सत्यमेव जयते

क्षतिग्रस्त ट्रांसमिशन लाइन टॉवरों पर विशेषज्ञों की स्थायी समिति की रिपोर्ट

(अप्रैल २०१९ –दिसम्बर २०२१)

REPORT OF THE STANDING COMMITTEE OF EXPERTS ON FAILURE OF EHV TRANSMISSION LINE TOWERS

(APRIL 2019 – DECEMBER 2021)

भारत सरकार
Government of India

केन्द्रीय विद्युत प्राधिकरण
Central Electricity Authority

विद्युत मंत्रालय
Ministry of Power

नई दिल्ली
New Delhi

(विद्युत अधिनियम,2003 की धारा 73(एल) के तहत के.वि.प्रा. के दायित्व का निर्वहन करते हुए)
(In fulfilment of CEA's obligation under section 73(l) of Electricity Act, 2003)

TABLE OF CONTENTS

EXECUTIVE SUMMARY

1.0 INTRODUCTION:

1.1 A Standing Committee of Experts in the field of design & operation of EHV Transmission lines (from CEA, POWERGRID & research/academic institutes) constituted by Central Electricity Authority in 1999 as per the Electricity (Supply) Act No. 54 of 1948, continues to carry out investigation of failure of transmission line towers of Power utilities as per the Section 73(l) of the Electricity Act, 2003. Office order vide which Standing Committee was constituted is enclosed at **Annexure-A**. As per the requirement of the Standing committee, all utilities / transmission licensees are supposed to report the failure of towers of 220 kV and above voltage class transmission lines to CEA.

1.2 The objective of Standing Committee is to investigate and analyze the probable causes of failure of towers of the transmission lines of power utilities in different parts of the country and recommend remedial measures to prevent repetition of such failures in future. In cases, where the visit to site of failure of tower does not materialize, analysis of failure is done based on information provided by the utilities and their participation in the Standing Committee's meeting.

1.3 The failure cases of EHV transmission towers of different power utilities, which are reported to CEA, are discussed during the meeting of Standing Committee of Experts and inferences are drawn in respect of causes of failure of the transmission tower based on site investigation report, information/data provided by the concerned utilities and deliberations during the meeting and various recommendations are made by the Committee to avert reoccurrence of such failure(s) in future.

1.4 The e-meeting of the Standing Committee of the Experts was held virtually on 11th & 12th January 2022 to discuss the causes of failure of the transmission line towers of different voltage levels belonging to various power transmission utilities which had failed during the period from April, 2019, to December, 2021. During this period, the failure of towers of EHV transmission lines of various transmission utilities [POWERGRID, M/s MPPTCL, M/s KPTCL, M/s RVPNL, M/s UPPTCL, M/s Sterlite Power, M/s DMTCL and M/s RSTCL] were reported to CEA. Accordingly, the Committee discussed in detail the nature and causes of failure of towers of transmission lines of these utilities. Minutes of the meeting are enclosed at **Annexure-B.**

2.0 BRIEF DETAILS OF FAILURE OF TOWERS OF VARIOUS TRANSMISSION LINES REPORTED TO CEA FROM APRIL, 2019 TO DECEMBER, 2021

2.1 Failure of total 179 Nos. of towers of forty seven (47) transmission lines of POWERGRID, M/s MPPTCL, M/s KPTCL, M/s RVPNL, M/s UPPTCL, M/s Sterlite Power, M/s DMTCL and M/s RSTCL were reported to CEA during

April, 2019, to December, 2021. Details of these failures are given in Table-1 below:

Table-1

S. No.	Name of the Transmission Line	Name of Utility	Date of Failure	Year of Commissioning	Wind Zone	No. of Towers Failed			Conductor
						Suspension	Tension	Total	
1.	400 kV D/C Khandwa- Indore I and II transmission line	POWER GRID	16.04.2019	2016	2	-	1	1	Vertical/ Twin ACSR Moose
2.	400 kV D/C Narendra-Devangere transmission line	POWER GRID	28.04.2019	2008	Line in WZ 1 Tension towers for WZ2 & Suspension tower for WZ1	9	1	10	Vertical/ Twin ACSR Moose
3.	400 kV D/C Pandiabili – Duburi – Baripada transmission line	POWER GRID	03.05.2019	2011	5	-	1	1	Vertical/ Twin ACSR Moose
4.	400 kV D/C Gooty – Nellore PS transmission line	POWER GRID	27.05.2019	2013	2	7	-	7	Vertical/ Quad ACSR Moose
5.	400 kV D/C Narendra-Devangere (Guttur) transmission line	POWER GRID	06.06.2019	2008	Line in WZ 1 Tension towers for WZ2 & Suspension tower for WZ1	5	1	6	Vertical/ Twin ACSR Moose
6.	400 kV D/C Agra – Sikar transmission line	POWER GRID	12.06.2019	2014	4	2	1	3	Vertical/ Quad ACSR Moose
7.	400 kV D/C Silchar – Meliriat transmission line	POWER GRID	19.07.2019	2018	6	-	1	1	Vertical/ Twin ACSR Moose
8.	400 kV D/C Kishanganj – Patna transmission line	POWER GRID	06.08.2019	2016	4	-	1	1	Vertical/ Quad ACSR Moose

9.	765 kV D/C Khandwa Pool-Dhule transmission line	M/s Sterlite Power	16.04.2019	Under Construction	4	3	6	9	Vertical/ Hexa AAAC Zebra
10.	765kV S/C Jabalpur – Bina transmission line	M/s Sterlite Power	07.06.2019	2015	2	5	1	6	Vertical/ Quad ACSR Bersimis
11.	220 kV D/C Bagalkot-Vajjramatti transmission line	KPTCL	09.08.2019	2001	...	-	1	1	Vertical/ ACSR Drake
12.	400 kV D/C Malwa (TPH)- Pithampur transmission line	MPPTCL	16.04.2019	2013	Medium	2	-	2	Vertical/ Twin ACSR Moose
13.	220 kV Omkareshwar Barwaha tap to Nimrani line	MPPTCL	16.04.2019	1982	Medium	1	-	1	Vertical/ ACSR ZEBRA
14.	400 kV D/C Malwa (TPH)- Pithampur transmission line	MPPTCL	02.06.2019	2013	Medium	20	4	24	Vertical/ Twin ACSR Moose
15.	400 kV D/C Rajgarh- Sardar Sarovar DCDS line	MPPTCL	11.06.2019	2002	Medium	4	1	5	Vertical/ Twin ACSR Moose
16.	220 kV D/C Jabalpur-Narsinghpur transmission line	MPPTCL	13.06.2019	Line commissioned in 1962	Line as per Old Design	1	-	1	Vertical/ ACSR Zebra
				Failed tower erected on 07.06.2019	Failed tower designed for wind zone 4				
17.	765 kV S/C Raichur Sholapur transmission line	RSTCL	03.06.2019	2014	2	6	1	7	Vertical/ Quad ACSR Bersimis
18.	400 kV D/C Motihari-Gorakhpur transmission line	DMTCL	15.08.2019	2017	4	-	1	1	Vertical/ Quad AAAC Moose
			25.09.2019			1	-	1	
19.	400 kV D/C Barh-Motihari transmission line	DMTCL	04.09.2019	2017	4	-	1	1	Vertical/ Quad AAAC Moose
			07.10.2019			1	-	1	
	Total (2019)					**67**	**23**	**90**	
20.	765 kV S/C New Ranchi-Dharamjaygarh transmission line-I	POWER GRID	21.04.2020	2014	2	3	-	3	Delta/ Quad ACSR Bersimis
21.	400 kV D/C Vindhyachal-Jabalpur Ckt I & II transmission line	POWER GRID	30.04.2020	1989	Russian Design	4	-	4	Vertical/ Twin ACKC

22.	765 kV S/C Varanasi-Fatehpur transmission line	POWER GRID	10.05.2020	2013	4	4	-	4	Delta/ Quad ACSR Bersimis
23.	765 kV S/C Sasan-Satna – I transmission line	POWER GRID	28.05.2020	2012	4	-	1	1	Delta/ Quad ACSR Bersimis
24.	765 kV S/C Sasan-Satna – II transmission line	POWER GRID	28.05.2020	2013	4	1	-	1	Delta/ Quad ACSR Bersimis
25.	400 kV D/C Agra-Sikar transmission line	POWER GRID	29.05.2020	2014	4	3	1	4	Vertical/ Quad ACSR Moose
26.	220 kV S/C RAPP C- Anta transmission line	POWER GRID	03.07.2020	2000	Medium	1	-	1	Horizontal/
27.	400 kV D/C Dulhasti- Kishenpur II & III	POWER GRID	10.09.2020	2018	4	-	2	2	Vertical/ Quad ACSR Moose
28.	765 kV S/C Anta-Phagi (Ckt-II) transmission line	RRVPNL	04.06.2020	2014	4	1	1	2	Delta/ Quad ACSR Bersimis
29.	765 kV S/C Lalitpur-Fatehabad (Agra) Ckt-I Transmission line	UPPTCL	03.05.2020	2016	4	2	-	2	Horizontal/ Quad ACSR Bersimis
30.	765 kV S/C Fatehabad – Lalitpur Ckt-I transmission line	UPPTCL	03.05.2020 & 28.05.2020	2017	4	6	2	8	Horizontal/ Quad ACSR Bersimis
31.	220 kV Malanpur-Auriya & 220 kV Mehgaon-Adani transmission line	MPPTCL	28.05.2020	1993	Medium	11	-	11	Vertical/ AAAC Zebra
32.	220 kV Malanpur-Morena (Ckt I & II) transmission line	MPPTCL	29.05.2020	2017	4	3	-	3	Vertical/ ACSR Zebra
33.	220 kV Malanpur-PGCIL (Ckt I & II) transmission line	MPPTCL	29.05.2020	2010	4	3	2	5	Vertical/ ACSR Zebra
34.	400 kV S/C Malwa TPH Pithampur Transmission line of MPPTCL	MPPTCL	26.03.2020	2013	Medium	6	1	7	Vertical/ Twin ACSR Moose
35.	220 kV D/C Shahapur/Shahabad to Kapnoor transmission line	KPTCL	17.04.2020	2003	Medium	1	2	3	Vertical/ ACSR Drake
	Total (2020)					**49**	**12**	**61**	
36.	765 kV S/C Bina-Gwalior-3 transmission line	POWER GRID	05.01.2021	2014	4	0	1	1	Delta/ Quad ACSR Bersimis
37.	765 kV S/C Jhatikara-Bhiwani Transmission Line	POWER GRID	06.05.2021	2012	4	1	-	1	Delta/ Quad ACSR Bersimis

38.	±800 kV HVDC Agra-BNC-Pole-II Transmission Line	POWER GRID	10.05.2021	2015	4	1	-	1	Horizontal/ Hexa ACSR Lapwing
39.	400 kV D/C Korba – Raipur III & IV Transmission line	POWER GRID	11.05.2021	2011	2	1	-	1	Vertical/ Twin ACSR Moose
40.	765 kV D/C Wardha-Aurangabad Transmission line	POWER GRID	27.05.2021	2014	2	5	-	5	Vertical/ Hexa ACSR Zebra
41.	400 kV S/C Korba-Bhilai-1 Transmission Line	POWER GRID	30.05.2021	1983	Medium	1	-	1	Horizontal / Twin ACSR Moose
42.	765 kV S/C Meerut-Moga Transmission Line	POWER GRID	10.06.2021	2015	4	3	-	3	Delta/ Quad ACSR Bersimis
43.	765 kV S/C Moga-Bhiwani Transmission Line	POWER GRID	12.06.2021	2012	4	-	3	3	Delta/ Quad ACSR Bersimis
44.	400 kV D/C Kaithal-Baghpat transmission line	POWER GRID	08.07.2021	2010	4	4	-	4	Vertical/ Quad ACSR Moose
45.	400 kV D/C Kishenpur-New Wangpoh (Ckt III & IV) Transmission Line	POWER GRID	23.10.2021	2017	2	-	1	1	Vertical/ Twin ACSR Moose
46.	400 kV D/C Malwa TPH -Pithampur Ckt I&II line	MPPTCL	29.05.2021	2013	Medium	5	-	5	Vertical/ Twin ACSR Moose
47.	220 kV Amarkantak-Panagar/SGTPS Birsinghpur transmission line	MPPTCL	21.09.2021	1996	Medium	2	-	2	Vertical/ ACSR ZEBRA
	Total (2021)					**23**	**5**	**28**	
	Total : **Transmission lines failed: 47** **Towers failed: 179**								

2.2 In the subject period, the 400 kV D/C Malwa (TPH)- Pithampur transmission line of MPPTCL failed four times & 400 kV D/C Narendra- Devangere transmission line & 400 kV D/C Agra – Sikar transmission lines of POWERGRID failed two times each.

2.3 The number of suspension and tension towers at various voltage level, failed during above mentioned period and discussed in the Standing Committee meeting are indicated in Table-2 below:

Table-2

Voltage Level	Utility	No. of affected Lines	No. of Towers failed					
			Suspension Towers	Tension Towers				Total No. of towers failed
			A	B	C	D	Total	
± 800 kV HVDC	POWERGRID	1	1	-	-	-	-	1
	Total	**1**	**1**	**-**	**-**	**-**	**-**	**1**
765 kV	POWERGRID	9	17	3	2	-	5	22
	Sterlite Power	2	8	-	1	6	7	15
	UPPTCL	2	8	1	-	1	2	10
	RRVPNL	1	1	-	1	-	1	2
	RSTCL	1	6	1	-	-	1	7
	Total	**15**	**40**	**5**	**4**	**7**	**16**	**56**
400 kV	POWERGRID	15	36	3	4	4	11	47
	MPPTCL	5	37	-	5	1	6	43
	DMTCL	2	2	-	-	2	2	4
	Total	**22**	**75**	**3**	**9**	**7**	**19**	**94**
220 kV	POWERGRID	1	1	-	-	-	-	1
	MPPTCL	6	21	-	1	1	2	23
	KPTCL	2	1	3	-	-	3	4
	Total	**9**	**23**	**3**	**1**	**1**	**5**	**28**
TOTAL		**47**	**139**				**40**	**179**

As can be seen from Table-2 and Fig. 1, the number of transmission lines and towers failed during the period from April 2019 to December 2021 was of 400 kV voltage level. Out of total 179 towers of 47 Nos. of transmission lines, 94 (52.5%) towers of 22 (46.8 %) transmission lines were of 400 kV voltage level. This includes the failure of thirty eight (38) towers of the 400 kV D/C Malwa (TPH)- Pithampur transmission line of MPPTCL which had failed four times in the given period.

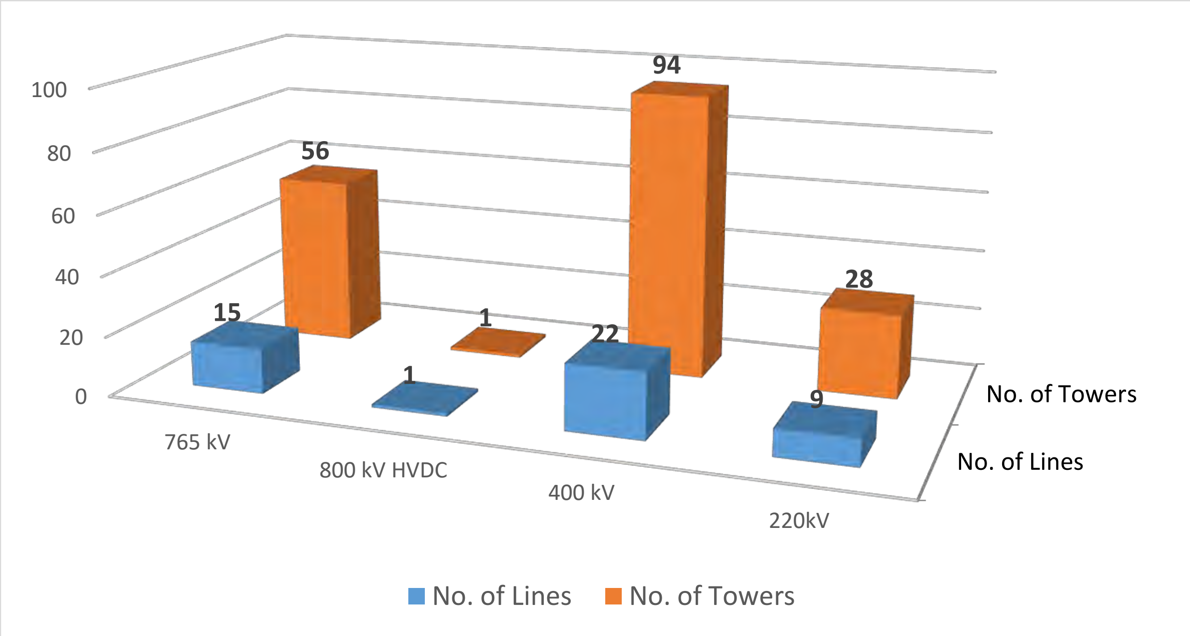

Fig. 1

2.4 The total No. of incidences of transmission line failures, and the No. of affected tension type & suspension type towers, that have been reported to CEA during the period of April, 2019 to December 2021 has been indicated in the Fig. 2 shown below. The No. of transmission lines and the No. of failed/affected towers (both suspension & tension type) in the respective years were observed to be progressively decreased during the years.

