572-2</td><td>TECHNICAL SPECIFICATIONS</td><td>PART-III SECTION-VI</td><td>Page T1-8/17</td></tr></table>			NABINAGAR STPP (3X660MW) 400/132kV SWITCHYARD PACKAGE	Bid Doc. No.: CS-0370-572-2	TECHNICAL SPECIFICATIONS	PART-III SECTION-VI	Page T1-8/17			
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Clause No.	TECHNICAL REQUIREMENTS				
5.02.04	To ensure uniformity of galvanizing, bolts and nuts should be galvanised by high temperature hot-dip galvanizing, at a minimum temperature of 530 deg.C . The temperature should be recorded continuously in the form of a continuous chart. The galvanised coating should be uniform and its value should be between 50 micron to 115 micron to be checked on random sampling basis, on the threaded portion as well. The facility to check the galvanised coating should be by metallographic method.				
5.02.05	Nuts should be double chamfered as per the requirement of IS:1363 Part-III, 1984. It should be ensured by the manufacturer that nuts should not be overtapped beyond 0.4 MM oversize on effective diameter for size upto M16.				
5.02.06	Fully threaded bolts shall not be used. The length of bolts shall be such that the threaded portion will not extend into the place of contact of the members.				
5.02.07	All bolts shall be threaded to take the full depth of the nuts and threaded enough to permit firm gripping of the members, but not further. It shall be ensured that the threaded portion of each bolt protrudes not less than 3 mm and not more than 8mm when fully tightened. All nuts shall fit and tight to the point where the shank of the bolt connects to the head.				
5.02.08	Flat and tapered washers shall be provided wherever necessary. Spring washers shall be provided for insertion under all nuts. These washers shall be of steel electro-galvanised, positive lock type and 3.5mm in thickness for 16mm dia.				
5.02.09	The Bidder shall furnish bolt schedules giving thickness of members connected, the nut and the washer and the length of shank and the threaded portion bolts and sizes of holes and any other special details of this nature.				
5.02.10	To obviate bending stress in bolts or to reduce to minimum, no bolt shall connect aggregate thickness of more than three (3) times its diameter.				
5.02.11	The bolt positions in assembled towers shall be as per IS:5613 (Part-II/Section-2)-1976.				
5.02.12	Bolts at the joints shall be so staggered that nuts may be tightened with spanners without fouling.				
5.03.00	<b>Tower Accessories</b>				
5.03.01	<b>Step Bolts &amp; ladders</b>  Each tower shall be provided with step bolts of not less than 16mm diameter and 175 mm long, spaced not more than 450mm apart and extending from about 3.5 meters above the ground level to the top of the tower. Step bolt shall be provided with two nuts on one end to fasten the bolt securely to the tower and button head at the other end to prevent the feet from slipping away. The step bolts shall be capable of withstanding a vertical load not less than 1.5 KN. For special structures, where the height of the super structure exceeds 50 meters, ladders along with protection rings as per the Owner approved design shall be provided in continuation of the step bolts on one face of the tower from 30 meters above ground level to the top of the special structure. From 3.5 m to 30 m height of super structure step bolts shall be provided. Suitable railing for access from step bolts to the ladder and from				
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Clause No.	TECHNICAL REQUIREMENTS			
	the ladder to each crossarm tip and the groundwire support shall be fixed on tower by using countersunk bolts.			
5.03.02	<b>Insulator Strings and Earthwire Clamps Attachments</b>  a) For the attachment of suspension insulator string a suitable dimensioned swinging hanger on the tower shall be provided so as to obtain requisite clearance under extreme swinging conditionings and free from swinging of the string. The hanger shall be designed to withstand an UTS equivalent to that of insulators. The supply of design & supply of hanger is in the scope of the Contractor.  b) At tension towers strain plates of suitable dimensions on the underside of each cross-arm tip and at the top of earthwire peak, suitable plate should be provided for taking the hooks or D-Shackle of the tension insulator strings or earthwire tension clamps, as the case may be. Full details of the attachments shall be submitted by the bidder for Owner's approval before starting the mass fabrication.			
5.03.03	Earthwire peaks/crossarms are to be suitably designed to accommodate the shackle of the suspension clamp/tension clamps.			
5.03.04	<b>Anti-climbing Device</b>  Barbed wire type anti-climbing device, as per enclosed drawing shall be provided and installed by the Contractor for all towers. The height of the anti-climbing device should be provided approximately 3m above ground level. The barbed wire shall conform to IS-278-1978. The barbed wires shall be given chromating dip as per procedure laid down in IS:1340-1959.			
5.03.05	Danger plate, Number plates, Circuit Plate, Phase plate & Bird Guards.  Danger, Number Plates, Phase Plates & Bird Guards shall be provided and installed by the Contractor:  a) Each tower shall be fitted with a number plate, and danger plate. Each tension tower shall be provided with a set of phase plates also. The arrangement for fixing these accessories shall not be more than 4.5m above the ground level. b) The letters, figures and the conventional skull and bones of data plates shall conform to IS:2551-1963 and shall be in a single red on the front of the plate. c) The corners of the number and danger plate shall be rounded off to remove sharp edges. d) To prevent birds from perching immediately above the suspension insulator strings and thus fouling it with droppings suitable birdguards shall be provided at cross arm tips of all suspension towers. The arrangement shall conform to IS:5613 part-2/Sec.I.			
6.00.00	<b>TOWER FABRICATION</b>			
6.01.00	Except where hereinafter modified, details of fabrication shall conform to IS:802 (Part-II) 1993 or the relevant international standards.			
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6.02.00	Butt splices shall be used and the inside Angle and outside plate shall be designed to transmit the load and inside cleat angle, shall not be less than half the thickness of the heavier member connected plus 2mm. Lap splice may be used for connecting members of unequal size and the inside angle of lap splice shall be rounded at the heel to fit the fillet of the outside angle. All splices shall develop full stress in the member connected through bolts. Butt as well as lap splice shall be made as above and as close to the main panel point as possible.	
6.03.00	Joints shall be so designed as to avoid eccentricity as far as possible. The use of gusset plates for joining tower members shall be avoided as far as possible. However, where the connections are such that the elimination of the gusset plates would result in eccentric joints, gussets plates and spacer plates may be used in conformity with modern practices. The thickness of the gusset plates required to transmit stress shall not be less than that of members connected.	
6.04.00	The use of filler in connection shall be avoided as far as possible. The diagonal web members in tension may be connected entirely to the gusset plate wherever necessary to avoid the use of filler and it shall be connected at the point of intersection by one or more bolts.	
6.05.00	The tower structures shall be accurately fabricated to connect together easily at site without any undue strain on the bolts.	
6.06.00	No angle member shall have the two leg flanges brought together by closing angle.	
6.07.00	The diameter of the hole shall be equal to the diameter of bolt plus 1.5mm.	
