Report of 4th Pilot audit of Transmission Tower by the audit team of the committee for Audit of Transmission Tower

1. Background

In pursuance of Ministry of Power Letter No. 3/5/2017-Trans. Dated 07.08.2017, for the audit of the transmission towers with respect to design and the life of the towers (on a 5% sampling basis), the 4th pilot audit was carried out for the towers of the transmission lines (tabulated below) on 16th ,17th & 18th January, 2019, wherein the following members participated:

Sl no.	Organization	Name	Designation (division)
1.	PGCIL	Shri Manoj Kumar Mittal	Independent Director
		Shri Abhishek	General Manager
2.	SERC-CSIR	Shri R. P. Rokade	Principal Scientist
3.	CPRI	Shri K Vijaya Kumar	Enginnering Officer -Gr.III
4.	CEA-CEI division	Shri A.K. Thakur	Director (CEI)
		Shri I.K. Mehra	Deputy Director (RIO- North)
		Shri R.K. Meena	Deputy Director (CEI)
		Shri Mohit Mugdal	Assistant Director (PSETD)
		Shri Mukul Kumar	Assistant Director (CEI)

As transmission lines of Northern India & NCR region were already done in previous pilot audits, so, Madhya Pradesh a central India location was chosen for better regional outlook. The Audit members decided to audit both older lines and the newer line for holistic overview. The older critical lines which were more than 29 years old were selected and for the new line, a 3-year-old line was selected. Moreover, the members selected the towers in these lines for auditing based on its locational criticality like Highway crossings, Railway crossings, river/canal crossings, closeness to substation, accessibility, etc. The details of the audit of tower of following lines with tower locational information are given below: -

Sl no.	Name of Transmission line	Utility	Audit date	Year of Commissioning	Tower no. (its location)
1	400 kV Seoni-Sarni D/C Transmission Line	MPPTCL	16-01-2019	1984	a. 716 (Near canal) b. 717 (Agricultural Field)
2	400 kV Jabalpur-Vindhayachal D/C Transmission line	PGCIL	17-01-2019	1989	a. 984 (Railway crossing) b.983(Agricultural Field) c. 999 (Near road to Village)
3.	765 kV Jabalpur-Bina D/C transmission line	Sterlite Power Transmission Ltd.	18-01-2019	2016	a. 9 (Near Highway) b. 10 (Near Highway) c. 3 (Near Substation)

2. Following tests/checks were conducted for tower audit: -

a. Visual inspection of the tower

The towers were inspected with the naked eye and with the use of binoculars for missing members and bolts, buckling, etc. Danger plate which is for safety, number plate, phase sequence markings which is for convenience and anti-climbing arrangement/device which prevents un-authorized climbing on the tower were also inspected.

Any missing force bearing members will cause uneven distribution of forces in the leg and the capacity of the leg will be reduced which in turn harm the safety of the tower & causes failure of towers/ cascading of failures if it is in the angle/section towers.

Any missing redundant members in the structure will cause uneven distribution of forces in the force bearing members to which they are connected thus reducing the

capacity of force bearing members. It will cause more stress in the members & may leads to failure of towers even if the field/climatic conditions are normal for which the line/towers are designed.

Similarly, missing bolts of member's connection will cause reduction in strength of joint and causing excessive stresses in the intact bolt of a joint leading failure of joint/s & in-turn may lead to failure of tower.

Figure 1. Holes in Members

Observation: Missing of members due to theft, absence of redundant members, bending, buckling of few members, missing of some bolts were found in the audited towers of 400 kV Seoni-Sarni D/C Transmission. Anti-climbing device (ACD) was absent in the two towers of 400 kV Jabalpur-Vindhayachal D/C Transmission line, bending of a member and absence of member was found in the first two audited towers of 765 kV Jabalpur-Bina D/C transmission, details of which can be referred from **Annexure A**.

Conclusion: Tower structures were found intact with some minor aberration i.e. missing of bolts in some towers, buckling of some tower members and missing of ACDs in some towers.

Recommendation: Bent/buckled members to be replaced at the earliest**,** Dummy bolts, missing step bolts need to be plugged in order to keep the line in healthy condition. Inspection / patrolling of towers to be carried out regularly.

Figure 2. Bent, Buckled Members

b. Dimensions of the base width, diagonal length, leg members, bracing members of the bottom panel

The exact overall dimensions of tower structure as a whole like base width & diagonal are necessary for ensuring actual strength of tower for normal functioning of tower for which it is designed. Similarly, the size of tower members shall be within the tolerance limit so that the strength of tower as whole will not get weakened.

The measurements of tower footings, stubs, and reachable members were taken. The length, width and diagonal measurements of tower structure were also taken.

Observation: The recorded readings are given at **Annexure A & Annexure B**.

Conclusion: 1. The dimensions for members of audited towers of 400 kV Jabalpur-Vindhayachal D/C Transmission line are within limits.

2. For 400 kV Seoni-Sarni D/C Transmission Line, except the dimensions of measured transverse bracings of tower no. 717, rest other members of the towers of this line are within limits.

3. For 765 kV Jabalpur-Bina D/C transmission line, except the dimension of the

measured longitudinal bracing of audited tower no. 9, rest other members of the audited towers of this line are within limits.