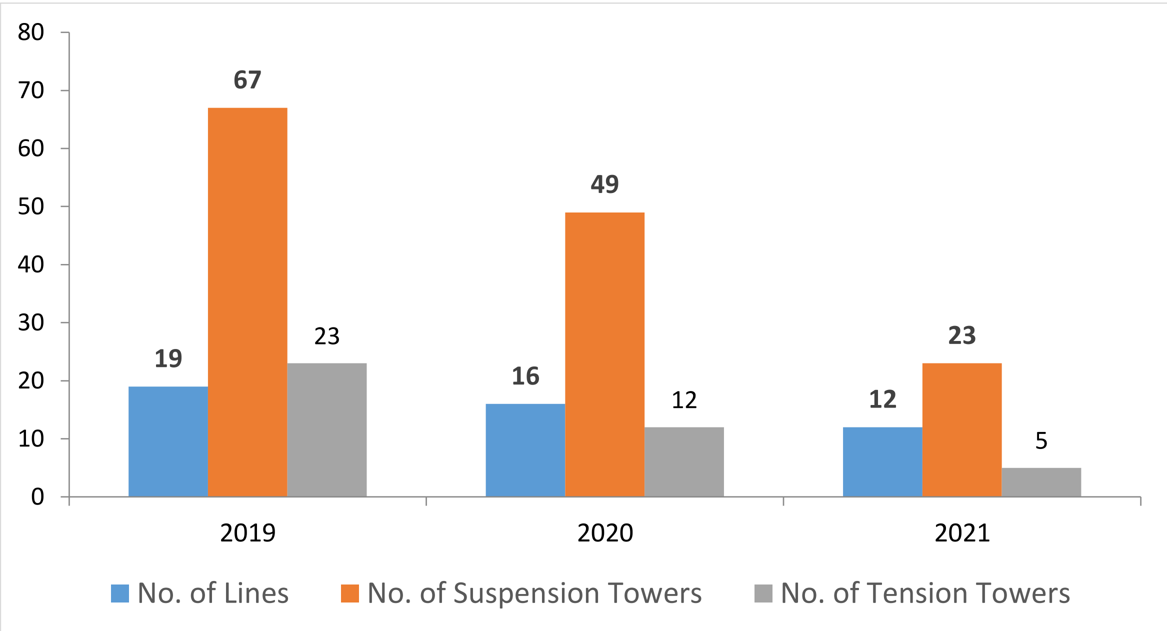

Fig. 2

Out of total 179 Nos. of failed towers, 139 Nos. (77.65%) are of suspension type towers and the remaining 40 Nos. (22.35%) are tension type towers (Fig. 3).

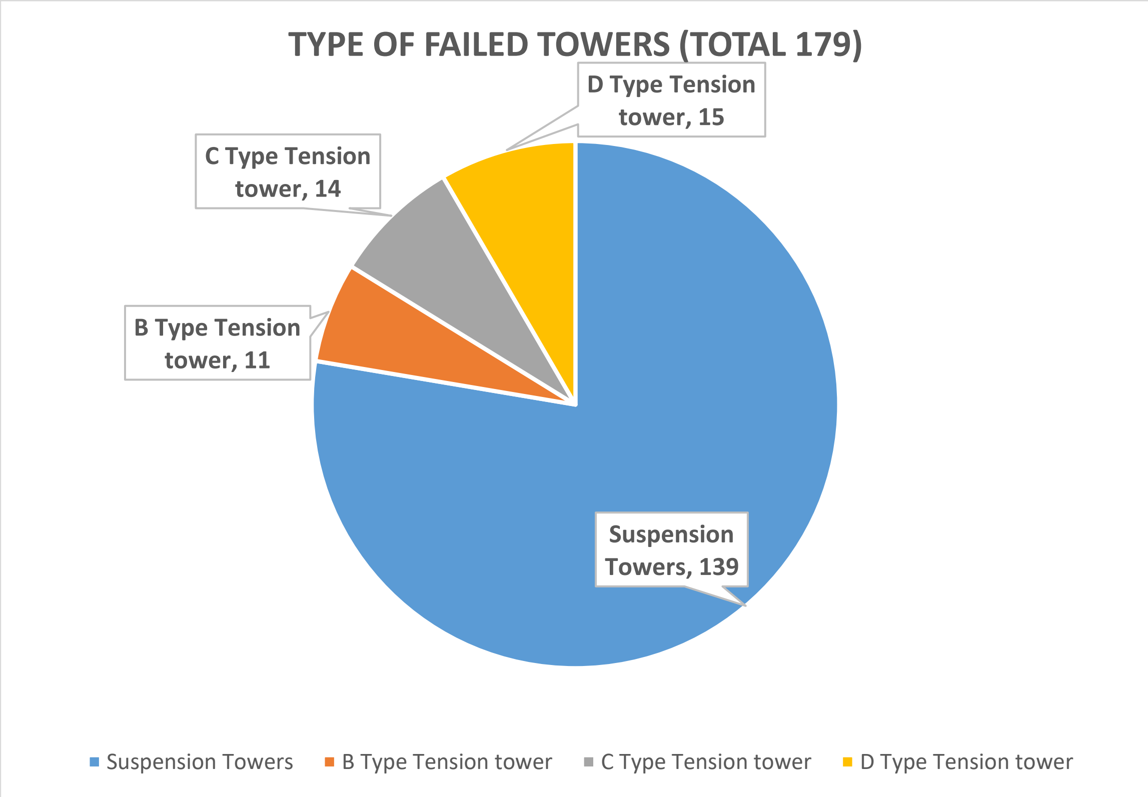

Fig. 3

2.5 It has been observed that the failure rate of suspension towers is much higher in comparison to tension towers. This may be because the Suspension towers are not designed to withstand horizontal forces in the longitudinal direction and hence the failures of one suspension type tower causes secondary failure of adjacent suspension towers due to the pulling force of conductors. It is highlighted that the loading criteria for the suspension type towers have been made more stringent and the longitudinal and transverse force acting on Suspension type towers under security condition has been increased in revised IS 802 (2015). However, none of the transmission lines failed during the period April 2019 to December 2021 was designed as per the revised IS 802 (2015). As reported by the utilities, in some of the transmission lines the suspension towers were designed considering narrow front wind condition and with 75% wind in security condition.

2.6 Before the revision of IS 802 in 1995, Indian wind map was divided into three wind pressure zones i.e. light, medium & heavy. In the third revision of IS 802 which was published in 1995, 6 wind zones were specified dividing various regions on the basis of 3 second wind gust speed. No. of transmission lines and towers, failed during the period from April 2019 to December 2021 with respect to various wind speed zones corresponding to which they were designed is given below (Fig. 4). It can be seen that the maximum No. of failures have occurred in the towers which were designed considering Wind Zone 4; also the maximum No. of transmission lines affected due to failure of towers traverse through Wind Zone 4. Further, the number of tower failure incidents & the affected transmission lines which were designed as per old IS 802:1977 for medium wind zone is also higher. It may be noted that the large percentage of the area of India was covered under the medium wind zone as per wind map given in old IS 802:1977 and as per latest wind map of India, wind zone 4 covers the large area of India.

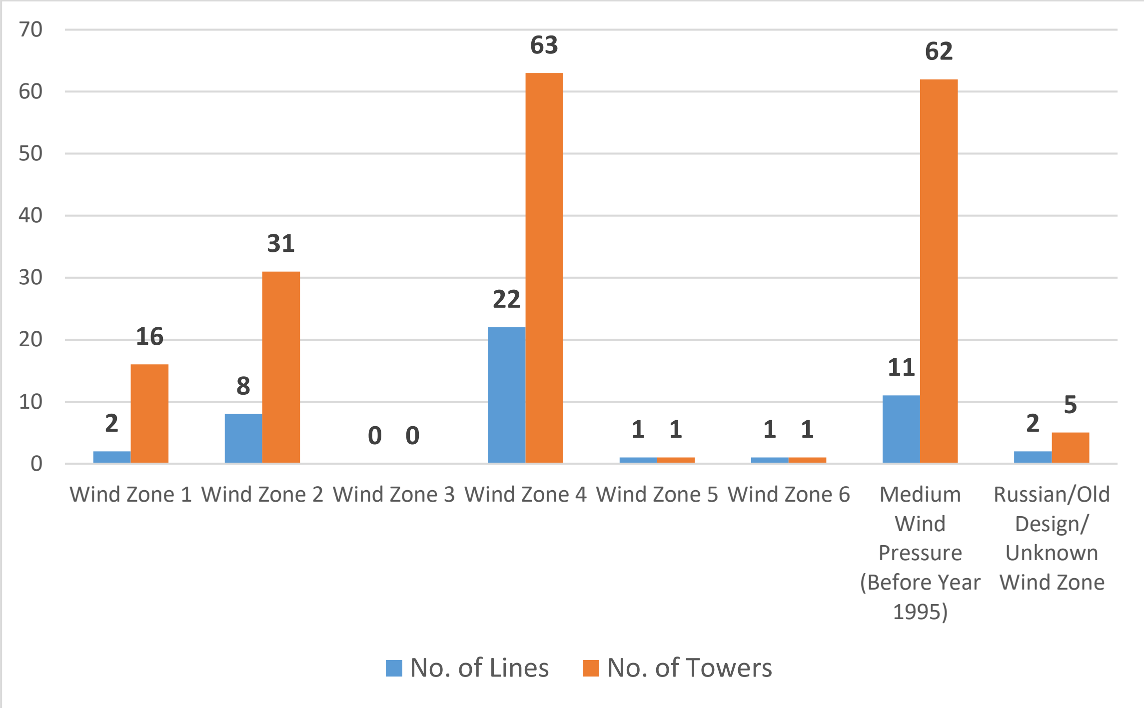

Fig. 4

2.7 Failure sites in respect of following transmission lines were jointly visited by representatives of CEA & the respective transmission utilities. Due to Covid-19 pandemic and the associated lockdown & restrictions, the No. of transmission line failure site visits by CEA officials were limited.

1. 400 kV D/C Narendra-Davangere Transmission line of POWERGRID
2. 400 kV D/C Gooty-Nellore PS Transmission Line of POWERGRID
3. 400 kV D/C Agra-Sikar Transmission line of POWERGRID
4. 765 kV S/C Bina – Gwalior-3 Transmission line of POWERGRID
5. 765 kV S/C Meerut – Moga Transmission line of POWERGRID
6. 400 kV D/C Kaithal-Baghpat Transmission line of POWERGRID
7. 400 kV D/C Motihari-Gorakhpur Transmission line of M/s DMTCL
8. 400 kV D/C Barh-Motihari Transmission line of M/s DMTCL

3.0 OBSERVATIONS OF THE COMMITTEE:

3.1 Committee observed that in cases of tower failures reported to CEA that have occurred during April 2019 to December 2021, the failure mostly can be attributed to high intensity wind, use of old IS code, use of lower reliability level, misalignment of stub, change in course of river, land slide etc. The details of all reported failures have been provided at **Appendix**.

3.2 Committee noted that as per Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, towers with more than two sub-conductors per phase and triple and quadruple circuit towers upto 400 kV are required to be designed for Reliability level 2. However, some of the 400 kV towers of the lines having conductors in Quad configuration (e.g. 400 kV Agra-Sikar transmission line, 400 kV Nellore-PS Gooty transmission line, 400 kV Dulhasti-Kishenpur-II transmission line, 400 kV D/C Kaithal-Baghpat transmission line) which have been commissioned after the notification of CEA Regulations, 2010, have been designed as per Reliability level-1 instead of Reliability level-2. Committee noted that CEA Regulations have been drafted after detailed consultation with the stakeholders and shall be adhered to in any case and the utilities shall ensure that Reliability level to be adopted for all the future transmission lines shall be in accordance to CEA Regulations.

3.3 In many of the cases the transmission utilities have attributed the cause of tower failure to high intensity wind. However, the utilities expressed their inability to make available the actual wind speed data. The Standing Committee observed that wherever cause of tower failure is reported to be wind, the utility needs to get the wind data for the area which would serve as representative wind speed prevailing in that area at the time of failure. It was agreed that the high wind velocity during storm and local condition of whirl wind might have exceeded the design wind speed for which the tower is designed, however the same could not be verified as wind data was not available. Assistance of India Meteorological Department (IMD) and other agencies involved in metrological field may be taken by the affected utilities in this regard to share the wind data obtained from observatory/ Satellite/Radar.

3.4 Committee noted that in case back to back dimensions are not in accordance to tower designs, the residual stresses may develop in the tower structure which may lead to its collapse. Committee advised utilities to ensure good erection practices and ensure that casting of chimneys and placement of stubs are done as per approved drawings. Further, in future during investigation of failed towers, wherever possible, stub setting dimensions, including back to back distance measurements, should be measured and submitted to the Committee along with the failure report.

3.5 Few cases of failure of 765 kV Single circuit Delta configuration towers of POWERGRID have been observed. It was brought to the notice of Standing Committee that the failure pattern of the 765 kV Delta configuration suspension type tower of POWERGRID have been examined in detail in the previous Standing Committee meetings including the design review analysis carried out by CPRI and the Standing committee had suggested strengthening of suspension towers (with delta configuration) of 765 kV S/C line by replacing the existing six (6) members with higher size members and adding two (2) more redundant members. POWERGRID has got reviewed this design by M/s Manitoba Hydro, Canada and they have also suggested strengthening of some of the members.

Committee was briefed by POWERGRID about the status of strengthening of such towers as advised in previous standing committee meetings. POWERGRID officials informed that, the strengthening of existing 765 kV S/C delta configuration suspension type towers which are located in Wind zone 4 & Wind zone 2, is being executed in phased manner and at present, only fifty-six (56) numbers of S/C 765 kV towers (Delta configuration) in the Western Region-1 are remaining to be strengthened. The method of strengthening of towers includes clamping of some of the members as well as replacement of few tower members. Strengthening of towers in same manner as suggested by the Standing Committee in the previous meetings, i.e. by replacement of all members, is not possible for already erected tower members as long shutdown of transmission lines will be required. However, failed towers are always replaced by completely strengthened tower in line with the recommendations of the Committee. Further, strengthening of few other tower members, as suggested by M/s Manitoba Hydro is also being adopted by POWERGRID. The tower with strengthening currently being adopted by POWERGRID (i.e. clamping of few members and replacement of some members) had also been successfully tested at the CPRI test bed.

3.6 Over the years the Indian Standards for design of transmission line tower has undergone changes. As revision of codal provisions is a continuous process, the changes are to be implemented prospectively. Strengthening of existing transmission line towers due to change in the codal provisions could be decided on case to case basis, if repeated failures are observed in a particular line.

3.7 In some of the cases, it is observed that even after the revision of IS codes, the transmission utilities have used the transmission towers which have been designed as per old IS codes. Committee noted that transmission utilities continue to use old designs of towers even after revision of IS codes to save the cost of designing & testing. Committee recommended that such type of practices should not be adopted by the utilities and it should be ensured that the transmission lines are designed and erected as per latest IS codes, Regulations and recommendations of the Standing Committee / Task Force, as applicable.

3.8 Committee deliberated on the possibility of designing of towers which are erected in open fields, with considering Terrain category-I. POWERGRID officials highlighted that out of a complete length of transmission line, there are few small sections which are located in the open areas & fall under Terrain Category-1, and it is not possible to design separate few towers specific to these locations considering Terrain Category-I factors. POWERGRID had executed a study in the Kutch area of Gujarat regarding Terrain category and it was found that the towers designed with Terrain category-II and 400 m span have to be spotted with reduced span of 370 m in locations under Terrain category-I conditions. Committee noted the above and highlighted that Utilities pay utmost care in adopting the design parameters as per the terrain category faced along the route of transmission lines.

3.9 Committee deliberated on the prospect of adopting wind speed corresponding to Wind zone-2 for designing of transmission towers located in area under Wind zone-1 and concluded that the decision of modification in wind zone cannot be taken on basis of single event of failure and holistic view based on analysis of frequency of failures of transmission lines in Wind zone-1 need to be taken. Thus, the decision to modify the wind zone can be taken at later stage in case multiple failures are observed in the Wind zone-1 area.

3.10 Committee deliberated on the likelihood of increase in the wind loads on the structures due to tunneling effect in the valley regions and the influence of topography of the location on the wind loads acting on the transmission towers. Representative from CPRI highlighted that topographical factor (of up to 30%) is included in the IEC 60826 for transmission lines located in mountains/complex topographical areas, however, at present the same is not considered in the design of transmission towers as per IS codes and this issue will be taken up in the next meeting of Bureau of Indian Standards (BIS).

3.11 Committee noted that all the utilities should intimate the failures of transmission lines timely and should provide all the relevant details/documents including images, duly filled CEA proforma, wind speed data, coordinates of failed towers, material test reports, etc, so that a proper investigation of cause of failure may be carried out. IMD and other agencies involved in metrological field may be requested to assist the affected utilities for obtaining the wind speed data of the failed tower locations.

3.12 Representative from SERC stated that in the North Western region of India, many towers had failed in past years in the pre-monsoon period. In 2016, SERC published a research paper in which it was observed that dust storms occur in the north western region particularly in the Gangatic region, every year, which may lead to tower failures. He informed that increase of 0.01% of dust in wind (by volume) will increase the load on the tower by ten (10) percent. Committee requested SERC to share the research paper and studies with the Committee for further examination and evaluation.

3.13 Committee noted that wind map of India may also need further revision as latest wind map was published by SERC in year 2009. Committee requested SERC to carry out the exercise for revision of Wind Map of India.

4.0 <u>INSIGHTS INTO TOWER FAILURE INCIDENTS DURING PAST 10 YEARS (2012-2021)</u>

4.1 The details of previous transmission line and tower failure incidents which were reported to CEA and have been discussed in the previous Standing Committee meetings from the year 2012 onwards have been analyzed by CEA.

4.2 The graph depicting the failures of towers occurred during past 10 years that have been discussed in the previous Standing committee meetings are shown below in Fig. 5. It is observed that the failure rate of suspension towers is much higher in comparison to tension towers which is due to the cascading effect of failure of suspension type towers i.e. secondary failure of adjacent suspension towers due to the pulling force of conductors which have been developed due to failure of another tower and due to the fact that in any line, suspension towers are more in numbers than tension towers (approximately 75:25 in plain area).