6.08.00	The structure shall be designed so that all parts shall be accessible for inspection and cleaning. Drain holes shall be provided at all points where pockets depression are likely to hold water.	
6.09.00	All similar parts shall be made strictly inter-changeable. All steel sections before any work is done on them, shall be carefully leveled, straightened and made true to detailed drawings by methods which will not injure the materials so that when assembled, the adjacent matching surfaces are in close contact through out. No rough edges shall be permitted in the entire structure.	
6.10.00	<b>Drilling and Punching</b>	
6.10.01	Before any cutting work is started all steel sections shall be carefully straightened and trued by pressure and not by hammering. They shall again be trued after being punched and drilled.	
6.10.02	Holes for bolts shall be drilled on punched with a jig but drilled holes shall be preferred. The following maximum tolerance of accuracy of punched holes is permissible.  a) Holes must be perfectly circular and no tolerance in this respect permissible. b) The max. allowable difference in diameter of the holes on the two sides of plates or angle is 0.8mm. i.e. the allowable taper in a punched holes should not exceed 0.8mm on diameter. c) Holes must be square with the plates or angles and have their walls parallel.	
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6.10.03	All burrs left by drills or punch shall be removed completely. When the tower members are in position the holes shall be truly opposite to each other. Drilling or reaming to enlarge holes shall not be permitted.
6.11.00	<b>Erection mark</b>
6.11.01	Each individual member shall have erection mark conforming to the component number given to it in the fabrication drawings. This mark shall be marked with marking dies of 16mm size before galvanising and shall be legible after galvanising.
6.11.02	Erection Mark shall be "A - BB- CC – DDD", where  A = Owner's code assigned to the Contractor Alphabet. BB = Contractor's Mark-Numerical CC = Tower Type-Alphabet DDD = Number mark to be assigned by Contractor.
6.12.00	<b>Quantities and Weights</b>
6.12.01	The estimated unit weight of each type of tower, stubs and extensions shall be furnished by the bidder. The final quantity of all the items associated with these lines shall be determined by the contractor after completion of the detailed route survey for which the rate quoted by the bidder shall be valid. The weight of tower shall mean the weight of tower calculated by using the black sectional (i.e. un-galvanised) weight of steel members of the size indicated in the approved fabrication drawings and bills of materials, without taking into consideration the reduction in weights, holes, notches and bevel cuts etc, but taking into consideration the weight of the fasteners, anti-climbing devices etc.
6.13.00	<b>Galvanising</b>  Fully galvanised towers and stub shall be used for the line. Galvanising of the member of the towers shall conform to IS:2629-1985 and IS:4759-1968. All galvanised shall conform to IS:5358-1969. The galvanising shall be done after all fabrication work is completed, except that the nuts may be tapped or re-run after galvanising. Threads of bolts and nuts shall have a neat fit and shall be such that they can be turned with finger throughout the length of the threads of bolts and they shall be capable of developing full strength of the bolts. Spring washers shall be electro-galvanised as per Grade 4 of IS:1573-1970.
7.00.00	<b>TOWER EARTHING</b>  The footing resistance of all towers shall be measured by the Contractor in dry weather after tower erection but before the stringing of earthwire. All the tower are to be earthed. In no case tower footing resistance shall exceed 10 ohms. Pipe type earthing and counterpoise type earthing wherever required shall be provided in accordance with the stipulations made in IS:3043-1987 and IS:5613 (part-II/Section-2) 1985. The details for pipe and counterpoise type earthing are given in drawing enclosed with the specification.
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Clause No.	TECHNICAL REQUIREMENTS						
8.00.00	<b>INSPECTION AND TESTS</b>						
8.01.00	All standard tests, including quality control tests, in accordance with appropriate Indian/International standard, shall be carried out unless otherwise specified herein.						
8.02.00	<b>Inspection</b>						
	In addition to the provisions contained in Vol. I of tenders documents, the following shall also apply:						
8.02.01	The Contractor shall keep the Owner informed in advance about the time of starting and the progress of manufacture and fabrication of various tower parts at various stages, so that arrangements could be made for inspection.						
8.02.02	The acceptance of any part of items shall in no way relieve the Contractor of any part of his responsibility for meeting all the requirements of the Specification.						
8.02.03	The Owner or his representative shall have free access at all reasonable times to those parts of the Contractor's works which are concerned with the fabrication of the Owner's material for satisfying himself that the fabrication is being done in accordance with the provisions of the specifications.						
8.02.04	Unless specified otherwise inspection shall be made at the place of manufacture prior to dispatch and shall be conducted so as not to interfere unnecessarily with the operation of the work.						
8.02.05	Should any member of the structure be found not to comply with the approved design, it shall be liable to rejection. No member once rejected shall be resubmitted for inspection, except in cases where the Owner or his authorised representative considers that the defects can be rectified.						
8.02.06	Defect which may appear during fabrication shall be made good with the consent of, and according to the procedure proposed by the Contractor and approved by the Owner.						
8.02.07	All gauges and templates necessary to satisfy the Owner shall be supplied by the manufacturer.						
8.02.08	The correct grade and quality of steel shall be used by the Contractor. To ascertain the quality of steel used the inspector may at his discretion get the material tested at an approved laboratory.						
8.03.00	<b>Tower Load Tests</b>						
8.03.01	The Contractor shall submit one set of shop drawings alongwith the bill of materials after award of Contract. Further, Contractor shall submit one copy of test reports and final tracings of shop drawings and Bill of materials for Owner's reference and record.						
8.03.02	The Contractor shall ensure that the specification of materials and workmanship of all towers actually supplied conform strictly to the towers which have successfully under gone the tests. In case any deviation is detected, the Contractor shall replace such defective towers free of cost to the Owner. All expenditure incurred in erection, to and fro transportation and any other expenditure or losses incurred						
<table><tr><td>NABINAGAR STPP (3X660MW) 400/132kV SWITCHYARD PACKAGE</td><td>Bid Doc. No.: CS-0370-572-2</td><td>TECHNICAL SPECIFICATIONS</td><td>PART-III SECTION-VI</td><td>Page T1-13/17</td></tr></table>			NABINAGAR STPP (3X660MW) 400/132kV SWITCHYARD PACKAGE	Bid Doc. No.: CS-0370-572-2	TECHNICAL SPECIFICATIONS	PART-III SECTION-VI	Page T1-13/17
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Clause No.	TECHNICAL REQUIREMENTS	
	by the Owner on this account shall be fully borne by the Contractor. No extension in delivery time shall be allowed on this account.	
8.04.00	<b>Tower Testing Procedure</b>	
	All type of tower offered should be tested type as per the procedure described below:	
8.04.01	<b>Bolt Slip Test</b>	
8.04.02	In the bolt slip test, the test loads shall be gradually applied up to the 50% of design loads under normal condition and held for two (2) minutes at that loads and then released gradually.	