Recommendation: Tower Drawings shall be followed during entire process of erection. It is essential to carry out pre stringing /charging inspection for each of the tower of a line and record the same. The members having dimensions not within limits shall be replaced by the members having correct dimensions.

c. Galvanized coating details of members in the leg portion

The galvanized coating protects the tower material from corrosion due to various pollutants persistent in air. The reduction/erosion of coating may lead to corrosion and reduction in original dimensions of tower member/s thus reducing the capacity of member/s which may lead to failure of tower. The thickness of coating was measured with the use of Alcometer.

Observation: The recorded readings are given at **Annexure A**.

Conclusion: inadequate Coating thickness were found at few locations in all the audited towers except tower no. 983 of 400 kV Jabalpur-Vindhayachal D/C Transmission .

Recommendation: Coating thickness shall be measured periodically and prompt action shall be taken to protect the tower/structure from corrosion by applying anti corrosive painting.

d. Corrosion to members

Corrosion is a natural process, which converts a refined metal to its oxide, hydroxide, or sulfide, etc. It is the gradual destruction of materials due to exposure to environment. Corrosion leads to loss of section size of structure and in turn reduces the strength of structure. The towers were observed for corrosion.

Figure 3. Corroded Members

Observation: Members were heavily corroded in the towers of 400 kV Seoni-Sarni D/C Transmission Line, members of other transmission towers were in adequate condition. Stubs were corroded at few locations in some of the audited towers.

Conclusion: The members, stubs have not been maintained in required condition.

Recommendation: Water logging near towers shall be avoided. Periodical inspection and anti-corrosive painting shall be applied for the tower members wherever onset of corrosion is noticed.

e. Differential settlements of towers

The foundation settlement occurs when the soil beneath a structure/ footings cannot bear the force imposed by the tower structure and conductor or the design parameters for foundation as per the soil under consideration turns erroneous. The settlement of a structure is the amount that the structure sinks after construction in all the four footings or differential settlement of footings. In case of uniform settlement of tower/s there may not be much problem for the structure. However,

differential settlements of legs/ footings become a big problem when the foundation settles unevenly causing additional stress in the tower members. The more uneven in the settlement, the greater shortcoming on the safety of the structure & the reliability causing premature failures, even when the field conditions are normal and all the deviations are within tolerable limits. Water tube method was used to know the differential settlement of the tower. The level of the stubs of all the four legs of the tower was measured and compared with respect to each other.

Differential settlements may lead to following problems: -

i) Tower may tilt towards settled side that may in turn produce strain in erected conductors and may cause snapping.

ii) Tower may collapse that will have cascading effect and adjacent towers may also be affected.

Observation: The recorded readings are given at **Annexure A**.

Conclusion: Differential settlements for tower no. 716 of 400 kV Seoni-Sarni D/C Transmission Line, tower no. 999 of 400 kV Jabalpur-Vindhayachal D/C Transmission line and tower no. 10 of 765 kV Jabalpur-Bina D/C transmission line were not within permissible limits, while the rest of the audited towers were within permissible limit.

Recommendation: The land around tower footing shall be compact, levelled and kept dry to provide strength to the soil. Water logging shall be avoided if the foundations of a given tower location is not designed for wet condition, condition and also suitable corrective measures shall be taken for the towers where the differential settlement is not within permissible limits.

f. Verticality of tower

This test was done to find out any undue eccentricity/leaning of the tower created due to constructional problem if any and or created by wind, excessive line loading buckling of towers, differential settlement of foundation, etc. The procedure adopted for this was by identifying the center of the tower and then measuring through the transverse & longitudinal axes taking reference of the intersection of bracings of bottom panel of the tower and tracking through the overall height of

the tower up to the intersection of bracings of top panel of the tower by use of Total station in both the directions.

Figure 4. Transverse view of Verticality

Observation: The recorded readings are given at **Annexure A & Annexure C**.

Conclusion: All the measured Transverse & longitudinal of towers were within permissible limit.

Recommendation: To avoid the eccentricity & deviation in verticality, the stubs to be casted to the correct position (Base width and Diagonal) & to the correct inclination (slope) and also at common level. Due care shall be taken during stringing to maintain the correct sag tension coordination for a given span.

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Data Sheet of Audited Transmission towers