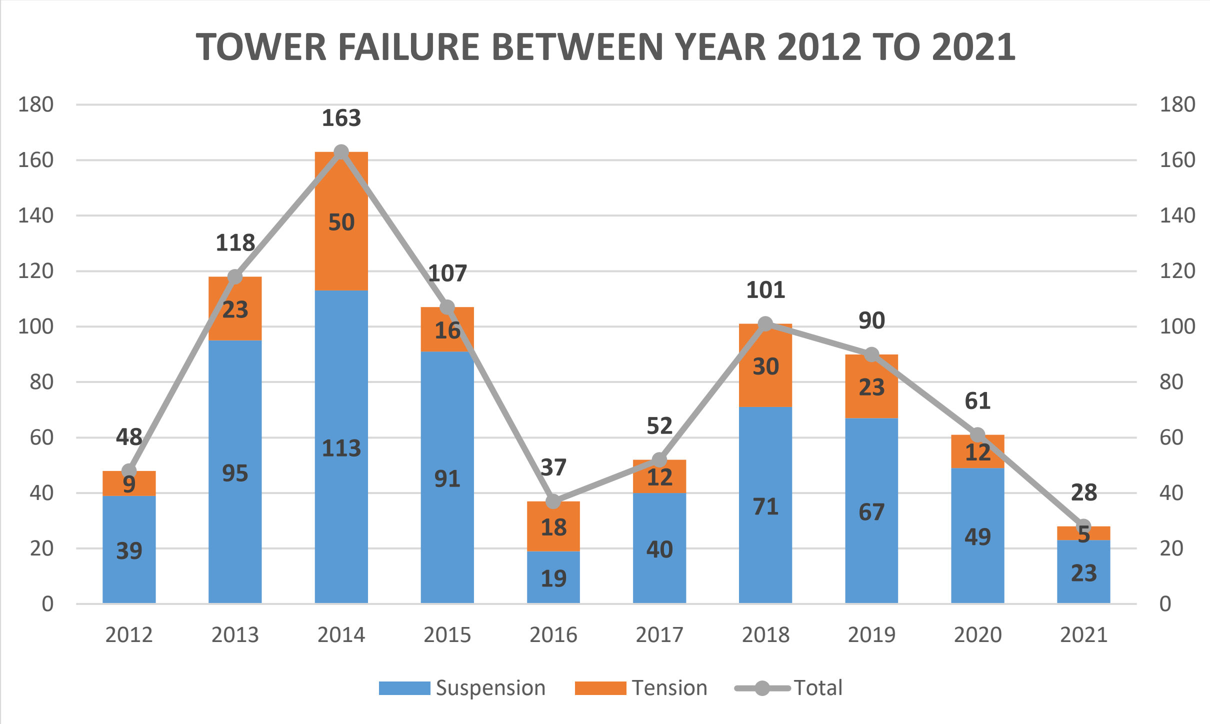

Fig. 5

4.3 The graph depicting the failures of towers at various voltage level that have occurred during past ten (10) years and intimated to CEA which have been discussed in the Standing committee meetings are shown in Fig. 6. It may be observed that towers of 400 kV voltage level have maximum incidents of failure. It may be noted that the mandate of the Standing Committee is to investigate failure of towers of 220 kV and above voltage class transmission line and the graph shows the details of only those transmission line failure which have been intimated to CEA and the large percentage of tower failure incidents reported to CEA pertains to POWERGRID which has maximum No. of transmission lines of 400 kV voltage level.

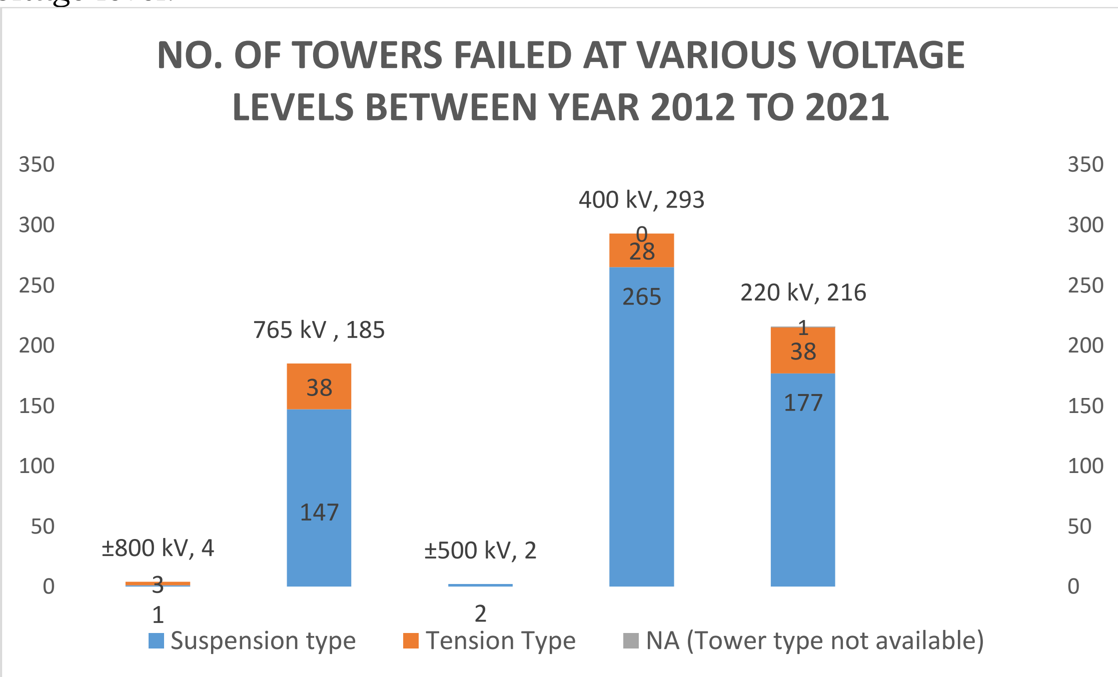

Fig. 6

5.0 RECOMMENDATIONS & REMEDIAL MEASURES SUGGESTED BY THE COMMITTEE

After detailed deliberations/discussions among all participants, the committee has recommended/suggested the following remedial measures

(a) It is observed that intensity of wind has changed in some parts of the country due to climate change and the wind map prepared by SERC in 2009 has been incorporated in the National Building Code 2016 Vol. 1 of BIS, however, IS 875 has not been amended to include this wind map. Till the time IS 875 is not revised, utilities should follow wind map given in National Building Code for designing of towers.

(b) After every failure the concerned utility needs to submit the actual wind velocity prevailed in the affected area so that the investigating team of standing committee could get reference wind speed prevailed over that area. In this matter, the respective utility may seek the help of IMD to estimate the wind speed in affected areas based on data obtained from observatory/ Satellite/Radar.

(c) In order to optimize the tower designs, the values of drag coefficient considered for flat sided tower members have been reduced in the revised version of IS:802 (Part-1/Section-1)- 2015. In the process the tower design margins got reduced. Hence, the lattice type towers shall be designed as per IS-802 (2015), however the drag coefficient considered for flat sided tower members shall be as follows:

Solidity Ratio	**Drag Coefficient**
Up to 0.05	3.6
0.1	3.4
0.2	2.9
0.3	2.5
0.4	2.2
0.5 and above	2.0

(d) Reliability level to be adopted for all the future transmission lines shall be in accordance to Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations.

(e) Additional precautions should be taken for routing of transmission lines so as to keep location of towers away from river banks. Pile type foundation shall be used for towers located in river or creek bed or on bank of river having scourable strata or in areas where river flow or change in river course is anticipated, based on detailed soil investigation and previous years' maximum flood discharge of the river, maximum velocity of water, highest flood level, scour depth & anticipated change in course of river based on river morphology data of at least past 20 years to ensure availability and reliability of the transmission line.

(f) As revision of codal provisions is a continuous process, the changes are to be implemented prospectively. Strengthening of existing transmission line towers due to change in the codal provisions could be decided on case to case basis by the Standing Committee, if repeated failures are observed in a particular line.

(g) Transmission lines to be laid within 50 km of the border of the wind zones may be designed with higher of the two zones. However, whether 50 km is appropriate or any change is required for this interface distance, shall be suggested by SERC based on studies.

(h) Utilities, while designing/erection of transmission lines in coastal areas, should follow the recommendations of "Task Force on Cyclone Resilient Robust Electricity Transmission & Distribution Infrastructure in coastal areas".

(i) Wherever, transmission lines are passing through cyclone prone areas i.e. areas upto 60 km from coast following practices shall be adhered to:

- Terrain category with terrain roughness factor (K2) shall be considered as per IS 802 (part 1/ Sec 1), as amended from time to time, for tower design.
- Importance factor for cyclonic region (K4) of 1.3 shall be considered for tower design.
- The number of consecutive spans between the section points/ angle point shall not exceed 10 spans or 3 km instead of conventional practice of 15 spans or 5 km, in order to reduce the failure of such towers in coastal areas due to cascading effect. The section shall be terminated with tension tower/ angle tower and angle of deviation should be based on the site requirement.
- The fabricated tower parts and stubs shall have a minimum overall zinc coating of 900 gram/m^2 of surface area except for plates and sections below 5 mm which shall have a minimum overall zinc coating of 610 gram/m^2 of surface area. The average zinc coating for all sections and plates 5 mm and above shall be maintained as 127 microns and that for plates and sections below 5 mm shall be maintained as 87 microns.
- Ready mix concrete of M30 Grade shall be used to avoid use of locally available saline water. However, design mix concrete of M30 Grade conforming to IS 456 with potable water can be used at locations where transportation of ready-mix concrete is not feasible. Minimum cement content in any case shall not be less than 330 kg/m^3.
- The surface of the reinforced steel shall be treated with epoxy-based coating to enhance corrosion performance of foundation. Use of epoxy coated reinforcement in foundation shall be as per IS 13620. In addition, two (2) coats of bituminous painting of minimum 1.6 kg/m^2 per coat shall be applied on all exposed faces of foundation (i.e. pedestal & base slab).
- Double coat 20 mm thick cement plaster shall be provided on all exposed concrete surface as well up to 300 mm below ground level to give protection to concrete surface from environmental and saline effect.
- Before coping of chimney top portion, three coats of anti-corrosive paint of minimum 30-35 microns dry film thickness each shall be

applied on the stub in the 50 mm coping portion as well as up to 350 mm above CL portion

(j) Due to climatic change, incidents of high winds are increasing. Transmission utilities need to take proactive measures such as increased line patrolling, immediate replacement of missing members/bolts.

(k) Utilities should take necessary precautions to ensure that there are no deficiencies such as missing members, missing bolts, bent members, incorrect attachment of cross arm, chimney covered with soil, rusted stub/members etc which are attributed to poor workmanship, erection deficiency, O&M issues etc. Utilities should carry out proper maintenance of their lines so as to avoid failure of towers due to such deficiencies.

(l) Coping of Chimneys of tower foundations, wherever required, should be taken up to avoid rusting of stubs.

(m) In case of towers in critical locations with regular high speed wind phenomenon, redundant members of tower should be designed with actual loads and non-linear analysis of tower should be carried out.

(n) Modern technique/methods should be adopted for erection & stringing of towers.

(o) The transmission towers erected near river banks should be frequently patrolled and assessment based on history should be made to anticipate the change in course of river and necessary protection should be provided to towers to avoid its damage during such incident.

(p) Best practices in quality control process for raw material, manufacturing, transportation, construction, storage, erection and stringing of towers shall be adopted.

(q) Frequency of patrolling of transmission lines should be more for the vulnerable tower locations (for thunder & cyclonic prone area, towers located close to river banks). Proper protection shall be provided for towers located in areas affected by soil erosion.

(r) Utilities shall assess the condition of structure of towers, conductors, earthwire, all associated accessories, foundation and earthing system periodically using modern techniques & diagnostic tools and shall take appropriate action, wherever abnormality is noticed.

(s) All transmission towers should be checked on topmost priority after major wind event to remove fatigue and distortions, if any, so as to restore the original strength and avoid failures in subsequent event of high intensity winds.

(t) In case of damage of foundation of towers, the foundation design is required to be examined.

(u) Material test for failed members including nuts and bolts of the tower should be carried out in NABL accredited laboratory to ascertain the quality, composition and mechanical properties of the material. Impact tests should also be conducted.

(v) Intensive care should be taken during erection and installation of towers such as Slope correctness, filling unplugged holes, tightening of Bolts, Tack welding, straightness of tower members etc.

(w) Regular patrolling of the lines is required for smooth and trouble free operation of line. During patrolling any unauthorized construction/use/ storage under & around the towers should also be checked and if such activity is observed, local administrative authority should be immediately informed for assistance and necessary action.

(x) Providing proper revetment & use of geo-synthetic material in foundation, concrete encasing & painting of stub in water logging areas etc. may also be considered, wherever required.

(y) Utilities shall ensure that casting of chimneys and placement of stubs are done as per approved drawings. Due to improper erection, residual stresses are developed in the towers which causes failure of towers.

(z) In future during investigation of failed towers, wherever possible, stub setting dimensions, including back to back distance measurements, should be measured and submitted to the Committee along with the failure report.

(aa) Practices of using towers designed as per older versions of IS codes shall not be adopted by the utilities and it shall be ensured that the transmission lines are designed and erected as per latest IS codes, Regulations and recommendations of the Standing Committee / Task Force, as applicable. The failed towers, which are designed as per old codes/Regulations shall be replaced by towers designed as per latest IS codes.

(bb) Proper geological investigation of the land mass is carried out before the spotting of tower structures and the necessary strengthening measures, for tower foundations for the hill slope, if required, shall be taken proactively, so that such incidences do not repeat and lead to failure of other towers.

(cc) In case of erection of towers with high body extensions, normally the stub setting templates are not available and props are used for erection of towers. Special precaution should be taken while erecting the towers with body extension so that the slope of stubs and back to back distance between the stubs are correctly maintained as per approved drawings.

(dd) Black (un-galvanized) towers shall not be used by the utilities in the erection of future transmission lines.

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APPENDIX

INVESTIGATION REPORTS OF FAILURE OF TOWERS OF VARIOUS TRANSMISSION UTILITIES

DETAILED REPORTS OF FAILURE OF TOWERS

A. POWERGRID

The towers of following Transmission Lines of POWERGRID had failed during above mentioned period :

S. No.	Name of the Transmission Line	Name of Utility	Date of Failure	Year of Commissioning	Wind Zone	No. of Towers Failed			Conductor
						Suspension	Tension	Total	
1.	400 kV D/C Khandwa- Indore I and II transmission line	POWER GRID	16.04.2019	2016	2	-	1	1	Vertical/ Twin ACSR Moose
2.	400 kV D/C Narendra- Devangere transmission line	POWER GRID	28.04.2019	2008	Line in WZ 1 Tension towers for WZ2 & Suspension tower for WZ1	9	1	10	Vertical/ Twin ACSR Moose
3.	400 kV D/C Pandiabili – Duburi – Baripada transmission line	POWER GRID	03.05.2019	2011	5	-	1	1	Vertical/ Twin ACSR Moose
4.	400 kV D/C Gooty – Nellore PS transmission line	POWER GRID	27.05.2019	2013	2	7	-	7	Vertical/ Quad ACSR Moose
5.	400 kV D/C Narendra- Devangere (Guttur) transmission line	POWER GRID	06.06.2019	2008	Line in WZ 1 Tension towers for WZ2 & Suspension tower for WZ1	5	1	6	Vertical/ Twin ACSR Moose
6.	400 kV D/C Agra – Sikar transmission line	POWER GRID	12.06.2019	2014	4	2	1	3	Vertical/ Quad ACSR Moose
7.	400 kV D/C Silchar – Meliriat transmission line	POWER GRID	19.07.2019	2018	6	-	1	1	Vertical/ Twin ACSR Moose

8.	400 kV D/C Kishanganj – Patna transmission line	POWER GRID	06.08.2019	2016	4	-	1	1	Vertical/ Quad ACSR Moose
	Total (2019) Transmission lines failed : 8					**23**	**7**	**30**	
9.	765 kV S/C New Ranchi-Dharamjaygarh transmission line-I	POWER GRID	21.04.2020	2014	2	3	-	3	Delta/ Quad ACSR Bersimis
10.	400 kV D/C Vindhyachal-Jabalpur Ckt I & II transmission line	POWER GRID	30.04.2020	1989	Russian Design	4	-	4	Vertical/ Twin ACKC
11.	765 kV S/C Varanasi-Fatehpur transmission line	POWER GRID	10.05.2020	2013	4	4	-	4	Delta/ Quad ACSR Bersimis
12.	765 kV S/C Sasan-Satna – I transmission line	POWER GRID	28.05.2020	2012	4	-	1	1	Delta/ Quad ACSR Bersimis
13.	765 kV S/C Sasan-Satna – II transmission line	POWER GRID	28.05.2020	2013	4	1	-	1	Delta/ Quad ACSR Bersimis
14.	400 kV D/C Agra-Sikar transmsison line	POWER GRID	29.05.2020	2014	4	3	1	4	Vertical/ Quad ACSR Moose
15.	220 kV S/C RAPP C- Anta transmission line	POWER GRID	03.07.2020	2000	Medium	1	-	1	Horizontal/
16.	400 kV D/C Dulhasti- Kishenpur II & III	POWER GRID	10.09.2020	2018	4	-	2	2	Vertical/ Quad ACSR Moose
	Total (2020) Transmission lines failed : 8					**16**	**04**	**20**	
17.	765 kV S/C Bina-Gwalior-3 transmission line	POWER GRID	05.01.2021	2014	4	0	1	1	Delta/ Quad ACSR Bersimis
18.	765 kV S/C Jhatikara-Bhiwani Transmission Line	POWER GRID	06.05.2021	2012	4	1	-	1	Delta/ Quad ACSR Bersimis
19.	±800 kV HVDC Agra-BNC-Pole-II Transmission Line	POWER GRID	10.05.2021	2015	4	1	-	1	Horizontal/ Hexa ACSR Lapwing
20.	400 kV D/C Korba – Raipur III & IV Transmission line	POWER GRID	11.05.2021	2011	2	1	-	1	Vertical/ Twin ACSR Moose
21.	765 kV D/C Wardha-Aurangabad Transmission line	POWER GRID	27.05.2021	2014	2	5	-	5	Vertical/ Hexa ACSR Zebra
22.	400 kV S/C Korba-Bhilai-1 Transmission Line	POWER GRID	30.05.2021	1983	Medium	1	-	1	Horizontal / Twin ACSR Moose

23.	765 kV S/C Meerut-Moga Transmission Line	POWER GRID	10.06.2021	2015	4	3	-	3	Delta/ Quad ACSR Bersimis
24.	765 kV S/C Moga-Bhiwani Transmission Line	POWER GRID	12.06.2021	2012	4	-	3	3	Delta/ Quad ACSR Bersimis
25.	400 kV D/C Kaithal-Baghpat transmission line	POWER GRID	08.07.2021	2010	4	4	-	4	Vertical/ Quad ACSR Moose
26.	400 kV D/C Kishenpur-New Wangpoh (Ckt III & IV) Transmission Line	POWER GRID	23.10.2021	2017	2	-	1	1	Vertical/ Twin ACSR Moose
	Total (2021) **Transmission lines failed : 10**					**17**	**4**	**21**	
	Total : **Transmission lines failed (POWERGRID): 26** **Towers failed: 71**								

DETAILS IN RESPECT OF EACH TRANSMISSION LINE

A.1 400 kV D/C Khandwa-Indore I & II transmission line failed on 16.04.2019

[Tower at Location No.196 (DD+0)]

➢ **Brief Background**

400 kV D/C Khandwa-Indore I & II transmission line of POWERGRID was commissioned in July 2016. The towers of this line were designed as per IS 802 (1995) considering Wind zone 2 with Twin ACSR Moose conductor in vertical configuration with Porcelain Disc insulators.