	The initial and final readings on the scales (for measurement of deflection) before application and after the release of Loads respectively shall be taken with the help of theodolite. The difference between these readings gives the values of the bolt slip.	
8.04.03	<b>Normal/Broken Wire Load Tests</b>	
	All the loads, for a particular load-combination test shall be applied gradually upto the full design loads in the following steps and shall also be released in the similar manner:	
	25 percent 50 percent 75 percent 90 percent 95 percent 100 percent	
8.04.04	<b>Observation Periods</b>	
	a) Under normal and broken wire load tests, the tower shall be kept under observation for sign of any failure for two minutes (excluding the time for adjustment of loads) for all intermediate steps of loading upto and including 95 per cent of full design loads.	
	b) For normal, as well as broken wire tests, the tower shall be kept under observation for five (5) minutes (excluding the time for adjustment of loads) after it is loaded upto 100 percent of full design loads.	
	c) While the loading operation are in progress, the tower shall be constantly watched, and if it shows any tendency of failure anywhere, the loading shall be immediately stopped, released and then entire tower shall be inspected. The reloading shall be started only after the corrective measures are taken.	
	d) The structure shall be considered to be satisfactory, if it is able to support the specified full design loads for five (5) minutes, with no visible local deformation after unloading (such as bowing, buckling etc.) and no breakage of elements or constituent parts.	
	e) Ovalization of holes and permanent deformation of bolts shall not be considered as failure.	
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Clause No.	TECHNICAL REQUIREMENTS			
8.04.05	<b>Recording</b>  The deflection of the tower shall be recorded at each intermediate and final stage of normal load and broken wire load tests by means of a theodolite and graduated scale. The scale shall be of about one meter long with marking upto 5 mm accuracy.			
8.04.06	<b>Destruction Test</b>  a) The destruction test shall be carried out under normal condition or broken wire condition. The Owner at the time of approval of rigging chart/test data sheet shall intimate the contractor. Under which load condition the destruction test is to be carried out. b) The procedure for application of load for normal/broken wire test shall also be applicable for destruction test. However, the load shall be increased in steps of five (5) percent after the full design loads have been reached.			
9.00.00	<b>PACKING</b>			
9.01.00	Angle section shall be wire bundled.			
9.02.00	Cleat angles, gusset plates, brackets, fillet plate, hanger and similar loose pieces shall be tested and bolted together in multiples or securely wired through holes.			
9.03.00	Bolts, nuts, washers and other attachments shall be packed in double gunny bags accurately tagged in accordance with the contents.			
9.04.00	The packings shall be properly done to avoid losses/damages during transit. Each bundle or package shall be appropriately marked.			
10.00.00	<b>DESIGN CALCULATION AND DRAWINGS</b>			
10.01.00	The following design calculation and drawings are required to be furnished during detailed engineering.  a) Computation of wind load b) Sag-tension calculation c) Tower loading d) Single line diagram of towers showing electrical clearances and steel sections. e) Sketches of foundation showing dimensions.			
10.02.00	The Contractor shall furnish following to the owner:  a) Detailed design calculation and drawing for towers and foundations. b) Detailed structural drawings indicating section size, length of members sizes of plate along with hole to hole distance, joint details etc. c) Bill of materials, indicating cutting and bending details against each member. d) Shop drawings showing all details relevant to fabrication.			
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Clause No.	TECHNICAL REQUIREMENTS					
e)	All the drawings for the tower accessories.					
	TABLE-T1-2 DESIGN LOADS					
	S.No	Tower Type	Longitudinal Loads		Transverse Loads	
			Reliability Condition	Security Condition	Reliability Condition	Security Condition
	1	2	3	4	5	6
	a.	DA	0.0	0.5 x MT For Conductor). 1.0 x MT (For Earth Wire)	WC + WI + DY	0.6 WC + WI +0.25 DY (For Conductor) 0.6 WC + 0.5 DY (For Earth Wire)
	b.	DB (Section Tower- 0° Deviation)	MT1	1.0 x MT	WC + WI + DY	0.6 WC + WI +0.5 DY
	c.	D B ( 15° Deviation)	MT1	1.0 x MT x Cos Φ/2	WC + WI + DY	0.6 WC + WI +0.5 DY
	d.	DC (Section Tower- 0° Deviation)	MT1	1.0 x MT	WC + WI + DY	0.6 WC + WI +0.5 DY
	e.	DC (30° Deviation)	MT1	1.0 x MT x Cos Φ/2	WC + WI + DY	0.6 WC + WI +0.5 DY
f.	D/DD (60° Deviation)	MT1	1.0 x MT x Cos Φ/2	WC + WI + DY	0.6 WC + WI +0.5 DY	
g.	D/ DD (Dead End with slack span of 100 Mtrs. Max.)	0.7 MT	1.0 x MT	WC + WI + ( 0.3 MT x Sin 15°)	0.6 WC + WI	
h.	D/ DD Complete Dead End	MT	1.0 x MT	WC + WI	0.1 WC + WI	
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Clause No.	TECHNICAL REQUIREMENTS																						
	<table border="1"> <thead> <tr> <th data-bbox="418 443 711 468">DESCRIPTION</th> <th data-bbox="711 443 906 468">SYMBOL</th> <th data-bbox="906 443 1333 468">REMARKS</th> </tr> </thead> <tbody> <tr> <td data-bbox="418 468 711 625">Maximum Tension Of Conductor/ Earth Wire under everyday temperature &amp; full wind condition or minimum temperature &amp; 36% Of max. wind which ever is more stringent</td> <td data-bbox="711 468 906 625">MT</td> <td data-bbox="906 468 1333 625" rowspan="2">For 400 KV Towers, twin bundle conductors shall be considered. Wind Span shall be the normal ruling span.</td> </tr> <tr> <td data-bbox="418 625 711 651">Wind On Conductor</td> <td data-bbox="711 625 906 651">WC</td> </tr> <tr> <td data-bbox="418 651 711 701">Wind On Insulator</td> <td data-bbox="711 651 906 701">WI</td> <td data-bbox="906 651 1333 701">In case of Double String Insulators, both their strings shall be considered</td> </tr> <tr> <td data-bbox="418 701 711 726">Angle Of Deviation (Degrees)</td> <td data-bbox="711 701 906 726"><math>\Phi</math></td> <td data-bbox="906 701 1333 726"></td> </tr> <tr> <td data-bbox="418 726 711 777">Load Due To Deviation Of Tower</td> <td data-bbox="711 726 906 777"><math>DY = 2 \times MT \times \sin \Phi/2</math></td> <td data-bbox="906 726 1333 777"></td> </tr> <tr> <td data-bbox="418 777 711 858">Difference In Tension For Equivalent Spans Of 400 M &amp; 200 M (For 400 KV Towers)</td> <td data-bbox="711 777 906 858">MT1</td> <td data-bbox="906 777 1333 858"></td> </tr> </tbody> </table> <p data-bbox="418 888 467 909"><b>Note:</b></p> <ol data-bbox="418 913 1299 1192" style="list-style-type: none"> <li>Vertical loads shall conform to IS 802 – Part I, 1995. Weight spans as furnished under Clause 2.03.00 shall be considered for computation of vertical loads.</li> <li>Safety loads and Anti-cascade loads as specified in IS 802- Part I, 1995 shall also be considered for design of Towers.</li> <li>Wind loads on the towers shall be considered in transverse loads as per clause 11, 12 and 13 of IS: 802 (Part-I/ Sec. I)- 1995.</li> <li>Any additional loads apart from the loads mentioned above, as required as per IS: 802- 1995 shall be considered for design purpose.</li> </ol>			DESCRIPTION	SYMBOL	REMARKS	Maximum Tension Of Conductor/ Earth Wire under everyday temperature & full wind condition or minimum temperature & 36% Of max. wind which ever is more stringent	MT	For 400 KV Towers, twin bundle conductors shall be considered. Wind Span shall be the normal ruling span.	Wind On Conductor	WC	Wind On Insulator	WI	In case of Double String Insulators, both their strings shall be considered	Angle Of Deviation (Degrees)	$\Phi$		Load Due To Deviation Of Tower	$DY = 2 \times MT \times \sin \Phi/2$		Difference In Tension For Equivalent Spans Of 400 M & 200 M (For 400 KV Towers)	MT1	
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**PART- III**