ANNEXURE A - PART A

General Information								
Line name	**400 kV Seoni-Sarni D/C Transmission Line (MPPTCL)**		**400 kV Jabalpur-Vindhayachal D/C Transmission line (PGCIL)**			**765 kV Jabalpur-Bina D/C transmission line Power Transmission Ltd.)**		**(Sterlite**
Tower number	**716**	**717**	**984**	**983**	**999**	**9**	10	3
Tower Type	**F30+3**	**F 60+7**	**C 60+14**	**A2+0**	**B 30+6**	**B+0**	D+0	A+6
location	(Near cannal)	(Agricultural Field)	(Near Railway crossing)	(Agricultural Field)	(near road to village)	(Agricultural Field near Highway)	(Agricultural Field near Highway)	Near Substation
Audit Date:	16-01-19	16-01-19	17-01-19	17-01-19	17-01-19	18-01-19	18-01-19	18-01-19
Visual Observations								
S/C D/C M/C	D/C	D/C	D/C	D/C	D/C	D/C	D/C	D/C
Configuration Vertical/ Horizontal,	Horizontal	Horizontal	Vertical	Vertical	Vertical	Vertical	Vertical	Vertical
Damage to Tower	Repeated Theft of members of the tower was reported by MPPCL	Repeated Theft of members of the tower was reported by MPPCL, one of the member was observed loose and repeated noise of metal clinking was heard.	Nil	Nil	Nil	Nil	Nil	Nil
Bending / buckling	Bending in Members of Hip bracing of leg B. In Leg A, the Bracing members got bent where the redundant member were jointed to the bracing.	Redundant Members of Leg B were buckled/bent & Members in Hip Bracing of Leg A were bent	Nil	Nil	Nil	Redundant member in Leg A is bent	Nil	Nil
Missing Members	Redundant members in the Leg B were absent	Redundant members in the Leg D and Leg C were absent	Nil	Nil	Nil	Nil	One member in Auxiliary cross arm bottom section was missing. And the other member was not connected.	Nil
Missing bolts/nuts	Bolts were missing at some locations in leg members and redundant members	Bolts were missing at some locations in leg C, members and redundant members	Nil	Nil	Nil	Nil	Nil	Danger plate holes were not plugged.
Leg slope alignment	Aligned	Aligned	Aligned	Aligned	Aligned	Aligned	Aligned	Aligned
Step bolts	Appropriately Placed	Appropriately Placed	Appropriately Placed	Appropriately Placed	Appropriately Placed	Appropriately Placed	Appropriately Placed	Appropriately Placed
Anti Climbing Device	Present & intact	Present & intact	No	No	Present & intact	Present & intact	Present & intact	Present & intact
Measured Tower Base width								
Btn. Stub 1&2	11.25 m	15.38 m	14.86 m	5.95 m	11.86 m	14.52 m	17.36 m	13.76 m
Btn. Stub 2&3	11.25 m	15.37 m	14.86 m	7.95 m	11.89 m	14.5 m	17.48 m	13.76 m
Btn. Stub 3&4	11.25 m	15.38 m	14.87 m	5.98 m	11.88 m	14.53 m	17.36 m	13.74 m
Btn. Stub 4&1	11.24 m	15.38 m	14.86 m	7.95 m	11.88 m	14.54 m	17.42 m	13.74 m
Stubs levelling difference (mm) at Top of Stub								
Btn. Stub 1&2	4 mm down	2 mm up	19 mm down	0 mm	1 mm down	2 mm up	40 mm up	1 mm up
Btn. Stub 1&3	11.5 mm down	8.2 mmup	5 mm up	4 mm down	18 mm down	1 mm down	42 mm up	7 mm down
Btn. Stub 1&4	1 mm down	6.2 mm up	6 mm up	2 mm up	4 mm up	16 mm down	48 mm up	4 mm up
Tolerance limit	11.25 mm	15.38 mm	14.87 mm	7.95 mm	11.89 mm	14.54 mm	17.48 mm	13.76 mm
Conclusion for differential settlement	**Not within limit**	It is within limit	It is within limit	It is within limit	**Not within limit**	It is within limit	**Not within limit**	It is within limit
Deflection / Verticality								
Tower Height (in meter)	33.67	39.17	54	46.5	46	47.375	47.375	58.575
Transverse Axis defelection (measured)	211	10	300	46	29	48	42	28
Longitudinal axis deflection (measured)	101	6	86	10	69	13	104	18
Tolerance	240.5	279.79	385.71	332.14	328.57	338.39	338.39	418.39
Conclusion for verticality	within limit	within limit	within limit	within limit	within limit	within limit	within limit	within limit

Part B

MEASUREMENTS OF INDIVIDUAL TOWER

Tower no. 716 Seoni-Sarni D/C Transmission Line (MPPTCL)

Parameter (Leg A)	Size as per measurement (mm)	Size as per drawing (mm)	Size devaition/conclusion	Galvanising Thickness measured (microns)	Galvanising Thickness required as per specifications (microns)	Galvanizing thickness deviation/conclusion	Condition (for corrosion)
Stubs	L 150.60x147.66x12.96x12.60	L 150x150x12x12	Deviation within tolerance limit	not measured	>86 micron (IS :2629)	not applicable	some members of bottom panel were corroded
						Except Leg A, Leg D & K Bracing Long. Face of Leg D , every member has the galvinsing thickness below 86 microns	
Leg	L 148.90x150.18x11.98x11.88	L 150x150x12x12	Deviation within tolerance limit	123, 63, 59, 176			
Bracing	L 99.90x100.80x6.40x6.66 (Trans.)	L 100x100x8x8	Deviation within tolerance limit	82,65,70,84			
	L 91.12x90.42x6.20x6.66 (Long.)	L 90x90x6x6	Deviation within tolerance limit	73,55,50,125			

Tower no. 717 Seoni-Sarni D/C Transmission Line (MPPTCL)