➢ **Observations**

a. The 400 kV Khandwa-Indore transmission line of POWERGRID was crossed over between tower locations 196(DD+0)-197(DC+9) by the 765 kV Khandwa - Dhule D/C transmission line of M/s Sterlite Power. At the time of failure incident, the 765 kV Khandwa - Dhule D/C transmission line with Hexa AAAC Moose conductor per bundle configuration was under construction, however, the stringing of crossing span between Towers AP4/0 and AP5/0 was complete.

b. As reported by POWERGRID, on 16.04.2019, there was high speed wind conditions in the affected area (village Toksar near Sanavad) during which the crossing Towers AP4/0 and AP5/0 of 765 kV D/C Khandwa-Dhule line of M/s Sterlite collapsed due to which the conductors of this line fell over POWERGRID's 400 kV D/C Khandwa-Indore Line in the span between towers 196-197.

c. Due to falling of Hexa AAAC Moose conductor on the span, the tower at Location No. 196 (DD+0)) was damaged from above waist level. Both earthwire peaks and two cross arms of the tower were damaged. The conductor and insulators in the span were also damaged. At Location No. 197 (DC+9) tower was intact, however, the insulators were observed to be damaged.

Location No. 196(DD+0)

➢ **Committee Observations and Recommendations :**

Committee noted the above and concluded that the failure of transmission tower of POWERGRID located at 196 (DD+0) was due to the sudden impact of Hexa Bundle conductors of 765 kV D/c line of M/s Sterlite Power falling on it.

A.2 400 kV D/C Narendra-Davangere Transmission line failed on 28.04.2019

[Towers at Location No. 237 (DA+6), 238 (DA+3), 239 (DA+3), 240 (DA+0), 241 (DA+3), 242 (DA+0), 243 (DA+3), 244 (DB+0), 245 (DA+3), 246 (DA+0)]

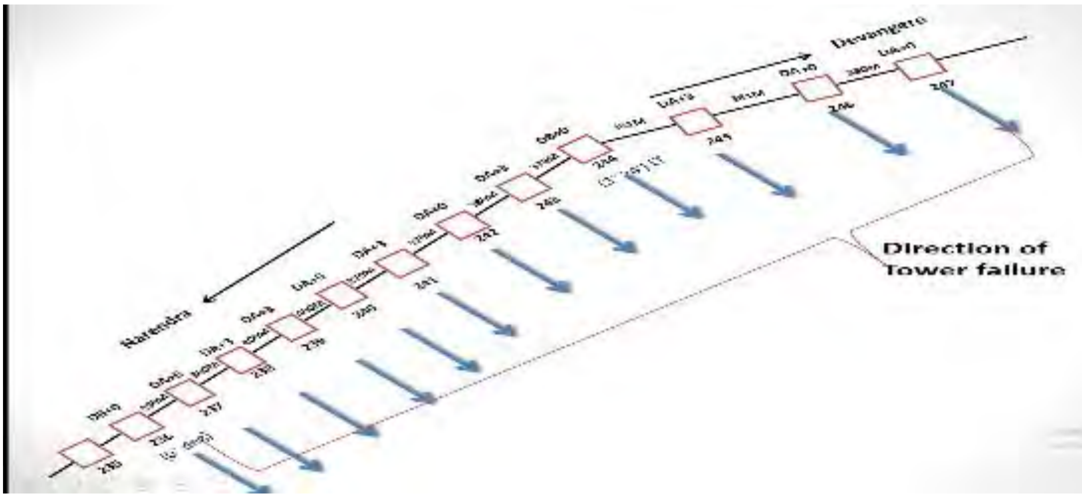
➢ **Brief Background**

400 kV D/C Narendra-Davangere line was designed by POWERGRID itself and was constructed by M/s L&T. The line was commissioned in February 2008 and total length of the transmission line is 155.5 km and falls under Wind Zone 1 as per the wind map provided in IS code. The suspension towers used in the line were designed for Wind Zone 1 (33 m/s) and

tension towers were designed for Wind Zone 2 (39 m/s). These towers have been designed as per the provision of IS 802-1995 in vertical configuration with Twin Moose ACSR Conductor. The towers were designed considering Terrain category-II. The line was constructed using Porcelain Disc insulators, however, in year 2012-13, the Disc insulators in suspension towers were replaced by Composite Long Rod (CLR) insulators. This line was in successful operation for last 11 years since commissioning and this was the first incident of failure.

➤ **Observations:**

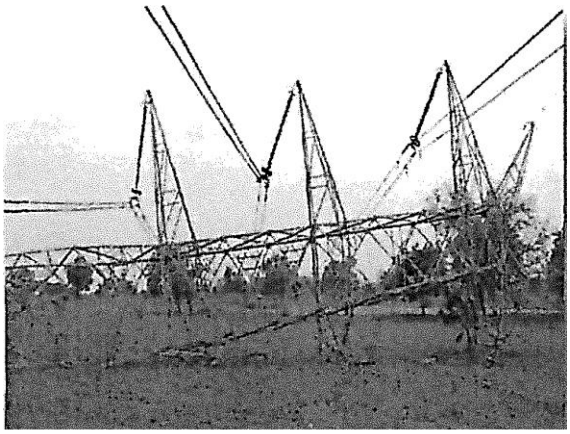
a. The affected tower locations 237 to 246 were located in undulated agriculture field with few trees in vicinity near village Kadkol, Savanur Taluk in Haveri district (Karnataka). All the ten towers had fallen in the direction perpendicular to the line. Indicative diagram of the fallen towers is shown below:



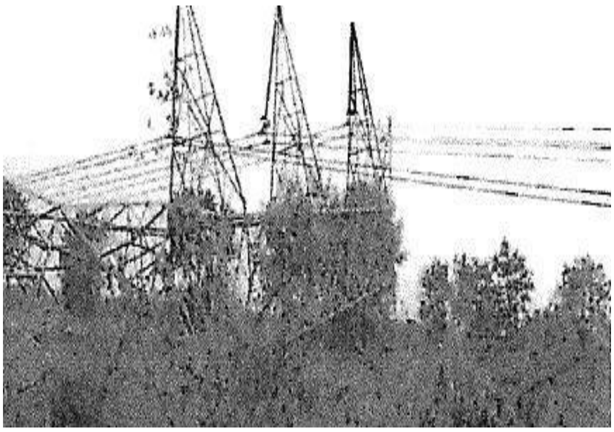
b. All the affected towers were collapsed completely to the ground in transverse direction of the line. The details of damaged towers are as follows:

SI. No.	Loc. No.	Tower Type	Span (in m)	Angle of Dev.	Extent of Damage
1	**237**	DA+6	360	NIL	• Tower collapsed completely. • All the four stubs were intact. • Minor damage to chimney at leg C was observed. Coping of the chimney was also damaged.
2	**238**	DA+3	400	NIL	• Tower collapsed completely. • Stub cleat of Leg C & Leg D of the tower were damaged & other two stubs along with foundation & chimney were intact.
3	**239**	DA+3	400	NIL	• Tower collapsed completely. • All the four stubs of the tower along with foundation and chimney were intact.

4	**240**	DA+0	370	NIL	• Tower collapsed completely. • All the four stubs of the tower along with foundation and chimney were intact.
5	**241**	DA+3	370	NIL	• Tower collapsed completely. • Stubs were observed to be bent, though foundations were intact.
6	**242**	DA+0	380	NIL	• Tower collapsed completely. • Stubs were observed to be bent, though foundations were intact.
7	**243**	DA+3	378	NIL	• Tower collapsed completely. • Stubs were observed to be bent, though foundations were intact.
8	**244**	DB+0	381	$3^{o}24'$ LT	• Tower collapsed completely. • Tower members below first cross arm level were badly damaged and entangled.
9	**245**	DA+3	381	NIL	• Tower collapsed completely. • The land at tower location was with gradient. The fall of the tower was towards the slope. • Stubs (cleats) of leg C & Leg D of the tower were failed. Other two stubs and chimney were intact.
10	**246**	DA+0	380	NIL	• Tower collapsed completely. • All the four stubs of the tower along with foundation and chimney were intact.

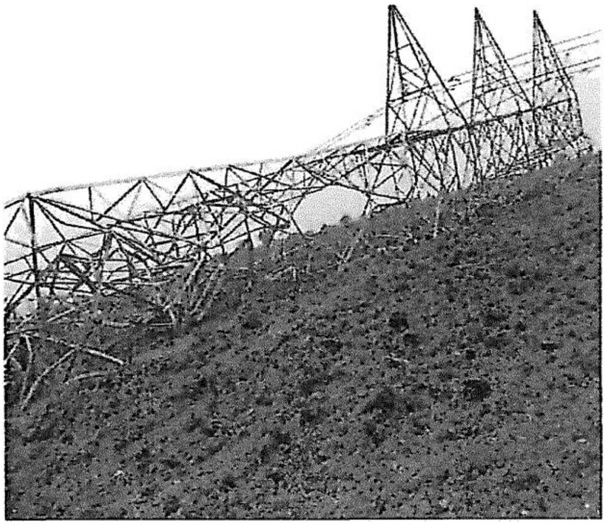


Tower at Loc. No.237 (DA+6)

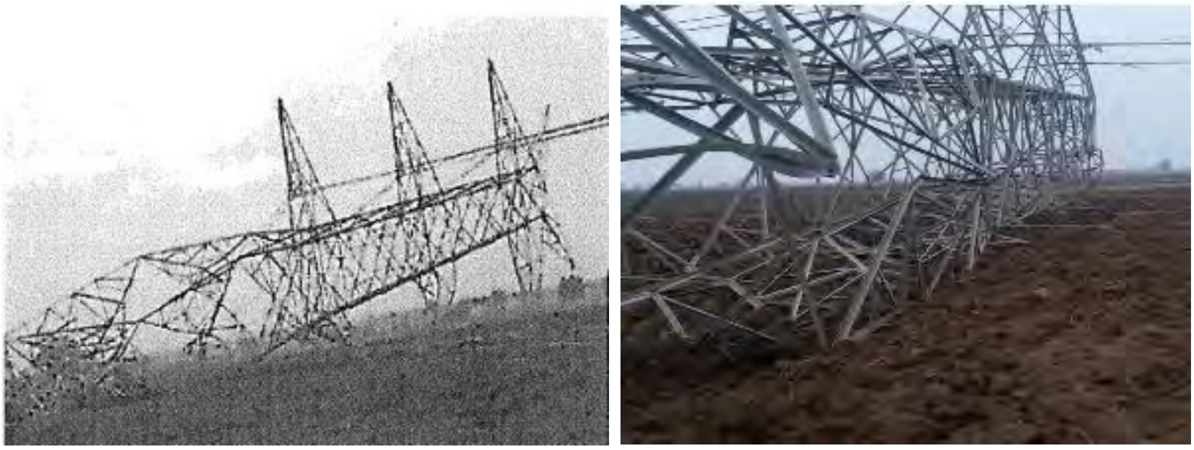


Tower at Loc. No. 238 (DA+3)

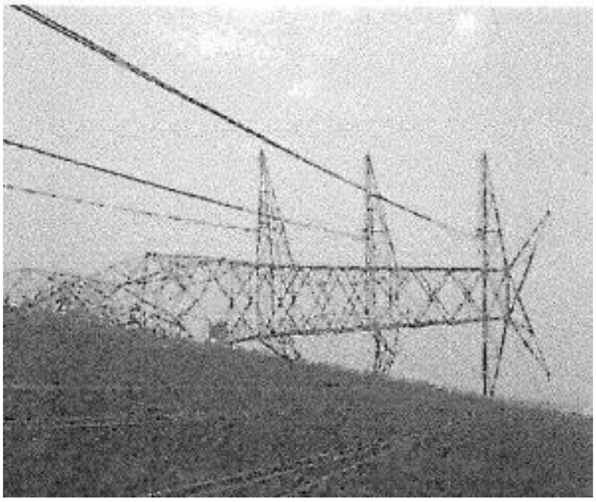
Tower at Loc. No. 239 (DA+3)



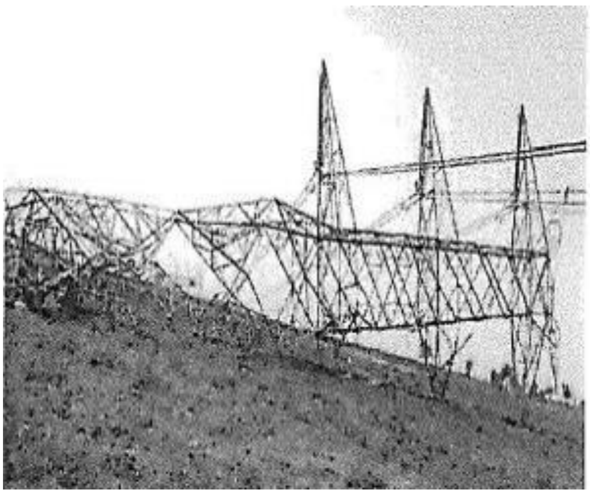
Tower at Location No.240 (DA+0)



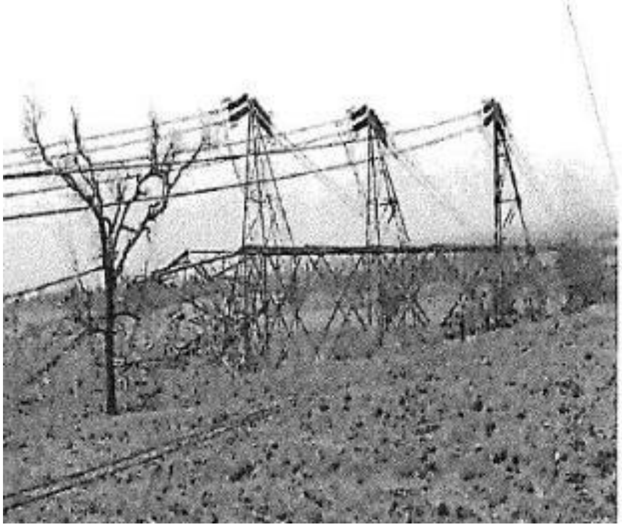
Tower at location No. 241 (DA+3)



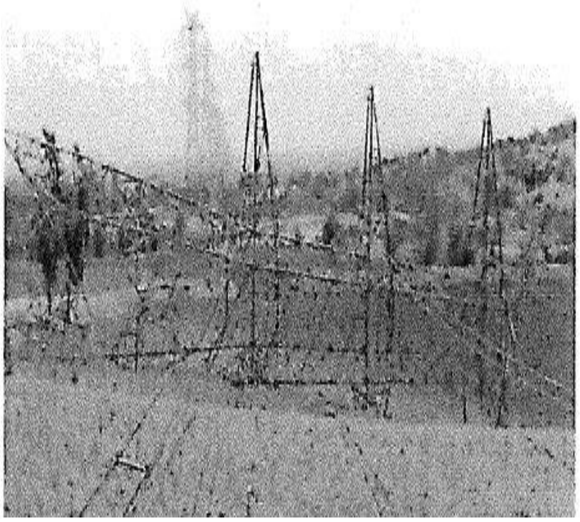
Tower at location No. 242 (DA+0)



Tower at location No. 243 (DA+3)



Tower at location No. 244 (DB+0)



Tower at location No. 245 (DA+3)

c. Representative from POWERGRID informed that the affected tower structures were examined and any of the tower members/ nut & bolts were not observed to be missing from the tower structures. Further, samples of tower parts were collected by CPRI from the tower failure site and testing was carried out by them. All the tower steel samples were found acceptable as per the relevant Indian Standards.

d. POWERGRID representative informed that, discussion was held with nearby local village residents and it was gathered that thunderstorm condition with high wind velocity prevailed in the area and the tower failure was initiated due to this high intensity localized wind observed during the storm. It was informed that the above windstorm has also caused damages to nearby trees. The same was reported in local newspapers as well.

e. Ministry of Power vide its order dated 02.09.2019 advised POWERGRID to carry out the detailed investigation of the cause of failure of towers of this line. Accordingly, a committee comprising of members from CEA, CPRI & CTU was constituted. The committee visited the tower failure site in January 2020 and key observations of the committee are as follows:

- There were very few obstructions in the vicinity of the transmission line to dampen the intensity of wind speed caused due to thunderstorm.
- Tower foundation chimneys were covered in the soil and surrounded by long grass.
- Stub levelling difference at the top of the stubs & Longitudinal and traverse deflections of tower were within limits.
- Coping of some of the chimneys were found damaged & due to ingress of water to the chimney, stubs were rusted.

- To ascertain the quality and workmanship of the concreting work done for the foundations, Non-Destructive Testing (NDT) – Rebound Hammer Test was conducted at locations 226 and 220 of the line in the presence of the Committee Members.
- The towers have been constructed generally in order and no major structural deficiency has been observed.
- The basic dimensions of the foundations, galvanization thickness on the tower parts, section sizes and type of steel (MS or HT) were found to be within the permissible tolerance limits.
- Extra/additional holes on the main legs and other tower members were not plugged with nut & bolt in few towers. Pitting corrosion on the face of the bracing was observed.

- Committee concluded that the combined effect of deficiencies in the erection and maintenance of transmission line like corrosion of stubs & bracings, unplugged holes etc and the wind storm observed in the area might have caused the failure of towers. Since, wind speed data during the storm was not available, it was not possible to ascertain whether the wind speed exceeded the specified wind speed corresponding to Wind Zone 1 (33 m/s) for which tower has been designed.

➢ **<u>Committee Observations and Recommendations :</u>**

Committee noted that nine (9) out of total ten (10) failed towers were of the suspension type. Further, the failed towers were located in the open field areas with very few trees/vegetation around the

towers, however, these were designed considering Terrain Category-II. Committee also noted that some of the erection and O&M deficiencies, like unplugged holes, rusting of stubs & bracings etc. improper coping of the chimney & covered in the grass, etc. were observed by the committee constituted to examine the failure incident.