**TECHNICAL SPECIFICATION**

**CHAPTER – T2**

**TOWER FOUNDATIONS**


(400 kV)


# **PART- III**


## **TECHNICAL SPECIFICATION CHAPTER – T2**


### **TOWER FOUNDATIONS**


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Clause No.	TECHNICAL REQUIREMENTS			
	<b>SECTION – T2: TOWER FOUNDATIONS</b>			
1.00.00	<b>TYPES OF FOUNDATION</b>			
1.01.00	General			
1.01.01	Cement concrete/Reinforced concrete footing shall be used for all type of normal tower in conformity with the present day practice followed in the country and the specifications laid herein. All the four footings of the tower and their extension shall be similar, irrespective of down thrust and uplift.			
1.01.02	Foundation includes supply of materials such as cement, sand, coarse aggregates etc. and also reinforcement steel, if required. Rates quoted for foundations in appropriate schedules shall include all items of work related to supply and installation of foundations such as form work, excavation and backfilling, stub setting, providing reinforcement (if required) etc.			
1.02.00	Classifications of Foundations			
	The foundation designs shall depend upon the type of soil, sub-soil water level and the presence of surface water which have been classified as follows:			
1.02.01	Normal Dry			
	To be used for locations where normal dry cohesive or non-cohesive soils are met.			
1.02.02	Wet			
	To be used for locations:			
	a) Where sub-soil water is met at 1.5 meters or more below the ground level.			
	b) Which are in surface water for long periods with water penetration not exceeding one meter below the ground level e.g. the paddy fields.			
1.02.03	Partially submerged			
	To be used at locations where sub-soil water table is met between 0.75 meter below the ground level.			
1.02.04	Fully submerged			
	To be used at locations where sub-soil water table is met at less than 0.75 meter below the ground level.			
1.02.05	Black Cotton Soil (Wet)			
	To be used at locations where soil is clayey type, not necessarily black in colour which shrinks when dry and swells when wet, resulting in differential movement extending to a maximum depth of about 3.5 meters below ground level. For designing foundations, for such locations, the soil is to be considered sub-merged in nature.			
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Clause No.	TECHNICAL REQUIREMENTS				
1.02.06	Fissured Rock				
a)	To be used at locations where decomposed or fissured rock, hard gravel kankar, limestone, laterite or any other soil of similar nature is met. Under cut type foundation is to be used for fissured rock locations.				
b)	To be used at fissured rock locations, where water table is met below ground level.				
1.02.07	Hard Rock				
	The locations where chiseling, drilling and blasting is required for excavation hard rock type foundations are to be used. For these locations rock anchoring is to be provided to resist uplift forces.				
1.02.08	In addition to the above, depending on the site conditions other types of foundations shall also be provided by the Contractor suitable for :				
a)	Intermediate conditions under the above classifications to effect more economy, or				
b)	For locations where special foundations (well type or piles)are necessitated.				
1.03.00	The proposal for these types of foundations shall be submitted by the Contractor based on the detailed soil investigation and approval for the same shall be obtained from the Owner.				
2.00.00	<b>SOIL INVESTIGATION</b>				
2.01.00	The transmission tower foundations shall be classified based on the soil conditions. Optimisation of foundation design and their safety mainly depends on correctness of soil data and their analysis.				
2.02.00	The Contractor shall be required to carry out detailed soil investigation at various tower locations such as angle points, crossings, etc. where soil strata is different from the other locations investigated. In addition the soil investigation may be required to be carried at other locations at the discretion of the Engineer.				
2.03.00	This specification covers all the work required for detailed soil investigation and preparation of a detailed report. It shall include mobilization of necessary equipment, providing necessary engineering supervision and technical personnel, carrying out field investigation and tests, laboratory tests, analysis and interpretation of data and results, collecting data regarding change of course of rivers from local sources, velocity, scour, etc., giving flood details of the area (past history), preparations for the type of foundations and the safe bearing capacity for different sizes of foundations, different founding strata for the various locations along the transmission lines.				
2.04.00	Soil Classification				
2.04.01	The type of soils normally encountered in construction of transmission lines can be broadly classified into the following four types of soils.				
a)	Sand				
b)	Mixed Soils				
c)	Clay soils				
d)	Rocky Soils				
2.04.02	The soil at any location shall be classified only after completion of the following field work and tests:				
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Clause No.	TECHNICAL REQUIREMENTS						
	<p>a) One bore hole of 150 mm id shall be drilled at the center point of tower.</p> <p>b) Standard penetration test (S.P.T) shall be carried out at 1.5 m interval or change of strata upto a depth of 7.0 meters below ground level or to refusal whichever occurs earlier. (By refusal it shall mean that a standard penetration below count (N) of 100 is a recorded for 30 cm penetration.</p> <p>c) Bore details shall be furnished upto 7.0 meters below ground level or refusal whichever occurs earlier.</p> <p>d) Details of water table upto 7.0 meters below ground level shall be furnished.</p>						
2.04.03	Based on the above SPT and other details collected the type of soil shall be classified as per clause 2.04.01 and the same shall be got approved by Engineer-in-Charge.						
2.04.04	If the soil is classified as 'same' the bearing capacity and angle of repose shall be furnished alongwith calculations and justification.						
2.04.05	<p>If the soils is classified as 'mixed soil' or 'clay soil' the following tests shall be carried out. The samples required for the following tests shall be collected at the time of preliminary investigation carried:</p> <p>a) Detailed bore log with the IS classification of soil and its properties such as specific gravity, bulk unit weight, moisture content etc.</p> <p>b) Collecting undisturbed samples of 100/75mm diameter, 450 mm long from the bore holes at 1.5 m intervals of change of strata, starting from 3 meter and upto 7 meter below ground level.</p> <p>c) To find out the following soil properties laboratory tests shall be carried out on the above undisturbed samples:</p> <ol style="list-style-type: none"><li>1) Type of soil and gradation (As per IS classification)</li><li>2) Atterberg limit (Liquid and plastic limit only)</li><li>3) Triaxial tests to determine shear parameters such as cohesion (c) and angle of internal friction.</li><li>4) Natural moisture content, specific gravity and bulk unit weight.</li><li>5) Consolidation test.</li><li>6) Unconfined compression test.</li><li>7) Unconsolidated undrained test.</li><li>8) Chemical tests on soil and water to determine the carbonates, sulphates, nitrates and organic matter and any other chemical harmful to the concrete foundations.</li><li>9) The bearing capacity of soil at different levels starting from 3.0 meter and upto 7.0 meter below ground levels. The above shall be calculated based on above determined soil data and considering a base width of foundation as 2.0 meters.</li></ol>						