Parameter (Leg A)	Size as per measurement (mm)	Size as per drawing (mm)	Size devaition/conclusion	Galvanising Thickness measured (microns)	Galvanising Thickness required as per specifications (microns)	Galvanizing thickness deviation/colclusion	Condition
Stubs	L 150.42x151.94x15.92x16.12	L 150x150x16x16	Deviation within tolerance limit	few locations in Leg A & its br	>86 micron (IS :2629)	not applicable	some members of bottom panel were corroded
						few locations in Leg A & its bracings, Leg B & its bracing (long.), Leg C bracings, Leg D & its bracings (trans.) has its galvinising thickness below 86 microns	
Leg	L 149.34x149.68x15.96x16.14	L 150x150x16x16	Deviation within tolerance limit	82,75,120,81			
Bracing	L 112.36x110.48x8.24x8.46 (Trans.)	L 110x110x8x8	**not within tolerence limit**	80,87,81,52			
	L 110.32x111.52x8.92x8.22 (Long.)	L 110x110x8x8	Deviation within tolerance limit	62,78,75,96			

Tower no. 984 400 kV Jabalpur-Vindhayachal D/C Transmission line (PGCIL)

Parameter (Leg A)	Size as per measurement (mm)	Size as per drawing (mm)	Size devaition/conclusion	Galvanising Thickness measured (microns)	Galvanising Thickness required as per specifications (microns)	Galvanizing thickness deviation/colclusion	Condition
Stubs	Not measured	L 200 X 200 X 20 X 20	Not Applicable	not measured	>86 micron (IS :2629)	not applicable	normal
						a single location in Leg A bracings has its galvinising thickness below 86 microns, rest all members have adequate thickness	
Leg	L 200.00x200.00x20.55x20.90	L 200 X 200 X 20 X 20	Deviation within tolerance limit	148, 145, 164, 151			
Bracing	L 125.20x124.90x7.85x8.20 (Trans.)	L 125 X 125 X 8 X 8	Deviation within tolerance limit	80,91,115,139			
	L 125.70x124.30x8.05x8.50 (Long.)	L 125 X 125 X 8 X 8	Deviation within tolerance limit	81,129,134,145			

Tower no. 983 400 kV Jabalpur-Vindhayachal D/C Transmission line (PGCIL)

Parameter (Leg A)	Size as per measurement (mm)	Size as per drawing (mm)	Size devaition/conclusion	Galvanising Thickness measured (microns)	Galvanising Thickness required as per specifications (microns)	Galvanizing thickness deviation/colclusion	Condition
Stubs	Not measured	L 180 X 180 X 12 X 12	Not Applicable	not measured	>86 micron (IS :2629)	not applicable	normal
						adequate thickness	
Leg	L 182.00x182.00x11.15x11.15	L 180 X 180 X 11 X 11	Deviation within tolerance limit	206, 123, 138, 186			
Bracing	L 111.70x111.30x8.60x8.65 (Trans.)	L 110 X 110 X 8 X 8	Deviation within tolerance limit	198, 144, 146, 127			
	L 91.70x88.00x6.60x6.80 (Long.)	L 90 X 90 X 6 X 6	Deviation within tolerance limit	141, 151, 107, 107			