Committee also noted that the towers were observed to be constructed generally in order and no major structural deficiency has been observed by the team which visited the tower failure site. Further, the chemical & strength tests conducted on the tower samples were found to be in order.

Committee concluded that the high wind velocity might have prevailed in the vicinity of transmission line in the transverse direction leading to failure of towers. However, wind speed data received from any authenticated observatory indicating speed of wind prevailing at the failure location at the time of the failure is not provided by the transmission utility. In absence of wind speed data from authenticated observatory, it is not possible to conclude that wind speed might have exceeded the design wind speed.

Committee suggested that the patrolling frequency of the line may be increased. Committee noted that the small deficiencies in the tower structure may lead to its collapse in the event of occurrence of high speed wind. Committee advised that utilities should improve their erection and operation & maintenance practices and ensure that structural strength is not compromised due to deficiencies like, unplugged holes, rusting of stubs, etc.

A.3 400 kV D/C Pandiabili -Duburi- Baripada transmission line failed on 03-05-2019

[Location No. 717 (DD+25+4m RC)]

- **Brief Background**

The portion of 400 kV D/C Pandiabili-Duburi-Baripada transmission line in which the tower collapsed, was constructed by M/s Tata Projects Ltd and the line was commissioned on 01.09.2011. Total length of the transmission line from Baripada to Pandiabili is 300 km. One Circuit of the line has been made LILO at Duburi substation of OPTCL. The length of Baripada to Duburi is 188.76 km and Duburi to Pandiabili-is 127.28 km. This is the first incident of tower failure in the transmission line.

As per wind map in IS -802 & IS -875, this line falls under wind zone -V (50 m/s). Towers of this line were designed for Wind Zone-5 (basic wind speed of 50 m/sec) and reliability level 1 as per IS 802-1995 for ACSR twin moose conductor with double tension disc insulator strings.

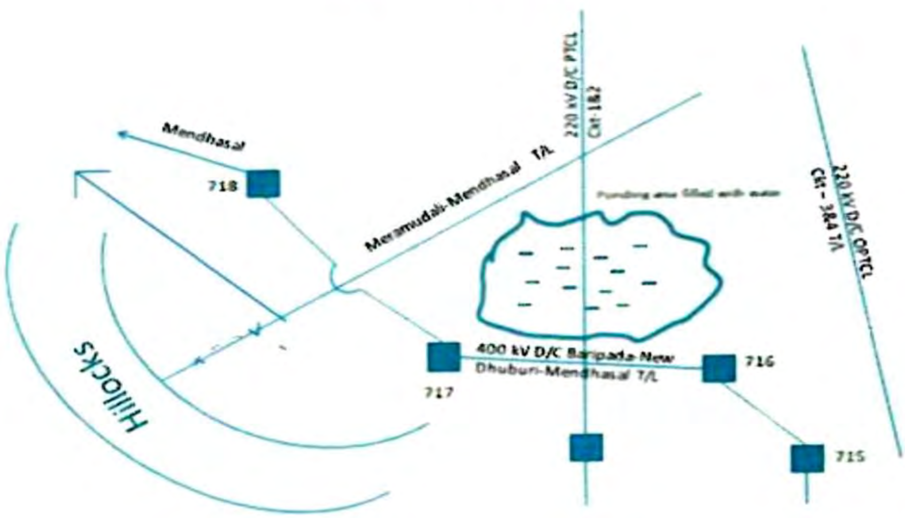
➢ **Observations**

f. The details of tower spotting in the relevant sections are as follows:

No.	Loc. No.	Type of Tower	Forward Span (m)	Angle of Dev.
1	715	DA		Nil
			330	
2	716	DD+9		30^{0}29M8 LT
			165	
3	**717**	**DD+25+4m RC**		**44051 '08' RT**
			170	
4	718	DD+25+4m RC		31 ^{0}5444 'LT
			372	
5	719	DB+0		

g. As reported by POWERGRID, the affected tower was situated in plain field with few trees in vicinity. On one side of the location, there was a hill at about 75 m-100 m distance, whereas other side was plain land with few undulations and sparse low height vegetation. In forward and backward span of collapsed tower, line was crossing over 400 kV D/C and 220 kV D/C (ckt-I & II) lines of OPTCL.

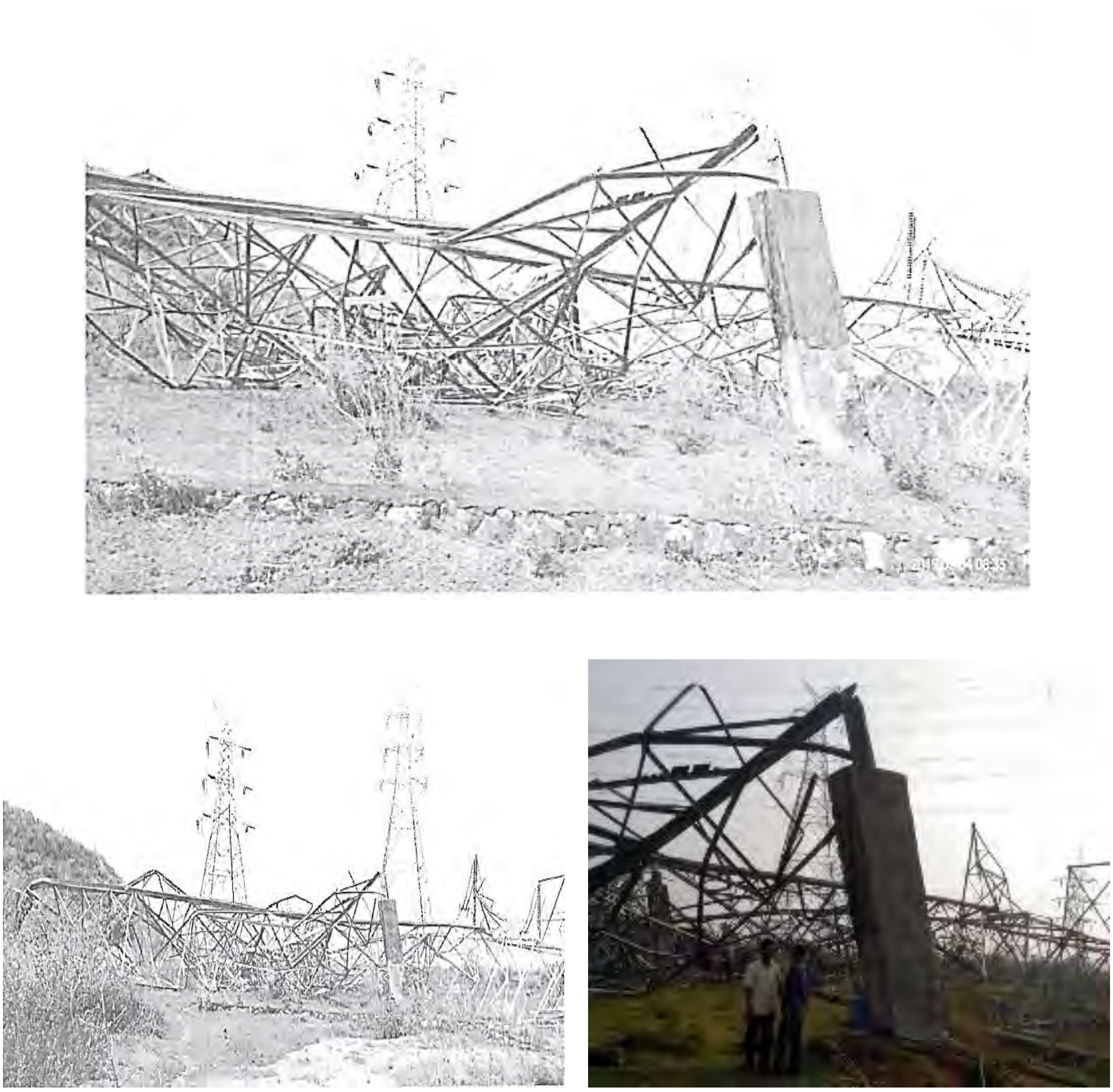
Tower Failure Location Details



h. As reported by POWERGRID, the tower located at Location No. 717 (DD+25+4 RC) collapsed completely on the ground in the transverse direction. The Main leg/stubs of the failed tower were double angle (star angle) parts. In three legs out of four legs, one of star angle section got torn near joint with stub, whereas in fourth leg, one of the angle section of the stub was torn.

i. The cyclone "Fani", which was categorized by IMD as extremely severe Cyclone with a gust wind speed ranging upto 200 kmph, made its landfall on the coast of Odisha on 02.05.2019. The impact of cyclone severely affected the transmission & distribution infrastructure in the State of Odisha. The intensity of the wind might have increased due to plain area with few vegetation in the vicinity of collapsed tower on the one side and the hill on the other side.

j. As reported by POWERGRID, the tower foundations were also checked for any damage and no failure of foundation was observed except the damage in chimney portion of foundation of one leg. The towers were checked thoroughly and no members and bolts & nuts were found missing.



Tower at location No. 717 (DD+25+4m RC)

➢ **Committee Observations and Recommendations :**

The massive damage to trees, electric poles, and public properties were observed due to the Cyclone "FANI" and as per the press release issued by IMD high gust wind speed were observed in the region. Committee observed that the failure of tower has taken place during the impact of Fani cyclone due to which high wind speed may have been observed at the failed tower location which led to failure of tower. The failed tower was designed with +25 m body extension and the chimney was raised with +4 m. The effect of high speed wind may have further increased due to increased height of tower and also due to topography of the area (i.e. nearby hills).

The recommendations of "Task Force on Cyclone Resilient Robust Electricity Transmission & Distribution Infrastructure in coastal areas" should be followed by utilities while designing/erection of transmission lines in cyclone affected area. Committee suggested that frequency of patrolling of transmission lines should be more for the vulnerable tower locations particularly in thunder & cyclone prone areas.

A.4 400 kV D/C Gooty-Nellore PS Transmission Line failed on 27.05.2019

[Towers at Location Nos. 546 (DA+0), 547 (DA+0), 548 (DA+0), 549 (DA+0), 550 (DA+0), 551 (DA+0) & 552 (DA+9)]

➢ **Brief Background**

400 kV D/C Gooty-Nellore PS transmission line of was designed by POWERGRID itself and executed by M/S KPTL. The transmission line was commissioned in April 2013. Total length of the line is 289 km. This line falls under wind zone - 2 (39 m/s) as per wind map provided in IS -802 & IS -875. The towers used in this line were designed as per IS 802-1995 for Reliability level 1 with vertical configuration having Quad Moose ACSR Conductor and one OPGW & one normal earth wire. Porcelain Disc insulator string was used in the line. As reported by POWERGRID, this line is in successful operation since commissioning and this was the first incident of tower failure in this line.

➢ **Observations**

a. The details of tower spotting in the relevant sections are as follows:

Sl. No.	Loc. No.	Type of Tower	Forward Span (m)	Angle of Dev.	Extent of damage
1	544	DA+0	395 m	Nil	Intact
2	545	DB+0	400 m	0°32'23" LT	Intact
3	**546**	**DA+0**	**400 m**	**Nil**	**One top cross arm damaged**
4	**547**	**DA+0**	**400 m**	**Nil**	**Collapsed**
5	**548**	**DA+0**	**395 m**	**Nil**	**Collapsed**

6	**549**	**DA+0**	**395 m**	**Nil**	**Collapsed**
7	**550**	**DA+0**	**395 m**	**Nil**	**Collapsed**
8	**551**	**DA+0**	**360 m**	**Nil**	**Collapsed**
9	**552**	**DA+9**	**378 m**	**Nil**	**Collapsed**
10	553	DB+3	412 m	2 °0'25" RT	Intact

b. All the affected towers were suspension type towers. The towers at location nos. 547 (DA+0), 548 (DA+0), 549 (DA+0), 551 (DA+0), 552 (DA+9) were completely collapsed & lying on ground and tower at location No. 550 (DA+0) was damaged above the 2nd panel level and tower at location No. 546 (DA+0) was intact however, damaged from top cross arm only. Anti-climbing device were provided and no missing of tower members observed in any of the tower.

c. **Tower at Location No. 546 (DA+0)** was located in plain terrain. When facing towards Gooty, the left side top cross arm of the tower was observed to be broken and conductor had fallen on ground. The rest of the tower structure was intact. All the foundation chimneys & stubs were intact. All Chimneys were above ground level. Anti-climbing device, name plate of tower, danger plate and phase sequence plate were provided.

Tower loc. No. 546 (DA+0)

d. **Tower at Location No. 547 (DA+0)** was completely collapsed to the ground from the stub level in transverse direction, towards left side when observed facing Gooty. All the four stubs of the tower were bent. Coping of legs were damaged due to the impact of falling tower. Chimney of leg A & leg C were damaged and other two chimneys were intact. Rusting at the bottom end of all the stubs and nuts & bolts (near to chimney) was observed. No missing tower members/nut bolts were observed in the failed tower.

Tower loc. No. 547 (DA+0)

e. **Tower at Location No. 548 (DA+0)** was completely collapsed to the ground from the stub level in transverse direction towards left side when observed facing Gooty. All four stubs of the tower were bent. Rusting at the bottom end of all the stubs (near to chimney) was observed. All chimneys were almost covered in the soil and found damaged. Coping of legs were damaged. No missing tower members/ nut bolts were found.

Tower loc. No. 548 (DA+0)

f. **Tower at Location No. 549 (DA+0)** was completely collapsed on the ground from the stub level in transverse direction towards left side when observed facing Gooty. All foundation chimneys were almost covered in the soil & grass. Rusted stub of Leg A was broken from bottom end (near to chimney) and the remaining three were bent. No missing tower members/ nut bolts were found.

Tower loc. No. 549(DA+0)

g. **Tower at Location No. 550 (DA+0)** was bent from 1st panel level and collapsed to the ground in transverse direction to the line towards left side when observed facing Gooty. All four stubs of the tower were bent. Rusting of all stubs, nuts & bolts at the bottom end of stubs (near to chimney) was observed. Coping of legs were damaged due to the impact of falling tower. No missing tower members/ nut bolts were found.

Tower loc. No. 550 (DA+0)

h. **Tower at Location No. 551 (DA+0)** was completely collapsed to the ground from the stub level in transverse direction towards left side when observed facing Gooty. All four stubs of the tower were bent.

Tower loc. No. 551 (DA+0)

i. **Tower at Location No. 552 (DA+9)** was located in plain terrain. The tower had completely collapsed to the ground from the stub level in transverse direction towards left side when observed facing Gooty. The Stub of leg D was observed to be not in centre of chimney. Stubs of Leg C & Leg D were broken from bottom end (near to chimney) and the remaining two stubs were bent. Rusting at the bottom end of stubs (near to chimney) was observed. Chimneys were found to be damaged.

Tower loc. No. 552 (DA+9)

j. As reported by POWERGRID officials, a high intensity localized wind prevailed near Kajhwan village, which was confirmed by broken tree branches, damage to the teen sheds of houses located in the vicinity of failed towers, damage to the wall & teen sheds of a Dal Mill located near by the failed towers etc. Numerous concrete poles of 11 kV line were also damaged. The same was confirmed by local people and was reported in the local newspapers. However, no damages was observed in the 765 kV D/C Kurnool-Kadapa line, one 220 kV D/C Transmission line and under construction 800 kV HVDC Raigarh-Pugalur transmission line which are traversing parallel/nearby to the 400 kV D/C Gooty-Nellore Transmission line.

➢ **Committee Observations and Recommendations :**

Committee noted that the transmission line has been commissioned after the notification of CEA (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2010. As per this Regulation, towers for transmission line with quad conductor configuration is to be designed for Reliability level-2. However, the

towers were designed as per Reliability level-1 which are inferior to towers designed for Reliability level 2.

Committee also observed that there are deficiencies in the erection of transmission line i.e. the mis-alignment of stub (i.e. tower legs not located in the centre of the chimneys) in Leg D of tower at location No. 552 (DA+9). The photographs of such observations were shared with the Committee. Committee deliberated on the impact of stubs being offset from the chimney, on the tower structure and noted that in case back to back dimensions are not in accordance to tower designs, the residual stresses may develop in the tower structure which may lead to its collapse.

The committee noted the above and concluded that due to improper erection, residual stresses were developed in the towers and these have failed due to loads developed due to high wind speed observed in the area on the date of failure.

Committee noted that CEA Regulations have been drafted after detailed consultation with the stakeholders and shall be adhered to in any case and advised POWERGRID to ensure that Reliability level to be adopted for all the future transmission lines shall be in accordance to CEA Regulations.

Committee also advised utilities to ensure good erection practices and ensure that casting of chimneys and placement of stubs are done as per approved drawings. Further, in future during investigation of failed towers, wherever possible, stub setting dimensions, including back to back distance measurements, should be measured and submitted to the Committee along with the failure report.

It was emphasized that after every failure the concerned utility needs to submit the actual wind velocity prevailed in the affected area so that the investigating team of standing committee could get reference wind speed prevailed over that area. In this matter, the respective utility may seek the help of IMD to get the wind data obtained from observatory/Satellite/Radar.

A.5 400 kV D/C Narendra-Davangere (Guttur) Transmission Line failed on 06.06.2019.

[Towers at Location No. 360 (DA+0), 361 (DA+3), 362 (DA+3), 363 (DA+9), 364 (DA+9)& to 365 (DB+0)]

- **Brief Background**

400 kV D/C Narendra-Davangere line of POWERGRID was designed by POWERGRID and was constructed by M/s L&T. The line was

commissioned in February 2008 and total length of the transmission line is 155.5 km and falls under Wind Zone-1 as per the wind map provided in IS. The suspension towers used in the line were designed for wind zone-1 (33 m/s) and tension towers, designed for wind zone-2 (39 m/s), were used in the line. These towers have been designed as per the provision of IS 802-1995 in vertical configuration with Twin Moose ACSR Conductor. The towers were designed considering Terrain category-II. Composite long rod (CLR) insulators were used in the line at the failed tower locations except Porcelain Disc insulator string at location No. 365(DB+0). This line had previously failed on 28.04.2019 in which 10 towers (09 suspension and 01 tension) type tower at location No. 237 to 246 had failed. The line was restored on 29.05.2019 and was in charged condition at the time of second failure incident.