2.04.06	While carrying out the SPT test if the blow count of 100 is recorded for 30 cm of penetration, the soil shall be classified as rocky soil. In case of rock the bore drilling shall be continued 3.0 meters further to ascertain its sufficient thickness. Core recovery and crushing strength of the rock shall also be reported.						
2.05.00	The laboratory tests shall be carried out progressively during the field work after sufficient number of samples have reached the laboratory in order that the test results of the initial boreholes can be made use of in planning the later stages of the field investigation and quantum of laboratory tests. All						
<table><tr><td>NABINAGAR STPP (3X660MW) 400/132KV SWITCHYARD PACKAGE</td><td>Bid Doc. No.: CS-0370-572-2</td><td>TECHNICAL SPECIFICATIONS</td><td>PART-II SECTION-VI</td><td>Page T2-3/11</td></tr></table>			NABINAGAR STPP (3X660MW) 400/132KV SWITCHYARD PACKAGE	Bid Doc. No.: CS-0370-572-2	TECHNICAL SPECIFICATIONS	PART-II SECTION-VI	Page T2-3/11
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Clause No.	TECHNICAL REQUIREMENTS								
	samples brought from field, whether disturbed or undisturbed shall be extracted/prepared and examined by competent technical personnel and the tests shall be carried out as per the procedures laid out in the latest editions of the relevant IS codes.								
2.06.00	Test Results and Report								
2.06.01	The Character shall submit the detailed report in ten (10) copies containing information, regarding the geological details of the site, summarised observations and test data.								
2.06.02	The report shall include, but not limited to the following:								
a)	Borelogs : Bore logs of each bore hole clearly identifying the satisfaction and the type of soil stratum with depth upto the refusal. The location of water table shall be identified in the borelog. The value of SPT at the depths where the tests were conducted from samples collected at various depths shall be clearly shown against the particular stratum.								
b)	Test results of field and laboratory tests shall be summarised stratawise as well in combined tabular form with all relevant graphs, charts, tables, diagrams and photographs, if any, shall be submitted alongwith the report.								
c)	Recommendations : The report should contain specific recommendations for the type of foundation. The Contractor shall acquaint himself about the type of structures and their functions from the Engineer-in-charge. The observation/recommendations, shall include but not limited to the following :								
i)	Geological information of the area, past observations or historical data, if available, for the area and for the structures in the nearby area, fluctuations of water table etc.								
ii)	Limit bearing pressure on the soil at various depths for different sizes of the foundations based on shear strength and settlements characteristics of soil with supporting calculations for the recommendations.								
iii)	Comments on the chemical nature of soil and ground water with due regard to deleterious effects of the same on concrete and steel and recommendations for protective measures.								
iv)	Recommendations for additional investigation, beyond the scope of the present work, if contractor feels that such investigation is necessary.								
2.07.00	Indian Standard References								
	<u>S.No.</u>	<u>Description</u>	<u>IS No.</u>						
	1.	Standard Penetration Test	IS:2131-1983						
	2.	Grain Size Analysis	IS:2720 (part - IV)-1975						
	3.	Moisture Content	IS:2720 (Part-II)1973						
	4.	Specific Gravity	IS:2720 (Part-III)-1980						
	5.	Liquid Limit, Plastic Limit	IS:2720 (Part-V)1970						
	6.	Triaxial Compression Test.	IS:2720 (Part-XI) - 1971						
	7.	Consolidation Test	IS:2720 (Part-XV)-1965.						
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Clause No.	TECHNICAL REQUIREMENTS			
3.00.00	<b>SOIL PROPERTIES</b>			
3.01.00	For design of foundations, the following properties of soil shall be considered:			
3.01.01	Weight of soil			
	a) Dry	1440 Kg/m <sup>3</sup>		
	b) In presence of surface water	940 Kg/m <sup>3</sup>		
	c) In presence of soil water	10 Kg/m <sup>3</sup>		
3.01.02	Submerged Fissured Rock			
	a) Ultimate Bearing Capacity	62,500 Kg/M <sup>2</sup>		
	b) Weight of Earth	1440 Kg/M <sup>3</sup>		
	c) Angle of Repose Degrees	20 degrees		
3.01.03	Hard Rock			
	a) Limit Bearing Capacity	12,50,00 Kg/M <sup>2</sup>		
	b) Ultimate Bond Between Steel and Concrete (M15)	10 Kg/M <sup>2</sup>		
3.01.04	Properties of Soil			
	Type of soil	Limit Bearing Capacity	Angle of Repose (Degrees)	
	a) Normal Dry Soil	24,000	20°	
	b) Wet earth in the presence of sub soil water	12,000	10°	
	c) Wet earth due to presence of sub surface water	12,000	10°	
	d) Wet Black Cotton Soil	12,000	0°	
4.00.00	<b>LOADS ON FOUNDATIONS</b>			
4.01.00	The foundations shall be designed to withstand the specific loads of the superstructure and for the full footings reactions obtained from the structural stress analysis in conformity with the relevant over load factors. The over load factor for foundation design shall be 1.10 for all loads except dead loads.			
4.02.00	The reactions on the footings shall be composed of the following type of loads for which these shall be required to be checked:			
	a) Max. tension or uplift along the leg slope.			
	b) Max. compression or down-thrust along the leg slope.			
	c) Max. horizontal shear or side thrust.			
4.03.00	The base slab of the foundation shall be designed for additional moments developing due to eccentricity of the loads.			
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Clause No.	TECHNICAL REQUIREMENTS			
4.04.00	The additional weight of concrete in the footing below ground level over the earth weight and the full weight of concrete above the ground level in the footing and embedded steel parts will also be taken into account adding to the down thrust.			
5.00.00	STABILITY ANALYSIS			
5.01.00	In addition to the strength design, stability analysis of the foundation shall be done to check the possibility of failure by over-turning, uprooting, sliding and tilting of the foundation.			
5.02.00	The following primary type of soil resistance shall be assumed to act in resisting the loads imposed on the footing in earth:			
5.02.01	Resistance against uplift  The uplift loads will be assumed to be resisted by the weight of earth in an inverted frustum of a conical pyramid of earth as per formula detailed in Annexure-A of this Section on the footing pad whose sides make an angle equal to the angle of repose of the earth with the vertical, in average soil. The weight of concrete embedded in earth and that above the ground will also be considered for resisting the uplift. In case where the frustum of earth pyramids of two adjoining legs super-impose each other, the earth frustum will be assumed truncated by a vertical plane passing through the center line of the tower base.			
5.02.02	Resistance against down thrust  The down-thrust load combined with the additional weight of concrete above earth will be resisted by bearing strength of the soil assumed to be acting on the total area of the bottom of the footings.			
5.02.03	Resistance against side-thrust  The chimney portion of the foundation shall be designed as per limit load method described at clause 38.6 of IS-456-1978, or as per any other international standard, considering the chimney as a column subjected to axial loads (down thrust loads) and biaxial bending moments resulting from side thrust forces. The passive earth pressure (as per Rankine's formula) shall be considered for the design of chimney against side thrust. If uplift and down thrust are computed in vertical direction for the foundation design, full resultant horizontal shear shall be taken at footing tip for design of the footing to resist side thrust.			
6.00.00	PROPERTIES OF CONCRETE			
6.01.00	The cement concrete used for the foundations shall be of grade M 25 with 20mm coarse aggregate.			