Tower no. 999 400 kV Jabalpur-Vindhayachal D/C Transmission line (PGCIL)							
Parameter (Leg A)	**Size as per measurement (mm)**	**Size as per drawing (mm)**	**Size devaition/conclusion**	**Galvanising Thickness measured (microns)**	**Galvanising Thickness required as per specifications (microns)**	**Galvanizing thickness deviation/colclusion**	**Condition**
Stubs	Not measured	L 200 X 200 X 16 X 16	Not Applicable	not measured	>86 micron (IS :2629)	not applicable	normal
						a single location in Leg A longitudinal bracing has its galvinising thickness below 86 microns, rest all members have adequate thickness	
Leg	L 201.00x201.00x14.50x15.40	L 200 X 200 X 14 X 14	Deviation within tolerance limit	134,225,205,180			
Bracing	L 100.20x00.60x8.25x8.10 (Trans.)	L 100 X 100 X 8 X 8	Deviation within tolerance limit	164, 137, 138, 173			
	L 100.40x99.70x8.30x8.70 (Long.)	L 100 X 100 X 8 X 8	Deviation within tolerance limit	67, 263, 167, 134			
Tower no. 9 Jabalpur-Bina D/C transmission line (Sterlite Power Transmission Ltd.)							
Parameter (Leg A)	**Size as per measurement (mm)**	**Size as per drawing (mm)**	**Size devaition/conclusion**	**Galvanising Thickness measured (microns)**	**Galvanising Thickness required as per specifications (microns)**	**Galvanizing thickness deviation/colclusion**	**Condition**
Stubs	Not measured	HT 150*150*15	Deviation within tolerance limit	not measured	>86 micron (IS :2629)	not applicable	normal
						few locations in Leg A & its bracings, Leg B bracing (trans.), Leg C & its bracings, Leg bracings has its galvinising thickness below 86 microns	
Leg	L 148.00x148.00x15.50x15.40	L 150*150*15	Deviation within tolerance limit	83, 95 ,86, 88			
Bracing	L 99.20x99.10x8.10x8.10 (Trans.)	100*100*8	Deviation within tolerance limit	81, 81, 65, 61			
	L 102.10x102.60x7.30x7.50 (Long.)	100*100*7	**not within tolerence limit**	84, 97, 73, 77			
Tower no. 10 Jabalpur-Bina D/C transmission line (Sterlite Power Transmission Ltd.)							
Parameter (Leg A)	**Size as per measurement (mm)**	**Size as per drawing (mm)**	**Size devaition/conclusion**	**Galvanising Thickness measured (microns)**	**Galvanising Thickness required as per specifications (microns)**	**Galvanizing thickness deviation/colclusion**	**Condition**
Stubs	Not measured	HT 150*150*20	Not Applicable	not measured	>86 micron (IS :2629)	not applicable	normal
						few locations in Leg A bracing(long.), Leg B bracings, Leg C bracing (long.) has its galvinising thickness below 86 microns	
Leg	L 150.00x148.00x20.00x20.00	L 150*150*20	Deviation within tolerance limit	95, 87, 108, 109			
Bracing	Inner L 91.20x89.00x6.80x6.30 Outer L 90.20x88.00x6.60x6.70 (Trans.)	Inner L 90*90*6 outer L90*90*6	Deviation within tolerance limit	92, 81, 102, 86			
	Inner L 74.80x74.00x6.10x6.20 (Long.)	Inner L 75*75*6	Deviation within tolerance limit	78, 83, 70, 98			
	Outer L 74.40x74.00x6.70x6.20 (Long.)	outer L 75*75*6	Deviation within tolerance limit				
Tower no. 3 Jabalpur-Bina D/C transmission line (Sterlite Power Transmission Ltd.)							
Parameter (Leg A)	**Size as per measurement (mm)**	**Size as per drawing (mm)**	**Size devaition/conclusion**	**Galvanising Thickness measured (microns)**	**Galvanising Thickness required as per specifications (microns)**	**Galvanizing thickness deviation/colclusion**	**Condition**
Stubs	Not measured	HT130*130*10	Not Applicable	not measured	>86 micron (IS :2629)	not applicable	normal
						few locations in Leg A bracing(long.) , Leg C & Leg D bracing (trans.) has its galvinising thickness below 86 microns	
Leg	L 131.45x129.40x10.20x10.30	L 130*130*10	Deviation within tolerance limit	114, 111, 92, 93			
Bracing	L 79.60x9.60x6.40x6.20 (Trans.)	L 80*80*6	Deviation within tolerance limit	87, 105, 84, 86			
	L 75.20x74.30x6.35x6.40 (Long.)	L 75*75*6	Deviation within tolerance limit	83, 145, 78, 88			
* long. = longitudinal	* trans = transverse *long = longitudinal						

Description	**Size**	**Tolerance**
Flange length/leg length	</=45mm	+/- 1.5mm
	>45mm & >/= 100mm	+/- 2.0mm
	>100mm	+/- 2%
Galvanising Coating thickness:	610 g/sq.m	Min. thickness 87 microns
Diff in Elevation of Stubs:		</= (1/1000)*base width
Verticality of Tower		</=1/360*height (under test bed/ without stringing) <= 1/140* height with stringing (up to 60 m height) * Suggested by CSIR-SERC

Annexure-B

CSIR-STRUCTURAL ENGINEERING RESEARCH CENTRE TOWER TESTING AND RESEARCH STATION

313(CEA_Audit)/2019-RPR
30th January 2019

To
The Chief Engineer,
Chief Electrical Inspectorate Division,
Central Electricity Authority,
18-A, Shaheed Jeet Singh Marg,
Katwaria Sarai New Delhi-110016

Sub: Observations of 4th pilot audit of transmission line towers – Reg.

Dear Sir,

Following are the observations made during the 4th pilot audit of Transmission Line (TL) towers:

1) Total eight numbers of towers were audited in three days in three different transmission lines. The general observations are missing secondary bracing members (refer Fig. 1), unplugged bolt-holes and missing bolts in the bottom panel. The missing members and bolts need to be replace immediately as per the respective original structural drawings. Further, all the open bolt-holes have to be plugged with bolts or welding.
2) Improper rectification/ replacement of stolen members (by cutting the original members) was observed for the first tower audited on 16/01/2019 in the 400 kV Seoni - Sarni TL, which is operated and maintained by M/s MPPTCL. For fixing the new member in place of stolen/missing member additional holes were drilled, which creates eccentricity leading to additional forces in the structure. Most of the secondary bracing members are bent during the rectification work. In some places replaced member has two pieces connected with single bolt in one of the flanges. All the above representative deficiencies are indicated in Fig. 2. In order to ensure the safety and stability of TL tower, it is necessary to carry out proper rectification immediately as per the structural drawings.
3) The section dimensions measured during the audit for all the towers at bottom panel main members are presented in Table-1.

Annexure-B

For TL tower audit, the following instruments in working condition are required to carry out the tower measurements accurately and efficiently,

a. Digital Vernier calliper minimum 30 cm long with least count 0.01 mm. Calibration/ checking for proper functioning prior to the audit is must for the digital Vernier callipers. In addition, a steel scale of 30 cm length is necessary.
b. Micrometre screw gauge with least count of 0.001 mm for member thickness measurement.
c. Steel tapes of 5m and 30 m length in good condition.
d. Drone camera with laptop for checking the condition of tower at different heights.
e. Total station theodolites with reflector prism, other necessary accessories and skilled operator to take the measurements in optimum time.
f. Instrument for galvanising thickness measurement with proper calibration.
g. Other accessories like levelling tubes of minimum 20 and 30 m length, nylon wire for tower diagonal measurement, earthing resistance measuring equipment etc.