- **Observations**

a. The affected tower locations 361 to 365 were located in undulated field with few trees in vicinity near village Medleri Village, Ranebennur Taluk, in Haveri district (Karna- taka). The details of tower spotting in the relevant sections are as follows:

Sl. No.	Loc. No.	Tower Type	Span	Angle of Dev.	Extent of Damage
1	359	DA+3	396 m	Nil	Intact
2	**360**	**DA+0**	**398 m**	**Nil**	**Earth wire peak bent**
3	**361**	**DA+3**	**398 m**	**Nil**	**Collapsed**
4	**362**	**DA+3**	**390 m**	**Nil**	**Collapsed**
5	**363**	**DA+9**	**400 m**	**Nil**	**Collapsed**
6	**364**	**DA+9**	**400 m**	**Nil**	**Collapsed**
7	**365**	**DB+0**	**420 m**	**11^0 07' 51" RT**	**Collapsed**
8	366	DA+0	364 m	Nil	Intact

b. **Tower at location No. 360 (DA+0)** was located in plain terrain with slope terrain in both side. Right side OPGW Earth wire peak of the tower was bent when facing towards Davangere. Anti-climbing device, name plate of tower, danger plate and phase sequence plate were provided.

Tower at location No. 360 (DA+0)

c. **Tower at location No. 361 (DA+3)** was located in sloped terrain. The tower had completely collapsed to the ground in transverse direction towards right side when observed facing Davangere. Failure of Stub Cleat of leg — A & C was observed. Other two stubs of the tower along with foundation & chimney were intact. Chimney of leg C was covered in the soil and remaining three chimneys were above ground. Rusting at the bottom end of all the Stubs (near to chimney) was observed. The tower got bent from 1st panel level and had fallen in transverse direction to the line. Coping was also damaged due to the impact of tower collapse. No missing tower members / nut bolts were found.

Tower at location No. 361 (DA+3)

d. **Tower at location No. 362 (DA+3)** was located in plain terrain. The tower got bent from 1st panel level and completely collapsed to the ground in transverse direction to the line towards right side when observed facing Davangere. All the four stubs of the tower along with foundation were intact. Leg B of the tower was found broken and other three legs were bent from 1st panel level. The leg member of the +3 m extension was found to be bent but the bracing members / diagonals of +3 m extension was found to be in order. All Chimneys were above ground level. Coping of chimneys were not done properly.

Tower at location No. 362 (DA+3)

e. **Tower at Location No. 363 (DA+9)** was completely collapsed to the ground from the stub level in transverse direction towards right side when observed facing Davangere. The Stub of Leg B was not in the center of chimney and it was broken from bottom end (near to chimney). The remaining three stubs were bent. Rusting at the bottom end of all the Stubs (near to chimney) was observed. All the chimneys were intact however, almost covered in the soil. Coping of the chimneys was found damaged.

Tower at location No. 363 (DA+9)

f. **Tower at location No. 364 (DA+9**) was completely collapsed to the ground from the stub level in transverse direction towards right side when observed facing Davangere. All the four stubs of the tower were bent. All chimneys were covered in the soil and rusting at the bottom end of all the Stubs (near to chimney) was observed. Chimneys of leg C & leg D were damaged and other two were intact. Coping of all chimneys was found damaged. Extra holes were not plugged with nuts & bolts.

Tower at location No. 364 (DA+9)

g. **Tower at location No. 365 (DB+0**) was B-Type Tension Tower with double string porcelain insulators. The tower got completely collapsed to the ground in transverse direction towards right side when observed facing Davangere. All 4 stubs of the tower were bent. Rusting at the bottom end of all the Stubs (near to chimney) was observed. Foundation chimneys were covered in the soil except leg A. Chimneys of leg C & leg D were damaged and other two were intact. Coping of all chimneys was found damaged. Many nuts & bolts of tower were plugged out.


Tower at location No. 365 (DB+0)

h. POWERGRID officials informed that it was gathered from nearby local village residents that thunderstorm condition with exceptionally high wind velocity prevailed at the time of tower collapse and the Tower failure was initiated due to this high intensity localized wind observed during the storm. The windstorm had also caused uprooting of two trees near the tower at location No. 365. However, one 220 kV D/C Transmission line, which was running near to the failed tower locations of 400kV D/C Narendra-Davangere Transmission line was reported to have no damage due to wind. The high speed wind incident was also reported in local newspapers.

i. POWERGRID officials highlighted that the transmission line is designed considering wind loads for Wind zone- I and is approximately in the 70-75 km from the boundary of the wind zone 2.

j. To examine the chemical and material properties, samples from the affected tower were selected from site and sent for testing at independent NABL accredited lab and the parameters were found to be within limits.

➢ **Committee Observations and Recommendations :**

Committee noted that two incidences of failure of this line had occurred within a time span of two months and in total sixteen (16) towers of the line had failed. Committee noted that deficiencies like, rusting in the stubs, miss-alignment of stubs & concrete pedestal, unplugged holes, improper coping of the chimney & covered in the grass, etc. were observed by the team which visited the tower failure sites. Further, the failed towers were located in the open field areas with very few trees/vegetation around the towers, however, these were designed considering Terrain Category-II.

The committee noted the above and concluded that due to improper

erection, residual stresses were developed in the towers and these have failed due to loads developed due to high wind speed observed in the area on the date of failure.

Committee suggested that since this transmission line has failed twice in a year, the patrolling frequency may be increased. Committee noted that even small errors during erection or compromises in the integrity of structure may lead to its collapse. Utilities should improve their erection and operation & maintenance practices and ensure that structural strength is not compromised due to deficiencies like, unplugged holes, rusting of stubs, etc.

A.6 400 kV D/C Agra-Sikar Transmission line failed on 12.06.2019.

[Towers at Location Nos. 339 (DA+0), 340 (DA+0) & 341(DC+0)]

- **Brief Background**

400 kV D/C Quad Agra-Sikar Transmission Line was designed by POWERGRID itself. The line was executed by M/s EMC and was commissioned in January, 2014. The length of line was 393.90 km. This line traverses through plain terrain & cultivating fields. The towers have vertical configuration Quad MOOSE conductor and one OPGW & one conventional earth wire. The towers were designed for Reliability level -1 and wind zone-4 as per IS 802:1995. POWERGRID informed that in design for suspension type towers, special consideration for narrow front wind (1.5 times basic wind speed i.e. 250 kmph) and 75% full wind under security condition were considered. The line had failed in year 2019 & 2020.

- **Observations**

a. The details of tower spotting in the relevant sections are as follows.

S. No.	Loc. No.	Tower Type	Span	Angle of Dev.	Extent of damage
1	338	DA+O	380	Nil	Intact
2	**339**	**DA+O**	**380**	**Nil**	**Collapsed**
3	**340**	**DA+O**	**380**	**Nil**	**Collapsed**
4	**341**	**DC+O**	**377**	**20°10’48’’(R)**	**Collapsed**
5	342	DA+O	375	Nil	Intact

b. The affected towers location was in plain terrain & cultivating fields with few trees in the vicinity. Name plates of tower, danger plates and phase sequence plates were provided. Anti-climbing devices were not provided. Extra holes present in the tower structures were not plugged with nuts & bolts.

c. **Tower at Location No. 339 (DA+0)** was completely collapsed to the ground in transverse direction towards right side when observed facing

Sikar. There were minor damages to all four stubs. No tower members/ nut bolts were found missing. It was observed that leg C and leg D were bent from stub level (near to chimney) and the remaining two legs were bent from 1st panel level. All the foundation chimneys were intact. Coping of chimneys were not provided. Rusting at the bottom end of all the Stubs (near to chimney) were observed. Few bolts were found missing in the Butt joint connecting leg B and stub. The spacing of bolts from the edge of the members was observed to be inadequate.

Tower loc. No. 552 (DA+9)

d. **Tower at Location No. 340 (DA+0)** was completely collapsed to the ground from the stub level in transverse direction towards right side when observed facing Sikar. Foundation chimney of leg D was found damaged & other three chimneys were observed to be intact. Chimneys of leg A & leg C were fully covered in soil. Coping of chimneys were not done. All four stubs were damaged.

Location No. 340 (DA+0)

e. **Tower at Location No. 341 (DC+0)** was completely collapsed to the ground in transverse direction, towards right side when observed facing Sikar. All four stubs were fully damaged. Coping of the chimneys was not provided and rusting at the bottom end of all the stubs (near to chimney) was observed. Extra holes were not plugged with nuts & bolts.

Location No. 341 (DC+0)

f. POWERGRID reported that a high intensity localized windstorm prevailed near the tower failure site, which was confirmed by broken tree branches, damage to the teen sheds of houses located in the vicinity of failed towers, damages to the numerous poles of 11 kV line etc. The same was confirmed by local people and was reported in the local newspapers.

g. As per POWERGRID, as all the failed towers had collapsed in transverse direction of the line, it is observed that the high intensity localized windstorm had resulted in large wind load on phase conductors and earthwire and on tower structure leading to its failure and subsequent transverse cascading failure of nearby towers. Further, considering the damage of one unreinforced brick wall in the affected area, the wind speed could be estimated to be in between 50 to 55 m/sec, as per the Guidelines on Improving Wind/ Cyclone Resistance of Housing 2010 released by BMTPC (Building Materials & Technology Promotion Council) under Ministry of Housing & Urban Poverty Alleviation.

h. POWERGRID was requested to provide the wind speed data received from any authenticated observatory indicating speed of wind prevailing at the failure location at the time of the failure, however, the same was not provided. The coordinates of the failed tower structures were also shared by CEA to IMD and wind data at the date & time of failure was requested. However, the requested information was not available.

➢ **<u>Committee Observations and Recommendations :</u>**

Committee noted that the transmission line has been commissioned after the notification of CEA (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations, 2010. As per this Regulation, towers for transmission line with quad conductor configuration is to be designed for Reliability level-2. However, the towers were designed as per Reliability level-1 which are not as robust as to towers designed for Reliability level-2.

Committee noted that there was deficiency in the erection/O&M practices of line/towers adopted by POWERGRID as number of bolts were found missing in the leg members at some of the failed tower locations. Also, the distance of bolt hole from the edge of the members also appeared to be on lower side.

The committee noted the above and concluded that due to improper erection, the strength of structure was reduced and these have failed on account of loads developed due to high wind speed observed in the area on the date of failure.

Committee advised POWERGRID to improve their operation & maintenance activities as there are many failures in Agra region in past years. Special measures like higher frequency of patrolling of the lines may also be adopted by POWERGRID. Committee also advised POWERGRID to ensure that Reliability level to be adopted for all the future transmission lines shall be in accordance to CEA Regulations and as per latest IS codes, recommendations of the Standing Committee and Task Force, as applicable.

It was emphasized that after every failure the concerned utility needs to submit the actual wind velocity prevailed in the affected area so that the investigating team of standing committee could get reference wind speed prevailed over that area. In this matter, the respective utility may seek the help of IMD to get the wind data obtained from observatory/ Satellite/Radar.

A.7 400kV D/C Silchar - Meliriat Transmission Line failed on 19.07.2019

[Tower at location No. 377 (DC+0)]

- **Brief Background**

400kV D/C Silchar-Melriat Transmission line of POWERGRID was constructed by M/s IVRCL and was commissioned at 132 kV Voltage Level in the month of Dec'2018. Total line length is 143 km. The 400 kV D/C Silchar-Melriat Line falls in wind zone-6 and connects Silchar substation in Assam with Melriat Substation in Mizoram. The Mizoram portion of the line traverses through hilly terrain mostly alongside the National Highway 54. The line has vertical conductor configuration with twin ACSR Moose. This is the first incident of tower failure in this transmission line.

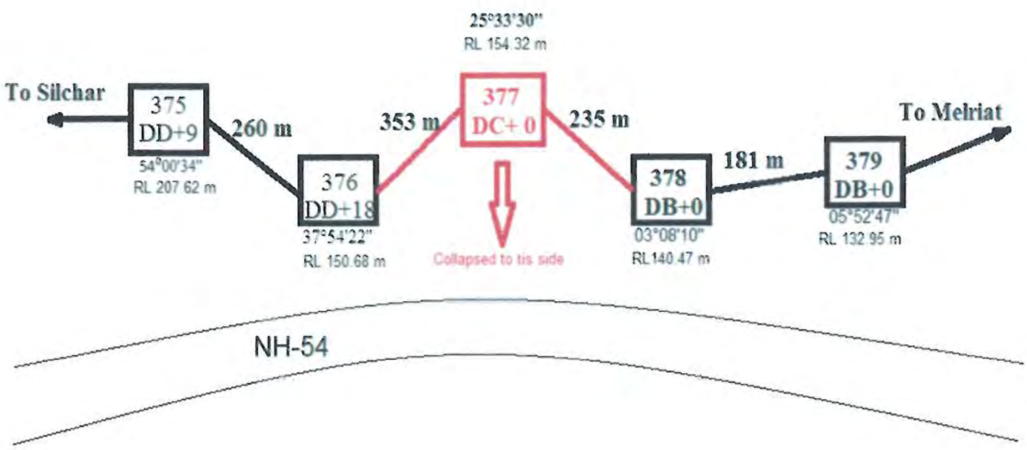
- **Observations**

a. The details of tower spotting in the affected sections are as follows:

Sl. No.	Loc. No.	Type of Tower	Forward Span	Angle of Deviation
1	375	DD+9	260 m	54°00'34"RT
2	376	DD+18	353 m	37° 54'22"LT
3	**377**	**DC+0**	**235 m**	**25°33'30"RT**
4	378	DB+0	181 m	03°08'10"LT
5	379	DB+0	441 m	05°52'47"LT

b. **The tower at location No. 377 (DC+0)** is located in Mualkhang Village, Sub Division Kawnpui, District Kolasib, Mizoram and was on uphill side of the NH 54. The Tower had collapsed completely in the direction as indicated in the diagram below.

c. As reported by POWERGRID, there was a landslide due to which a huge land mass got separated from the hill downwards creating a deep canyon in between the hill. The fault line of the separation passed through the foundation of the Leg-A due to which tower completely collapsed. Due to the landslide, large boulder/stones also fell on the NH-54 and blocked it completely damaging about 150 m of the National Highway.



Destroyed Highway 54

Location No. 377 (DC+0)

d. As reported by POWERGRID, the collapsed tower was checked for healthiness and completeness thoroughly. No missing members and missing bolts & nuts were found in the affected tower.

➢ **Committee Observations and Recommendations :**

Committee noted the above and concluded that due to sudden movement of the landmass during the landslide, the foundation of the tower became instable which led to collapse of tower at location No. 377 (DC+0).

Committee suggested that Utilities should ensure that proper geological investigation of the land mass is carried out before spotting of the tower structures and the necessary strengthening

measures, for tower foundations for the hill slope, if required, should be taken proactively, so that such incidences does not repeat and lead to failure of other towers.

A.8 400 kV D/C Kishanganj – Patna Transmission Line failed on 06.08.2019

[Tower at Location No.409 (DD+25)]

➢ **Brief Background**

400 kV D/C (Quad moose) Kishanganj- Patna transmissions Line of M/s POWERGRID was commissioned on 29.03.2016. The total length of the line is 346.718 km. Towers of the line were designed for Wind Zone 4. The line was constructed by M/s EMC Ltd. However, the pile foundations were constructed by M/s Simplex. The transmission line had failed due to change in the course of river Ganga in the year 2016. Also, three towers of the same transmission line had again failed in September, 2018 due to change in course of River Ganga and the same was under breakdown since 02.09.2018.

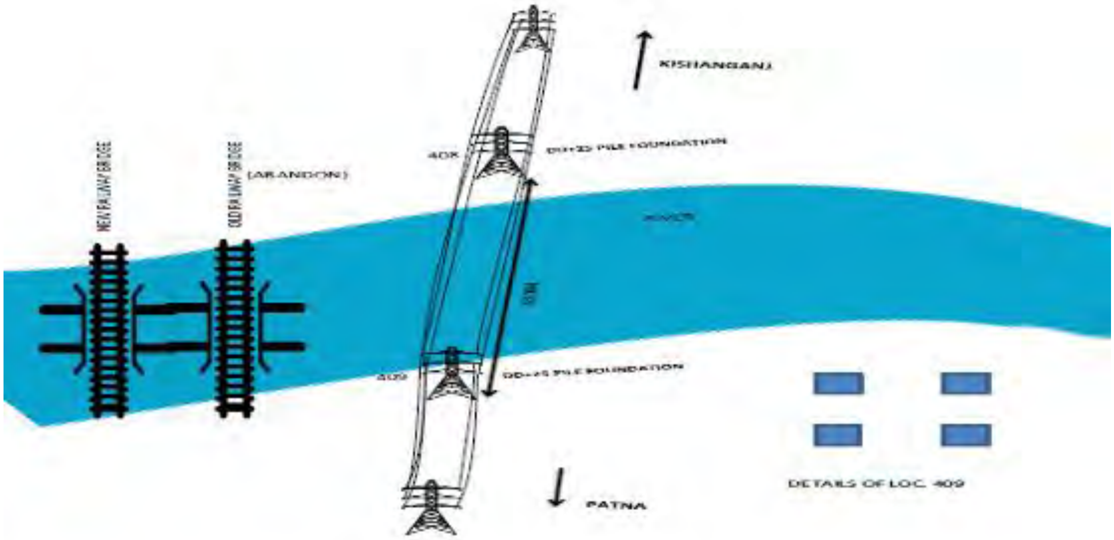
➢ **Observations**

a. The affected tower location was in village Dhamhara Ghat near Phungo halt, on Saharsa-Mansi Railway section, Dist. Khagaria, Bihar. Location was approx. 35 km from Saharsa and about 15 km from Simri Bakhtiyarpur Railway Station. Affected location was on the right bank of river at about 300 m of Kosi River Railway Bridge. POWERGRID reported that based on the discussion held with the local villagers, it was gathered that every year the river course was changing towards right bank due to bank erosion and approximately 13-14 m soil erosion took place just approx. 500 m downstream the location 409 in 2019.

b. The details of tower spotting in the affected sections are as follows:

TOWER No.	Loc. No.	Type of Tower	Forward Span (m)	Angle of Deviation
406	99F/0	DB		12°55'29"LT
			400	
407	99G/0	DD		22°14'36"LT
			280	
408	99G/1	DD		00°00'00"
			650	
409	**99G/2**	**DD**		**00°00'00"**
			370	
410	99H/0	DC		24°36'30"RT
			230	
411	99H/1	DB		10°48'01"LT

c. A schematic representation indicating affected location on piles and normal foundation is shown below:



d. Tower at location No. 409/0 (DD+25) of 400 kV D/C (Quad) Patna-Kishanganj transmission line was designed with Pile foundation. As reported by POWERGRID officials, during the recent heavy flood in the Kosi River, the tower had become vulnerable due to sinking of two legs due to soil erosion by the river. Leg D and some other members were deformed due to differential settlement of pile foundation under leg A and leg D. POWERGRID officials at site undertook de-stringing work between loc. 409 to 410 to isolate the location number 409 for protecting other locations of possible damage due to likely collapse of tower at location 409. However, on 06.08.2019 during de-stringing work between locations 409 & 410, deformed tower at location 409 collapsed completely at and fell down in the river Kosi towards location number 408.

e. **Leg A & D:** Pile caps were partially submerged in water and it was excessively tilted. Differential settlement of the pile caps was clearly visible. Chimney of both legs were intact however stub was sheared from the top.