6.02.00	All the properties of concrete regarding its strength under compression tension, shear, punching and bend etc. as well as workmanship will conform to IS:456-1978.			
6.03.00	The weight of concrete to be considered for design of foundations below:			
	Type of concrete	Weight of dry region KN/m <sup>3</sup> (Kg/m <sup>3</sup> )	Weight in presence of sub-soil water KN/M <sup>3</sup> (KG/m <sup>3</sup> )	
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Clause No.	TECHNICAL REQUIREMENTS			
	Concrete	21.96 (2240)	12.16 (1240)	
	Reinforced	23.54 (2400)	13.73 (1400)	
6.04.00	The Portland Cement used in concrete shall conform to IS: 269-1967.			
6.05.00	The Pozzolana cement used in concrete shall conform to IS: 1489-1976. The curing time of Pozzolana cement will be decided at the time of execution of the contract.			
6.06.00	Concrete aggregates shall conform to IS:383-1970.			
6.07.00	The water used for mixing concrete shall be fresh, clean and free from oil, acids and alkalies, organic materials or other deleterious substances. Portable water is generally preferred.			
6.08.00	Reinforcement shall conform to IS:432-1966 for MS bars and hard drawn steel wires and to IS:1139-1966 and IS:1786-1966 for deformed and cold twisted bars respectively. All reinforcement shall be clean and free from loose mill scales, dust, loose rust, and coats of paint, oil or other coating, which may destroy or reduce bond. Contractor shall supply, fabricate and place reinforcement to shapes and dimensions as indicated or as required to carry out the intent of drawings and specifications.			
7.00.00	DESIGN OF FOUNDATIONS			
7.01.00	Structural design of the foundations shall be done by limit State method.			
7.02.00	Partial safety factor shall be considered 1.5 for concrete and 1.15 for steel.			
7.03.00	The physical properties of soil under various conditions as furnished in clause 3.00.00 are to be considered for the design of various types foundations.			
7.04.00	No extra payment for these foundations shall be made beyond the lumpsum rate quoted by the bidder. However, it may be noted that the soil properties furnished above are tentative in nature. After soil investigations, if it is found that the foundations listed above cannot be used at that location, new foundation design shall be developed based on properties furnished in soil report. No extra payment for these foundations shall be made beyond the rates quoted,			
7.05.00	The thickness of concrete in the chimney portion of the tower footing would be such that it provides minimum cover of not less than 100mm from any part of the stub angle to the nearest outer surface of the concrete in respect of all dry locations limiting the minimum section of chimney to 300mm square. In respect of all wet location, the chimney should have all around clearance of 150mm from any part of stub angle limiting to 450mm sq. minimum.			
7.06.00	The chimney top or muffing must be at least 225 mm above ground level and also the coping shall be extended upto lower most joint level between the bottom lattices and the main corner legs of the tower.			
7.07.00	The spread of concrete pyramid or slabs for both P.C.C. type foundations shall be limited to 45 degree with respect to the vertical. The centroidal axis of the slab shall coincide with the axis of the chimney and pass through the center of foundation base. The design of the foundations (base slab and its reinforcement) shall take into account the additional stresses in the foundation resulting from the eccentricity introduced due to non-compliance of this requirement.			
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Clause No.	TECHNICAL REQUIREMENTS	
7.08.00	At least 50mm thick pad of size equal to the base of pyramid with its sides vertical will be provided below the pyramid to account for the unevenness of soils and impurities likely to be mixed in concrete due to direct contact of wet concrete with earth and also for allowing stone aggregate reaching upto corner edges. This pad will also be provided in cases where pyramids are provided over concrete slabs.	
7.09.00	In case of fully submerged type foundation, at least one base slab of not less than 200 mm thick shall be provided. In case of reinforced concrete slab, the slab thickness should not be less than 300 mm.	
7.10.00	The minimum distance between the lowest edge of the stub angle and the bottom surface of concrete footing shall not be less than 100mm or more than 150 mm in case of dry locations and not less than 150 mm or more than 200mm in case of wet locations.	
7.11.00	The total depth of foundations below the ground level shall not be less than 1.5 meters and more than 3.0 meters. To maintain the interchangeability of stubs for all types of foundations, for each type of tower, the same depths of foundations shall be used for different types of foundations.	
7.12.00	The portion of the stub in the pyramid (or slab) shall be designed to take full down-thrust or uplift loads by the cleats combined with the bond between stub angles and pyramid concrete. The Contractor shall furnish the calculation for uprooting of stub along with the foundation design.	
7.13.00	In case of foundation having steel reinforcement in pyramid or base slab, at least 50mm thick pad of lean concrete corresponding to 1:3:6 nominal mix shall be provided to avoid the possibility of reinforcement rod being exposed due to unevenness of the bottom of the excavated pit.	
7.14.00	Over Load Factor  The overload factor for foundations shall be considered as 1.1 i.e. the reaction except due to dead loads on foundations shall be increased by 10 per cent.	
8.00.00	<b>CONSTRUCTION OF TOWER FOUNDATION</b>	
8.01.00	Excavation	
8.01.01	Excavation work must not be started until the tower schedule and profile has been approved by the Owner.	
8.01.02	Except as specifically otherwise provided, all excavation for footing shall be made to the lines and grades of the foundation. The excavation wall shall be vertical and the pit dimensions shall be such as to allow a clearance of 150mm on all sides from the foundation pad. The Contractor should ensure clearance of 150 mm from the foundation pad for quality work. All excavation shall be protected so as to maintain a clean subgrade, until the footing is placed, using timbering/shuttering, shoring etc., if necessary. Any sand, mud, silt or other undesirable materials which may accumulate in the excavated pit shall be removed by the Contractor before placing concrete.	
8.01.03	The soil to be excavated for tower foundations shall be classified as under:  a) Normal Soil : Soil removable by means of an ordinary pick axe, spade and shovel.	
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Clause No.	TECHNICAL REQUIREMENTS	
b)	Wet Soil : Where the subsoil water table is encountered within the range of foundation depth or/and where pumping or bailing out of water is required due to presence of surface water will be treated as wet soil.	
c)	Rocky Soil : hard conglomerate or other soft or fissured rock which can be quarried or split with crow bars, wedges or pickaxes. However, if required, light blasting may be resorted to for loosening the material, but this will not in any way entitle the material to be classified as hard rock.	
d)	Hard Rock : Any rock excavation other than specified under fissured rock above for which blasting, drilling, chiseling are required..	
8.01.04	Where soil is of composite nature, classification of foundation shall be made accordingly.	
8.01.05	No extra charge shall be admissible for the removal of the fallen earth in the pit, when once excavated. Shoring and timbering/shuttering as approved by authorized representative of the Owner shall be provided by the Contractor when the soil condition is so bad that there is likelihood of accident due to the falling of earth.	