For better serviceability of the TL towers,

i. Condition assessment of tower and foundation has to be carried out using non-destructive techniques at least once in 5 years and
ii. The strengthened tower design designs have to be proof checked every 15 years with respect to for the latest design standards

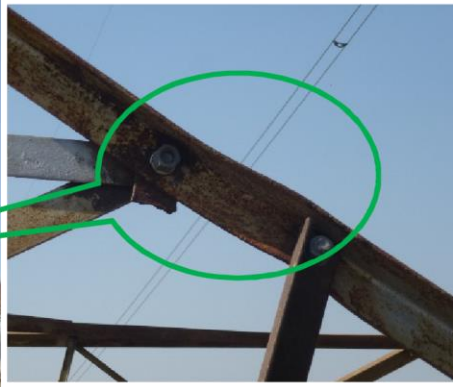
R.P. Rokade

(Principal Scientist)

Annexure-B

Fig.1 Typical Missing Member

Fig. 2 Tower-1 Audited on 16/01/2019



2.a) Improper rectification with bent member

2.b) Unplugged Holes

2.c) Bent/sagged members

2.d) Rectification with two member pieces connected with single bolt on one flange

Annexure-B

Table-1 4th Pilot Audit for Audit of Transmission L ine Towers - Details of Member Section Dimensions

Audit Date	Trans. Line & Agency	Tower No.	Tower Member	Member Section Dimensions				Refer Tower Location Figure
				Leg-A	Leg-B	Leg-C	Leg-D	
16-01-2019	400 kV Seoni - Sarni Transmission Line M/s MPPTCL	1	Stub	L 150.60x147.66x12.96x12.60	L 149.90x149.40x12.64x12.20	L 149.94x149.12x12.42x12.64	L 149.52x150.52x12.12x12.12	Fig. 3 - 1
			Leg	L 148.90x150.18x11.98x11.88	L 150.62x150.40x11.68x11.94	L 149.34x149.82x12.12x12.82	L 149.62x151.10x11.82x12.42	
			Trans. Bracing	L 99.90x100.80x6.40x6.66	L 99.86x99.42x6.18x6.14	L 99.12x99.52x6.22x6.42	L 99.22x99.82x6.92x6.86	
			Long. Bracing	L 91.12x90.42x6.20x6.66	L 91.90x90.10x6.60x6.42	L 91.72x89.42x6.52x6.72	L 91.22x90.34x6.82x6.62	
		2	Stub	L 150.42x151.94x15.92x16.12	L 152.14x152.12x16.12x15.96	L152.42x151.62x15.92x16.18	L 152.42x152.22x16.42x16.92	Fig. 3 - 1
			Leg	L 149.34x149.68x15.96x16.14	L 150.42x148.32x16.22x16.12	L 149.72x150.58x16.12x16.38	L 150.12x151.12x16.48x16.34	
			Trans. Bracing	L 112.36x110.48x8.24x8.46	L 110.12x106.22x10.82x10.42	L 111.54x110.78x8.56x8.32	L 111.12x110.92x8.54x8.62	
			Long. Bracing	L 110.32x111.52x8.92x8.22	L 100.46x100.82x8.64x8.42	L 100.68x100.72x8.48x8.28	L 109.74x111.32x8.72x8.82	
17-01-2019	400 kV Jabalpur - Vindhyachal Transmission Line M/s PGCIL	1	Leg	L 200.00x200.00x20.55x20.90	L 200.00x200.00x21.00x21.05	L 200.00x00.00x21500x20.80	L 200.00x200.00x20.70x20.50	Fig. 3 - 2
			Trans. Bracing	L 125.20x124.90x7.85x8.20	L 126.50x123.60x8.65x8.30	L 125.75x125.90x9.90x8.80	L 125.90x125.10x8.70x8.90	
			Long. Bracing	L 125.70x124.30x8.05x8.50	L 126.10x125.20x7.65x8.80	L 126.30x125.00x8.70x9.20	L 125.10x126.10x8.25x8.65	
		2	Leg	L 182.00x182.00x11.15x11.15	L 181.50x181.50x11.30x11.10	L 179.00x180.00x12.00x12.00	L 182.00x179.00x12.00x11.60	Fig. 3 - 3
			Trans. Bracing	L 111.70x111.30x8.60x8.65	L 111.10x109.00x9.00x9.00	L 110.15x111.00x8.80x8.10	L 109.15x111.60x8.55x8.30	
			Long. Bracing	L 91.70x88.00x6.60x6.80	L 91.90x90.85x6.55x7.90	L 91.50x90.50x6.30x6.75	L 89.00x88.45x6.50x7.70	
		3	Leg	L 201.00x201.00x14.50x15.40	L 201.00x201.00x15.20x15.05	L 201.00x199.00x15.30x15.30	L 200.00x200.00x14.90x14.30	Fig. 3 - 3