Leg B & C: Chimney were completely torn/broken and some of reinforcement of the chimney was exposed/deformed. Stubs were torn/bend and separated from concrete of chimney. Pieces/lump of concrete of chimney were observed to be fallen on ground.

f. The details of failed tower pile foundations considered for designing are as follows:

Pile Foundations– 4.0 Nos., 1.2 m dia pile of 37.6 m length under each leg with 1.2 m deep pile cap with 3.5 m raised chimney. Scour depth– 27.0 m & HFL*- 40.27 m respectively.

* CWC HFL as mentioned on a post near the old railway bridge is 38.55 m.

Location No. 409 (DC+0)
(Just before Collapse of Tower)

Location No. 409 (DC+0) (After Collapse)

g. As reported by POWERGRID, due to river flow, the tower foundations got displaced from their original position and the back to back distances between legs were different from the design dimensions.

h. POWERGRID informed that the failed tower has been shifted to another location for restoration and higher scouring depth has been considered for new pile foundation.

i. POWERGRID submitted the reports of Concrete cube tests & the Non Destructive Tests conducted on the pile foundations which were done at the time of erection of the line and these were found to be in order.

- **Committee Observations and Recommendations :**

Committee noted that the transmission line had failed earlier in the years 2016 & 2018 due to similar cause of change of river course of River Ganga. Committee also observed that at the time of construction of line, the location 409 was on the right bank of River Kosi, and the river course is changing towards right bank. The erosion of bank had got extended up to the tower location and two legs on pile foundation which has led to failure and subsequent collapse of the tower have now come in the main stream.

Committee noted that even though the highest water level measured during the flood was lower than the HFL level considered in designing of pile foundations, the Pile foundations had failed. Further, Committee noted that one of the failed tower had been tested for +9 m body extension and has been erected with +25 m body extension with the tower structure. Committee requested POWERGRID to review the design of Tower extension part adopted in the failed tower location to ensure the stability of bottom most panels as the K-bracing placed at this panel appears to be not bearing the loads because of very high base width to height ratio.

Committee recommended that proper anticipation of change in course of river on the basis of river flow data of previous years should be done by the transmission utilities. Additional precautions like routing of transmission lines few kilometres away from the river bank/ anticipated future river course, use of pile foundation/additional piles etc. should be adopted by utilities. Moreover, in case of damage of foundation of towers, the foundation design is required to be examined.

Providing proper Protection (retaining wall, Gabion wall etc., proper revetment & use of geo-synthetic material in foundation, concrete encasing & painting of stub in water logging areas etc. may also be considered, wherever required.

A.9 765 kV S/C New Ranchi-Dharamjaygarh transmission line-I failed on 21.04.2020

[Towers at Location No. 90 (A+3), 91 (A+0) & 92 (A+3)]

➢ **Brief Background**

765 kV S/C Ranchi-Dharamjaygarh transmission line-I of M/s POWERGRID was constructed by M/s EMCO and the same was commissioned on 31-03-2014. The total length of the line is 302 km. The suspension towers (Delta Configuration) of this line were designed for basic wind speed of 39 m/s corresponding to Wind Zone-2 and reliability level 2 as per IS 802-1995. Further, narrow front wind on tower body and 75% wind in broken wire (security) condition have also been considered for designing the tower. The line is having Quad ACSR BERSIMIS conductor with porcelain insulators in I-V-I configuration. This is the first incidence of failure of towers in this transmission line.

➢ **Observations**

a. The affected towers were located in open agricultural field of village-Burka, Police station- Sisai, District-Gumla (Jharkhand) and was about 50 km from New Ranchi SS of POWERGRID. Collapsed tower at location No.-92(A+3) was in low lying area between location No.-91 and 93. There were very few low height trees around the collapsed tower location.

b. The details of tower spotting in the relevant section are as follows:

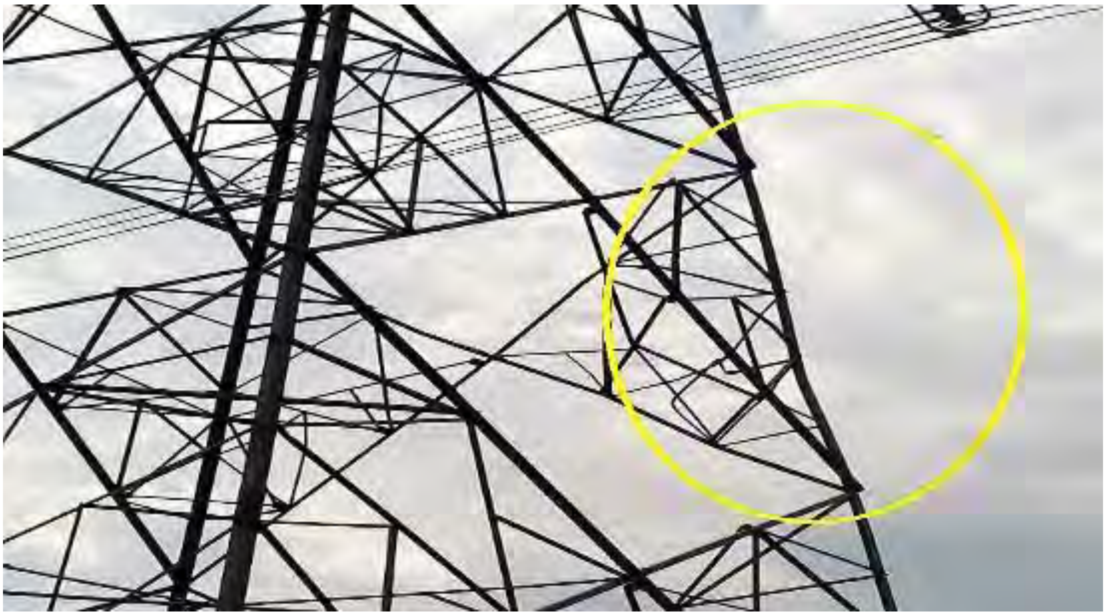
Sl. No.	Loc. No.	Type of Tower	Forward Span	Angle of Dev.	Extent of damage

			(m)		
1	90	A+3	390	Nil	Earth peak damaged
2	91	A+0	395	Nil	Partial deformation above third panel
3	**92**	**A+3**	**390**	**Nil**	**Tower collapsed**
4	93	D+0	345	30° 9’ 00” LT	Tower intact

c. **Tower at location No. 90 (A+3)** was in erect position. The earthwire peaks of the suspension tower have got damaged due to sudden force exerted by conductor due to collapse of tower at location number 92. Rest of the tower was reported to be intact with no missing tower members and nuts & bolts.

Tower Location No. 90 (A+3)

d. **Tower at location No. 91 (A+0)** was partially damaged due to sudden jerk exerted by the pull of conductors during collapse of tower at location No. 92. POWERGRID informed that the main leg along with bracing members and few redundant members of the tower had buckled. Foundations of all the four legs were intact. The tower was also checked for any missing members /nuts & bolts. No missing members/bolts & nuts were found. However, few blank holes were visible in members at different places.



Tower Location No. 91 (A+0)

e. **Tower at location No. 92 (A+3)** had collapsed above the +3 M body extension portion and fell over in twisted condition in transverse direction. Due to tower collapse, two stubs were also observed to be damaged. POWERGRID official informed that the tower was checked thoroughly and no missing tower members/ nut bolts were found. The anti-climbing device (ACD) was also in place and condition of concrete in the visible chimney portion were observed to be good.

Tower Location No. 92 (A+3)

f. As reported by POWERGRID, the records of line patrolling of this line were checked and as per the data furnished by site, patrolling of above locations were carried out on 18th March 2020 and no defects like missing members, missing nut & bolts were reported. Further, for collapsed tower location different foundation dimensions like back to back, diagonal distance, levels and the same were found to be generally in line with approved drawing. Further, patrolling of 3-4 other towers adjacent to the affected towers were also carried out and no abnormalities were observed.

g. POWERGRID official reported that based on the previous failures of the 765 kV Delta type suspension towers of wind zone 2 in other POWERGRID lines, POWERGRID had taken up the process of strengthening of all such suspension towers in phased manner and Strengthening of towers in this line was scheduled from the month of April'20 but couldn't be taken-up due to complete lockdown caused by COVID-19.

h. POWERGRID informed that the localized whirlwind storm has also caused widespread damages in the vicinity. Many big trees were reported be found uprooted/broken around the nearby villages which indicate that strong wind storm was prevailing at the time of tower collapse.

i. The report of patrolling of POWERGRID site team and the material test reports of the parts of failed towers were found to be in order.

➢ **<u>Committee Observations and Recommendations :</u>**

The committee noted that this is the first tower failure incident of this line since commissioning. It was observed that tower at location No. 92 (A+3) failed first, which led to secondary partial damages to nearby suspension type towers at location No. 90 (A+3) and location No. 91 (A+0) due to pulling force of the conductors.

The Committee noticed that transmission line was erected using 765 kV S/C Delta configuration designed for wind zone-2. The high wind velocity might have induced the failure of towers. The Committee in its previous meeting had recommended that the rate of failure of suspension towers (with delta configuration) of 765kV S/C line traversing through wind zones, other than Wind Zone -4, and areas prone to cyclone / storm needs to be monitored. In case repeated failure is observed in those lines, exercise for review of design, as has been done for 765 kV Gaya-Fatehpur S/C transmission line (Wind Zone-4) with Delta configuration towers, has to be taken up by PGCIL for different wind zones for suspension towers (with delta configuration) of 765 kV S/C line. In case further failures are observed in the line, POWERGRID need to take up the exercise for review of design.

Committee also noted that due to climatic change, incidents of high winds are increasing. Transmission companies need to take proactive measures such as increased line patrolling, immediate replacement of missing members/nuts & bolts and intensive care

should be taken during erection and installation of towers (Slope correctness, filling unplugged holes, tightening of Bolts, Tack welding, straightness of tower members etc.).

A.10 400 kV D/C Vindhayachal-Jabalpur Ckt-I & II Transmission line failed on 30.04.2020

[Towers at Location No. 948 (DA+0), 949 (DA+0), 950 (DA+0) & 951 (DA-6)]

➢ **Brief Background**

400 kV D/C Vindhyanchal-Jabalpur–I & II transmission line of POWERGRID was constructed by M/s TPE (USSR) and was commissioned on 07.11.1989. Length of the transmission line is 360 km and the towers used in the transmission line were designed by Russian agencies as per Russian Codes/Standards. The transmission line is designed with Twin ACKC conductor with Glass Disc insulators in single suspension I String configuration. The transmission line had previously failed in year 2009 in which three suspension type towers were failed.

➢ **Observations**

a. The affected suspension towers were situated/located in open field having very few trees in village Gosalpur, Police station Siroha, District Jabalpur, Madhya Pradesh. The Tower spotting details of relevant section of the transmission line is as follows:

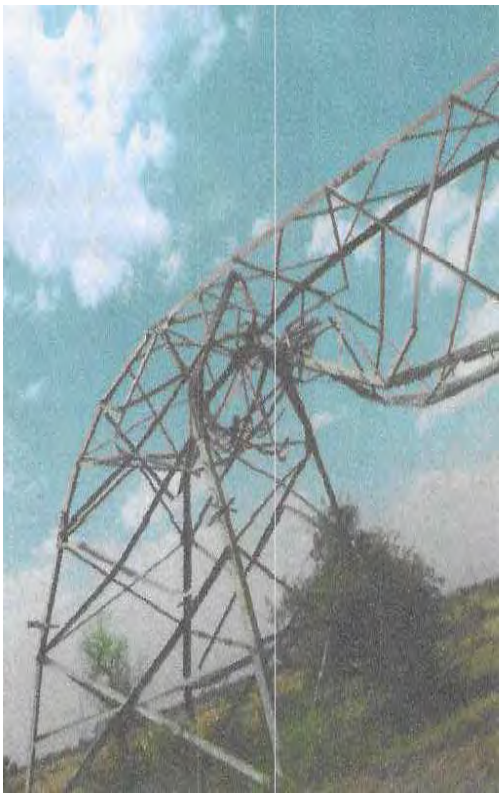
Sl. No.	Loc. No.	Type of Tower	Forward Span (m)	Angle of Dev.	Extent of damage
1	946	DB	356		
2	947	DA+0	340	0^0	
3	**948**	**DA+0**	**365**	$\mathbf{0^0}$	Tower collapsed above 1st level and stubs are intact.
4	**949**	**DA+0**	**415**	$\mathbf{0^0}$	
5	**950**	**DA+0**	**380**	$\mathbf{0^0}$	
6	**951**	**DA-6**	**359**	$\mathbf{0^0}$	
7	952	DA+0	336	0^0	
8	953	DA+0	335		
9	954	DA+0	390		
10	955	DA+0	330		
11	956	DA+0	325		
12	957	DA+0	375		

13	958	DA+0	350		
14	959	DA+0	375		
15	960	DB	335		

b. All the collapsed towers fell in the same transverse direction of line and all the failed towers had collapsed above the 1st section level. All of the stubs, in each of the four towers, were reported to be intact.

c. POWERGRID officials informed that at the time of tower collapse, heavy localized whirling wind storm prevailed in the vicinity of affected stretch of transmission line and the above windstorm has also caused extensive wide spread damages to nearby trees and nearby other structures. The same was also reported in local newspapers as well. From the failure pattern it appears that tower failure was initiated due to high intensity localized wind storm at Location number 951(DA-6) and because of cascading effect, other three towers at location numbers 948(DA+0), 949(DA+0), 950(DA+0) also collapsed.

Tower Location No. 948 (DA+0)



Tower Location No. 951 (DA-6) **Tower Location No. 950 (DA+0)**

d. As per information received from POWERGRID, the patrolling of above locations was carried out on 17th Jan 2020 and no major defects like missing members, missing nuts/bolts were reported.

e. The material tests were conducted on samples selected from site at independent lab and it was observed that three members (member 4, 8 & 9) failed in ultimate stress test and two members (member 3 & 6) had silica content more than prescribed limit. POWERGRID representatives highlighted that these tower members are also satisfying the minimum yield strength criteria required as per IS codes. Further, the transmission line was commissioned in 1989. The tower structure steel was imported from Russia and was designed as per Russian standards, however, the copies of codes used in design of these towers are not available with POWERGRID. As these towers had been designed as per Russian Codes, it is not prudent to compare the minimum properties requirement as per present codal requirements.

➢ **Committee Observations and Recommendations :**

Committee noted that UTS of the transmission tower members may be degraded since the line is in operation for so many years, but the chemical composition should remain same. Committee further concluded that in most of the failed transmission towers, the tower got bent from the panel above the diaphragm level indicating that the tower is not able to take the torsional load. Further, as different design codes had been used for design of these towers, it is not

correct to compare the material properties with respect to codes currently in practice.

Committee advised POWERGRID to observe & monitor the transmission line and if further incidences of failures are observed in the line in future, POWERGRID may review the design of the towers in view of present codes & practices and the decision for adopting any strengthening of transmission line, if any, may be discussed and finalized in the subsequent meetings of the Committee.

A.11 765 kV S/C Varanasi-Fatehpur transmission line failed on 10.05.2020

[Towers at Location No. 640 (A+3), 641(A+0), 642(A+0), & 643(A+0)]

- **Brief Background**

765 kV S/C Varanasi-Fatehpur transmission line of POWERGRID was constructed by M/s EMCO and was commissioned in June 2013. The length of the transmission line is 222.5 km. The suspension towers were designed in Delta configuration as per IS: 802:1995 for wind zone-4 with Quad ACSR Bersimis Conductor with porcelain insulators. In addition to existing codal provisions the suspension towers have also been designed considering narrow front wind condition and with 75% wind in security condition. As reported by POWERGRID, this is the first incident of failure of tower in this line.