8.01.06	Where rock is encountered, the holes for tower footings, shall preferably be drilled, but where blasting is to be resorted to as an economy measure, it shall be done with the utmost care to minimise the use of concrete for filling the blasted area. In case where drilling is done, the stubs may be shortened suitably with the approval of the Owner or his authorised representatives.	
8.01.07	The Contractor shall supply requisite blasting materials and be responsible for the purpose of the storage and use of this material.	
8.02.00	Setting of Stubs	
8.02.01	The stubs shall be set correctly in accordance with approved method at the exact location and alignment and precisely at correct levels with the help of stub setting templates and leveling instrument. Stubs shall be set in the presence of Owner's representative available at site where required and for which adequate advance intimation shall be given to the Owner by the Contractor.	
8.02.02	Setting of stub at each location shall be approved by the Owner's representative.	
8.02.03	Stub setting templates shall be designed and arranged by the Contractor at his own cost for all types of towers with or without extension and also for leg extension. Stub templates for standard towers and towers with extension upto 6M shall be of adjustable type. The stub templates shall be painted. Generally for each transmission line tower package, following numbers of stub setting templates shall be deployed by the Contractor:  For each A type tower : 3 Nos. For each of B, C and D type : 2 Nos.  However, if Owner feels that more number of templates are required for timely completion of a particular line the Contractor shall have to deploy the same without any extra cost to Owner.	
8.02.04	One set of each type of stub setting template as applicable, shall be supplied to the Owner, on completion of the project at no extra cost to Owner.	
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Clause No.	TECHNICAL REQUIREMENTS	
8.03.00	Mixing, Placing and Compacting of Concrete	
8.03.01	The concrete shall be mixed in a mechanical mixer. However, in case of difficult terrain hand mixing may be permitted at the discretion of Owner. The water for mixing concrete shall be fresh, clean and free from oil, acids and alkalies. Saltish or blackish water shall not be used.	
8.03.02	Mixing shall be continued until there is uniform distribution of material and the mix is uniform in colour and consistency, but in no case the mixing be done for less than two minutes. Normally mixing shall be done close to the foundation, but in case it is not possible the concrete may be mixed at the nearest convenient place. The concrete shall be transported from the place of mixing to the place of final deposit as rapidly as practicable by methods which shall prevent the segregation or loss of any ingredient. The concrete shall be placed and compacted before setting commences.	
8.03.03	Form boxes shall be used for casting all type of foundations. The concrete shall be laid down in 150mm layers and consolidated well, so that the cement cream works up to the top and no honey-combing is left in the concrete. The mechanical vibrator shall be employed for compaction of the concrete. However, in case of difficult terrain, manual compaction may be permitted at the discretion of Owner. After concreting the chimney portion to the required height, the top surface should be finished smooth with a slight slope towards the outer edge, to drain off any rain water falling on the coping.	
8.03.04	In wet locations, the site must be kept complete de-watered, both during the placing of the concrete and for 24 hours thereafter. There should be no disturbance of concrete by water during this period.	
8.03.05	After the form-work has been removed if the concrete surface is found to be defective, the damage shall be repaired with rich cement and sand mortar to the satisfaction of the Owner's representative before the foundation pits are backfilled.	
8.04.00	Back-Filling and Removal of Stub Template	
8.04.01	After opening of form-work and removal of shoring and timbering, if any, backfilling shall be started, after repairs, if any, to the foundation concrete. Backfilling shall normally be done with excavated soil, unless it consists of large boulders/stones, in which case the boulders shall be broken to a maximum size of 80 mm. At such locations where borrowed earth is required for backfilling, shall be done by the Contractor at his own cost, irrespective of lead.	
8.04.02	The backfilling materials should be clean and free from organic or other foreign materials. The earth shall be deposited in maximum 200 mm layers, leveled and wetted and tempered properly before another layer is deposited. Care shall be taken that the backfilling is started from the foundation ends of the pits, towards the outer ends. After the pits have been backfilled to full depth, the stub template may be removed.	
8.04.03	The backfilling and grading shall be carried to an elevation of about 75 mm above the finished ground level to drain out water. After backfilling 50 mm high earthen embankment (bandh) will be made along the sides of excavation pits and sufficient water will be poured in the backfilled earth for atleast 24 hours.	
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Clause No.	TECHNICAL REQUIREMENTS						
8.05.00	<p><b>Curing</b></p> <p>The concrete after setting for 24 hours shall be cured by keeping the concrete wet continuously for a period of 10 days after laying. The pit may be back filled with selected earth sprinkled with necessary amount of water and well consolidated in layers not exceeding 200 mm of consolidated thickness after a minimum period of 24 hours and thereafter both the backfilled earth and exposed chimney top shall be kept wet for the remainder of the prescribed time of 10 days. The uncovered concrete chimney above the backfilled earth shall be kept wet by providing empty cement bags dipped in water fully wrapped around the concrete chimney for curing and ensuring that the bags are kept wet by the frequent pouring of water on them.</p>						
8.06.00	<p><b>Benching</b></p> <p>When the line passes through hilly/undulated terrain, for a few tower locations it may be required to level the ground for casting of tower footings on same elevation. All the activities related to make the required area of ground in same elevation for casting of foundation, shall be termed as benching work. Benching work shall include cutting of excess earth and removing the same to a suitable point of disposal as required by the Owner. Benching shall be resorted to only after getting specific approval from the Owner.</p>						
8.07.00	<p><b>Protection of Tower Footing</b></p>						
8.07.01	<p>The work shall include all necessary stone revetments, concreting and earth filling above ground level and the clearance from stacking on the site of all surplus excavated soil, special measures for protection of foundation close to or in nallahs, river bed hilly/undulated terrain etc, by providing suitable revetments or galvanised wire netting and meshing packed with boulders. The top seal cover of the stone revetments shall be done with M-150 concrete (1:2:4:mix). The Contractor shall furnish recommendations for providing protection at these locations wherever required.</p>						
8.07.02	<p>The quantity of excavated earth obtained from a particular location shall generally be utilised in back-filling work in protection of tower footing of same locations, unless it is unsuitable for such purpose. In the latter case, the back-filling shall be done with borrowed earth of suitable quality. The consolidation of earth shall however be done after backfilling.</p>						
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### **SECTION - 3**