			Trans. Bracing	L 100.20x00.60x8.25x8.10	L 100.60x99.80x9.20x9.30	L 100.85x100.40x8.50x8.80	L 100.90x100.80x8.70x8.45	
			Long. Bracing	L 100.40x99.70x8.30x8.70	L 100.70x101.30x8.25x8.30	L 100.40x100.00x8.90x8.90	L 100.00x100.00x8.15x9.00	
18-01-2019	765 kV Jabalpur - Bina Transmission Line M/s Sterlite Power Transmission Ltd.	1	Leg	L 148.00x148.00x15.50x15.40	L 150.00x150.00x15.30x15.20	L 148.00x150.00x15.50x15.30	L 148.00x150.00x15.30x15.00	**Fig. 3 - 3**
			Trans. Bracing	L 99.20x99.10x8.10x8.10	L 100.70x99.30x8.50x8.20	L 100.30x99.20x8.60x8.10	L 99.50x01.20x8.20x8.20	
			Long. Bracing	L 102.10x02.60x7.30x7.50	L 100.30x99.00x7.00x7.30	L 103.50x101.40x7.40x7.30	L 99.80x99.30x7.00x7.00	
		2	Leg	L 150.00x148.00x20.00x20.00	L 150.00x148.00x20.00x20.00	L 152.00x150.00x20.00x19.80	L 148.00x150.00x20.00x20.00	**Fig. 3 - 4**
			Trans. Bracing	Inner L 91.20x89.00x6.80x6.30	Inner L 90.40x88.00x6.50x6.20	Inner L 91.90x90.00x6.25x6.30	Inner L 90.50x88.00x6.30x6.20	
				Outer L 90.20x88.00x6.60x6.70	Outer L 91.30x89.00x6.20x6.30	Outer L 90.10x89.00x6.30x6.20	Outer L 90.40x89.00x6.50x6.00	
			Long. Bracing	Inner L 74.80x74.00x6.10x6.20	Inner L 75.40x73.00x6.20x6.10	Inner L 75.70x75.00x6.25x6.40	Inner L 75.00x75.00x6.20x6.30	
				Outer L 74.40x74.00x6.70x6.20	Outer L 75.00x73.00x6.50x6.20	Outer L 75.20x75.00x6.50x6.35	Outer L 75.20x74.00x6.30x6.20	
		3	Leg	L 131.45x129.40x10.20x10.30	L 129.90x130.25x10.20x10.20	L 130.90x130.30x10.25x10.35	L 130.20x130.30x10.70x10.25	**Fig. 3 - 5**
			Trans. Bracing	L 79.60x9.60x6.40x6.20	L 79.40x79.10x6.20x6.20	L 79.40x80.20x6.20x6.20	L 79.20x79.40x6.30x6.45	
			Long. Bracing	L 75.20x74.30x6.35x6.40	L 77.70x73.50x6.60x6.20	L 76.00x74.90x6.25x6.20	L 75.20x75.40x6.20x6.10	

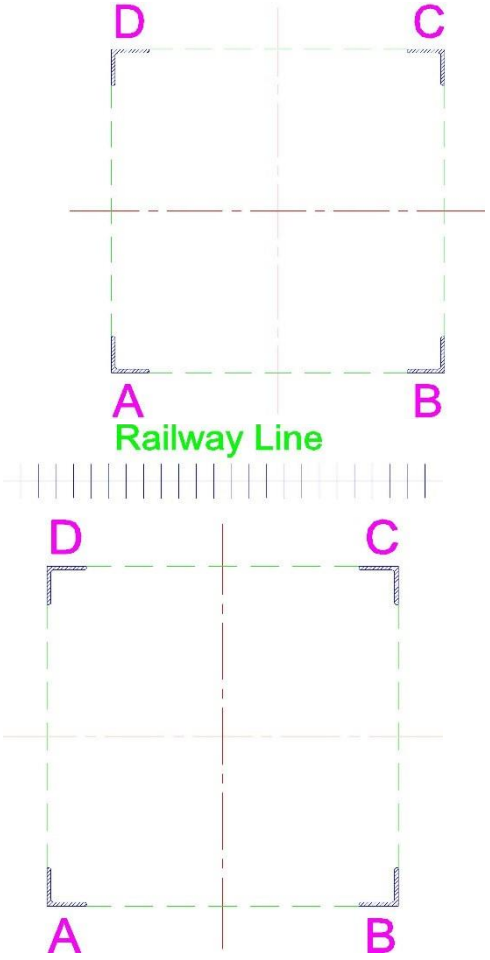
Section Dimension Nomenclature for Stub/Leg Member : L - Angle Section Trans. Face Width x Long. Face Width x Trans. Face Thk. X Long. Face Thk.

Section Dimension Nomenclature for Bracing Member : L - Angle Section Horz. Face Width x Vert. Face Width x Horz. Face Thk. X Vert. Face Thk.