#### **GENERAL SPECIFICATIONS**

##### **3.0 GENERAL**

This section stipulates the General Technical Requirements under the contract and will form an integral part of the Technical Specification.

The provisions under this section are intended to supplement general requirements for the materials, equipment and services covered under other sections and is not exclusive. However in case of conflict between the requirements specified in this section and requirements specified under other sections, the requirements specified under respective sections shall hold good.

##### **3.1 DRAWINGS, BILL OF MATERIALS AND CDs**

*At each stage following set of Type Tested design and fabrication drawings/Bill of materials shall be submitted.*

- |     |                                   |          |
|-----|-----------------------------------|----------|
| i)  | Type tested Tower Design/Drawings | : 4 sets |
| ii) | Bill of Materials                 | : 4 sets |

After final approval from customer, the following sets of fabrication drawings/shop drawings/bill of materials/CDs shall be submitted:

- |      |                      |          |
|------|----------------------|----------|
| i)   | Fabrication Drawings | : 4 set  |
| ii)  | Shop Drawings        | : 1 set  |
| ii)  | Bill Of Materials    | : 4 set  |
| iii) | CDs                  | : 2 sets |

##### **3.2 CATEGORIES OF APPROVAL**

- |              |  |
|--------------|--|
| CATEGORY I   | This means that the documents/drawings is approved.  |
| CATEGORY II  | This means that the document/drawing is approved with comments i.e, some corrections are required but the contractor can go ahead with the manufacture after incorporating comments. |
| CATEGORY III | This means that the document/drawing is not approved i.e major revisions are required and the contractor cannot proceed with the manufacture.  |

##### **3.3 TERMS OF PAYMENT**

Please refer terms and conditions of NIT

##### **3.4 COMPLETION TIME**

The work under this scope of work shall be completed within one month including approval from customer and submission of approved drg/docs in required number of sets.

**SECTION-4**

**SCHEDULE OF TECHNICAL DEVIATION.**

**BHEL ENQUIRY. NO:**

**BIDDER:OFFER REFERENCE:**

**6.1 Deviations**

Tick

☐ YES

☐ NO

If yes,

S.No.	Deviation	Clause No.
1		
2		
3		
4		
5		
6		
7		
8		
9		

(Signature & Seal of Bidder)