Abbrevations used : Trans. - Transverse, Long. - Longitudinal, Horz. - Horizontal, Vert. - Vertical

Tower Location Figures for Leg Identification

Annexure-B



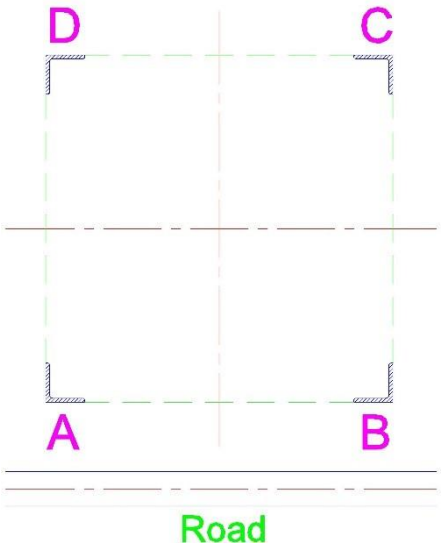


Fig. 3 – 1 for Towers Audited on 16/01/2019

Fig. 3 – 2 for Tower-1 Audited on 17/01/2019

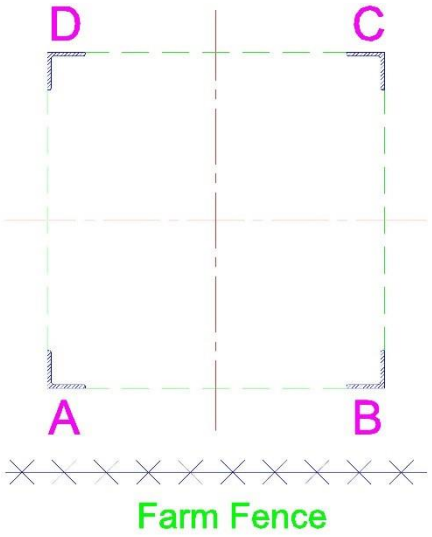


Fig. 3 – 3 for Towers 2 & 3 Audited on 17/01/2019 and Tower-1 Audited on 18/01/2019

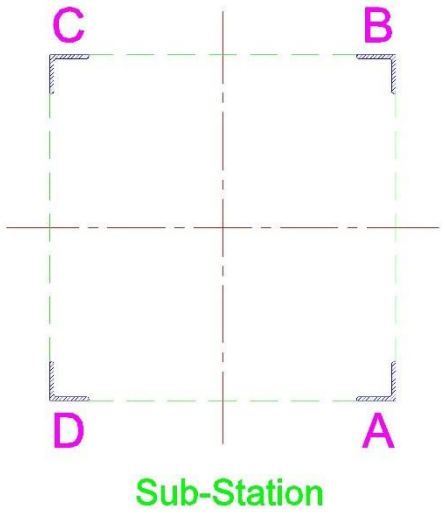


Fig. 3 – 4 for Tower-2 Audited on 18/01/2019

Fig. 3 – 5 for Tower-3 Audited on 18/01/2019

Annexure-C

Deflections Report of the Transmission Line Towers

Date:11/02/2019

Deflection of the inspected towers under 4th pilot audit program from dated.16/01/2018 to 18/01/2018 at Jabalpur, Madhapradesh has given in the table below: -

SL. No	Deflection Axis	Units (mm)	Tower No-1	Tower No-2	Tower No-3	Remarks
1	**MPPTCL Line (Audited date.16/01/2018)**					
	Transverse Axis Deflection	mm	211	10	-	OK
	Longitudinal Axis Deflection	mm	101	6	-	OK
2	**Powergrid Line (Audited date.17/01/2018)**					
	Transverse Axis Deflection	mm	300	46	29	OK
	Longitudinal Axis Deflection	mm	86	10	69	OK
3	**Sterlite Line (Audited date.18/01/2018)**					
	Transverse Axis Deflection	mm	48	42	28	OK
	Longitudinal Axis Deflection	mm	13	104	18	OK

The deflections as mentioned above were observed during the inspections of towers at the peak level of the tower.

Feedback of the program: - It is a very good program of auditing the existing towers, though this program it can be known that the condition of the existing tower. As per the data collected through the auditing of the towers, The assessment of the tower can be done such as strengthening of the tower and its foundations if required, replacement with new towers etc. It can be ensured that the failing of towers can be avoided to make the uninterrupted power supply without loss of human, animal life and property/ etc.,

The suggestions on the program may please be considered as mentioned below: -

1) The surveyor must be a skilled person having good knowledge about the surveying instrument as well as to take the deflection reading in minimum time with accuracy.
2) Residual Life Assessment of the old transmission lines to be carried out to know the probability of remaining life/ adequacy to latest standards and strengthening of the same if needs.
3) Mandatory periodic maintenance of the complete line to be taken up at least for every six months.
4) The concerned authority might have the information about the critical locations of failures of towers, thefts of the tower members at approachable locations, corrosion due to environmental problem etc., The scope of audit to be specified based on the above.
5) The auditing of entire transmission line takes lot of time the same can be done by assigning the third party in the relevant filed of experience. After completion of the auditing the concerned authority may randomly pick up 5% of the towers in the line shall be cross checked by the CEA/Committee. By assigning the audit program to the third party agency the maximum number of lines can be audited.

Sincerely,

K Vijaya Kumar
Engineering Officer-3(Structural)
Tower Testing Station/Mechanical Engg Division
Central Power Research Institute
Bangalore-560 080