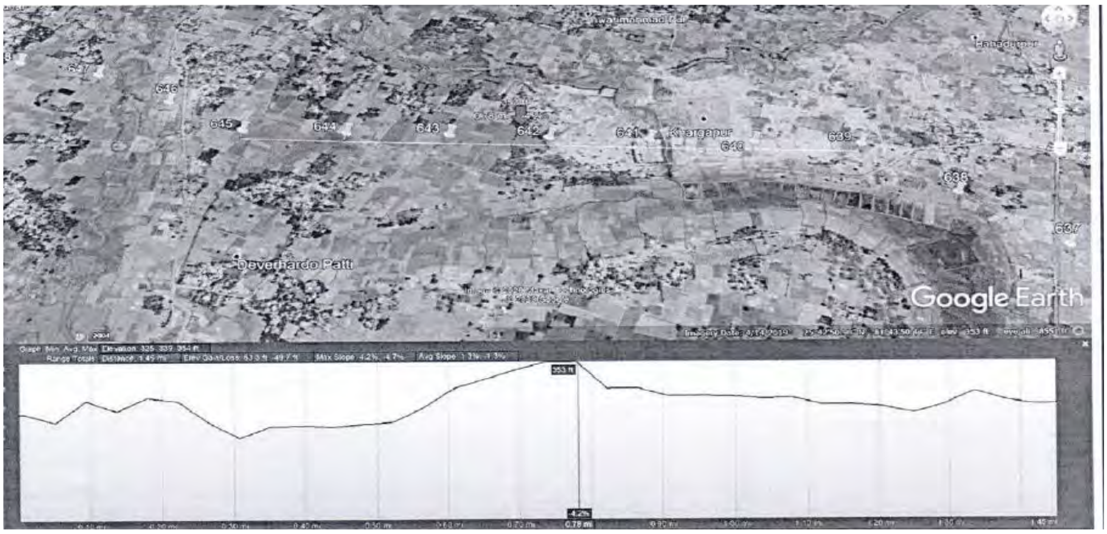
Further, this line was earlier known as Gaya-Fatehpur transmission line and after the LILO to the Varanasi substation, it was renamed as Varanasi-Fatehpur transmission line. The Gaya-Fatehpur transmission line had earlier instances of failure, the details of which are as under:

Date of tower collapse	Section affected	No. of Towers affected
11/ 12th April' 2012	314 (A+0)	1
31st May' 2014	305(A+3), 306(A+0), 311(A+0), 315(A+3), 320(A+0), 321(A+0), 322(A+0), 323(A+0), 324(A+0), 325(A+0), 326(A+0), 327(A+0), 328(A+0), 329(A+0), 330(A+0)	15
14th May' 2015	283(A+3) , 284(A+0)	2
12th June' 2015	334 (A+0)	1
7th March 2016	715 (A+3)	1

In addition to above the 765 kV Gaya-Varanasi Transmission line had also failed on 17th May 2017 (5 towers) & 13th May 2018 (1 tower).

➢ **Observations**

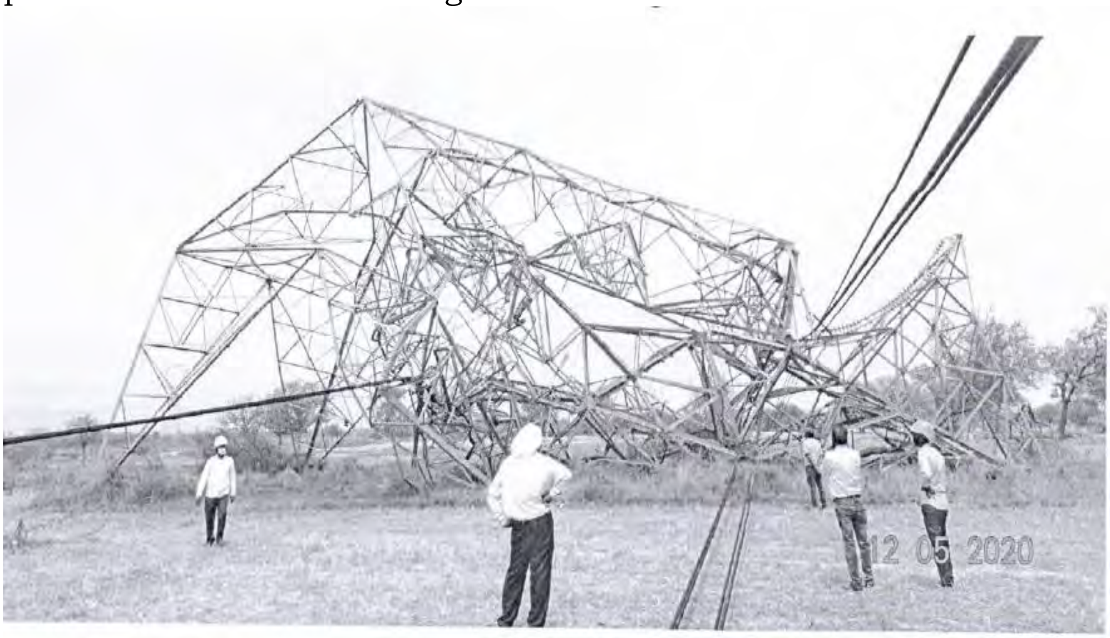
a. The affected suspension towers were situated/located in open agricultural field of Deori Hardo Patti, Police Station Baghrai, Tehsil Kunda, Pratapgarh (U.P.) and were about 70 km from Allahabad substation of POWERGRID. Google map & profile of failed tower stretch is produced below:



b. The Tower spotting details of relevant section of the transmission line is as follows:

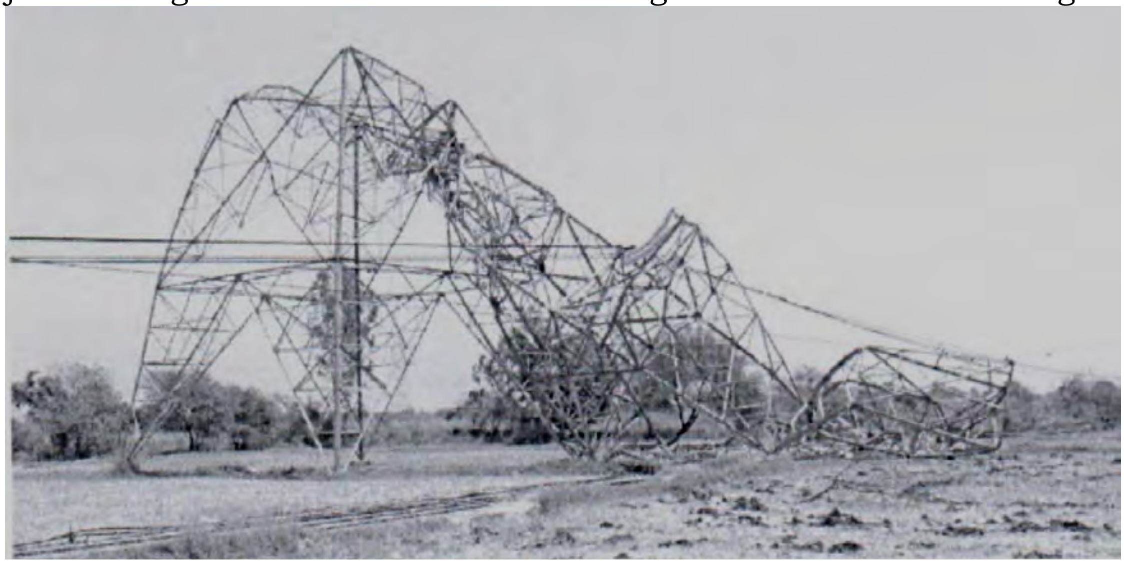
Sl. No.	Loc. No.	Type of Tower	Forward Span (m)	Extent of damage
1	639	D+0	397	
2	**640**	**A+3**	**395**	Both Earthwire Peak Bent
3	**641**	**A+0**	**379**	Collapsed and 1 Stub damaged
4	**642**	**A+0**	**381**	Collapsed and 3 Stubs damaged
5	**643**	**A+0**	**387**	One Earthwire Peak Bent
6	644	A+0	400	
7	645	C+0	373	

c. **Tower at location No. 642 (A+0)** had collapsed from second panel level and fell over in transverse direction. Due to tower collapse, three stubs were also observed to be damaged. The top portion of the tower was toppled and hit the bottom panel. POWERGRID official informed that the tower was checked thoroughly and no missing tower members/ nuts & bolts were found and condition of concrete in the visible chimney portion were observed to be good.



Tower at Location No. 642 (A+0)

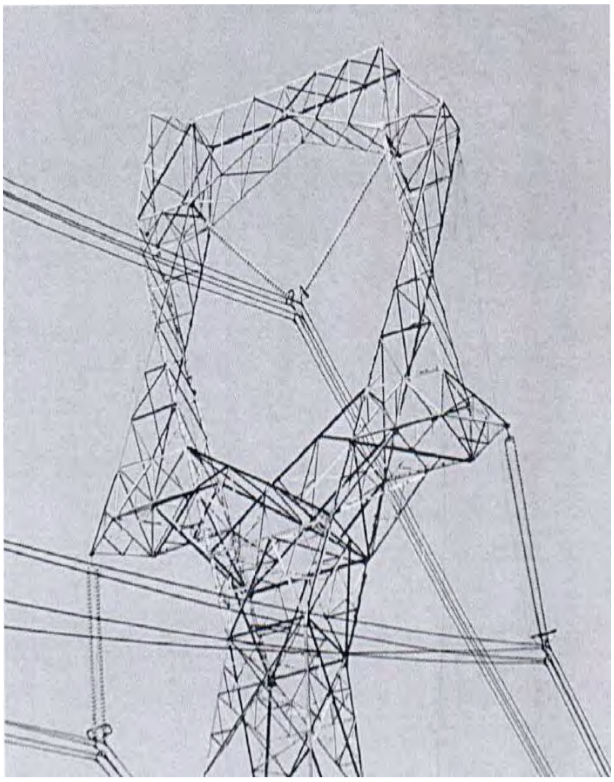
d. **Tower at location No. 641 (A+0**) had failed from third panel level and collapsed in diagonal direction towards location No. 640. It was observed that the main leg along with the bracing members and few redundant members on one of the transverse faces were severely buckled and jumbled together. The stub of one of the leg was observed to be damaged.



Tower at Location No. 641 (A+0)

e. **Towers at location No. 640 (A+3) & 643 (A+0)** were in erect condition. One Earthwire peak of the tower at location No. 643 was damaged whereas both of the earthwires peaks were damaged at tower at location No. 640. These were observed to be secondary failures due to sudden force exerted by tower collapse at nearby locations. It was reported by POWERGRID that rest of the structure of these towers were intact and no missing members/nut bolts were observed at these sites.


Tower at location No. 640 (A+3)


Tower at location No. 643 (A+0)

f. The previous failures of the 765 kV S/C Delta configuration towers were investigated by Standing Committee and the Committee had suggested strengthening of these towers. It was informed by POWERGRID that the failed tower locations were already strengthened. POWERGRID also informed that they have got reviewed this tower design by M/s Manitoba Hydro, Canada and they have also suggested strengthening of some of the members. However, the strengthening suggested by M/s Manitoba Hydro was yet to be executed at the failed tower locations.

g. As reported by POWERGRID, a localized whirlwind storm prevailed in the vicinity of transmission line which was confirmed by the local people from nearby villages and the local newspaper. It was reported that some trees were found uprooted/broken in nearby area of the failed tower location.

h. As reported by POWERGRID, the records of line patrolling of this line were checked and as per the data furnished by site, patrolling of above locations were carried out on 1st Feb 2020 and no defects like missing members, missing nuts & bolts were reported. Further, for collapsed tower location different foundation dimensions like back to back, diagonal distance, levels and the same were found to be generally in line with approved drawing. Further, patrolling of 3-4 other towers adjacent to the affected towers were also carried out and no abnormalities were observed.

i. The material tests were conducted on samples selected from site at independent NABL accredited lab and these reports were generally found to be within limits except the elongation percentage of two MS members was observed to be marginally lower, i.e., 21.84 % and 22.10% in place of desired 23%. POWERGRID representatives highlighted that the material testing has been performed on tower members gathered from failed tower site and the lower values observed in the elongation may be due of failure of samples near gripping point.

- **Committee Observations and Recommendations :**

The Committee noticed that this transmission line has faced multiple failure incidences in the past. The failure of these 765 kV Gaya-Fatehpur S/C transmission line (Wind Zone-4) with Delta configuration suspension type towers had been investigated by the Standing Committee of Experts for investigating failure of transmission line towers in the year 2015. Design review analysis of this type of tower of PGCIL was carried out by CPRI on directions of the Standing Committee and strengthening of few members above waist level by replacing existing members with new members were proposed. Committee enquired POWERGRID about the status of strengthening of such towers as advised in previous standing committee meetings.

POWERGRID officials informed the Committee that, the strengthening of existing 765 kV S/C delta configuration suspension type towers which are located in Wind zone 4 & Wind zone 2, is being executed by POWERGRID in phased manner and at the time of meeting, only fifty-six (56) numbers of S/C 765 kV towers (Delta configuration) in the Western Region-1 are remaining to be strengthened.

The strengthening of towers includes clamping of some of the members as well as replacement of few tower members. Strengthening of towers in same manner as suggested by the Standing Committee in the previous meetings, i.e. by replacement of all members, is not possible for already erected tower members as long shutdown of transmission lines will be required. However, failed towers are always replaced by completely strengthened tower in line with the recommendations of committee. Further, strengthening of few other tower members, as suggested by M/s Manitoba Hydro is also being adopted by POWERGRID. The tower with strengthening currently being adopted by POWERGRID (i.e. clamping of few members and replacement of some members) had also been tested at the CPRI test bed.

Committee noted that the failed tower was already strengthened by POWERGRID. Committee advised that failed tower should be replaced with already strengthened tower and POWERGRID should ensure that the strengthening mechanism adopted is in accordance with the suggestions of Standing Committee which were recommended in previous meetings. Committee also advised that Best practices in quality control process for raw material, manufacturing,

transportation, construction, storage, erection and stringing of towers should be adopted by utilities.

A.12 765 kV S/C Sasan-Satna-I transmission line failed on 28.05.2020
[Tower at Location No. 430(B+0)]

➢ **Brief Background**

765 kV S/C Sasan-Satna-I transmission line of POWERGRID was constructed by M/s KPTL and the same was commissioned in December 2012. The 'B' type towers of this line having Delta Configuration were designed for basic wind speed of 47 m/s corresponding to Wind Zone 4 and reliability level 2 as per IS 802-1995. The line is having porcelain insulators in double V-V-V (DSV string) configuration. This was reported as the first incidence of tower failure in this line.

➢ **Observations**

a. The affected suspension tower was situated/located in Belhai village of Satna District, Madhya Pradesh. The tower was situated in forest land and is located on hillock land. Google map and profile of failed tower stretch is shown below:

b. Tower spotting details of relevant section of the transmission line is as follows:

Sl. No.	Loc. No.	Type of Tower	Forward Span	Extent of damage

			(m)	
1	428	D+0	557	Nil
2	429	C+0	368	Nil
3	**430**	**B+0**	**283**	**One side Cross arm, K-frame section & above damaged**
4	431	C+9	264	Nil
5	432	C+0	387	Nil

c. **Tower at location No. 430 (B+0)** was damaged from the cage section at side cross arm level. One of the cross arms, the K-frame portion of the tower body and both earth-wire peaks were damaged.

d. As reported by POWERGRID, tower members in cross arm cages and K-frame portion have failed due to excessive transverse wind load on conductor and tower during the localized wind storm which had prevailed on the date of occurrence. Further, the tower was checked thoroughly and no tower members/nuts & bolts were found missing in the affected section of the tower.

Tower at Location No. 430 (B+0)

e. As reported by POWERGRID, a localized wind storm prevailed in the vicinity of transmission line which has caused widespread damages in the vicinity of Satna & Rewa, M.P. Some towers of 220 kV Satna-Chhatarpur (MPPTCL) transmission line, 132 kV Satna- Satna (Prism Cement), 132 kV Satna -Majhgawan transmission line, 132 kV Satna-Satna Cement transmission line were also reported to be collapsed during the aforementioned cyclonic wind storm. It was reported that some trees were found uprooted/broken in nearby area of the failed tower location.

f. The material tests were conducted on 8 samples selected from site at independent NABL accredited lab and these reports were generally found to be within limits except for two members which were found marginally higher than limit i.e. Member 6 [Phosphorous (0.062 > 0.05)] and Member 7 [(Carbon (0.231 > 0.23)].

➢ **Committee Observations and Recommendations :**

This was the first failure incident of the transmission line. The Committee noted that the material content observed in the failed tower structure members was marginally higher than the prescribed limit & further, the increase in content of Phosphorous & Carbon, though decreases the ductility of the tower members but also increases the strength of steel.

Committee noted that multiple incidents of tower failure had occurred in the transmission lines traversing in the same region of Madhya Pradesh on the date of failure of this transmission line, i.e., on 28.05.2020. The committee noticed that the high wind velocity might have prevailed in the vicinity of transmission line in the transverse direction leading to failure of tower at location No. 430 (B+0). However, wind speed data from any authenticated observatory indicating speed of wind prevailing at the failure location at the time of the failure was not provided by the transmission utility. In absence of wind speed data from authenticated observatory, it is not possible to conclude that wind speed might have exceeded the designed wind speed.

Committee further noted that the failure of tower has been observed in the Cage portion of the tower, which is peculiar to the failure of the Delta Configuration towers observed & discussed in previous Standing Committee meetings. Committee advised that the transmission line utilities should avoid the use of the Delta Configuration towers in the future.

A.13 765 kV S/C Sasan-Satna-II transmission line failed on 28.05.2020 [Tower at Location No. 673(A+0)]

➢ **Brief Background**

765 kV Sasan-Satna-II transmission line of POWERGRID was constructed by Ranjit Singh Company and the same was commissioned on 30.04.2013. The suspension type towers of this line have Delta Configuration and have been designed for basic wind speed of 47 m/s corresponding to Wind Zone 4 and reliability level 2 as per IS 802-1995. The line is having porcelain insulators in I-V-I (DI -DV-DI String) configuration. This was reported as the first incidence of tower failure in this line.

➢ **Observations**

a. The affected suspension tower was situated/located in Amdari village of Satna District, Madhya Pradesh. The tower was situated in plain terrain with very few low height trees around the location. Google map and profile of failed tower stretch is shown below:

b. Tower spotting details of relevant section of the transmission line is as follows:

Sl. No.	Loc. No.	Type of Tower	Forward Span (m)	Extent of damage
1	670	A+0	344	Nil
2	671	D+3	397	Nil
3	672	C+0	385	Nil
4	**673**	**A+0**	**383**	**Tower bent from above the waist Level**
5	674	A+0	376	Nil

6	675	B+0	400	Nil

c. **Tower at location No. 673 (A+0)** was bent from above the waist level in the transverse direction. The delta portion of the tower members got buckled and was resting on lower tower body. All stubs (including chimneys) and legs just above stubs were intact.

d. As reported by POWERGRID, tower failure was initiated due to high intensity localized wind storm. Tower members in K-frame portion have failed due to excessive transverse wind load on conductor and tower. Further, the tower was checked thoroughly and no tower members/nuts & bolts were found missing in the tower.

Tower at Location No. 673 (A+0)

e. POWERGRID informed that patrolling of the failed location was carried out on 16th March 2020 and no defects like missing members, missing nuts & bolts were reported. Further, patrolling of 3-4 other towers adjacent to the affected tower were also carried out and no abnormalities were observed.

f. It was informed by POWERGRID that as suggested by the Standing

Committee during the investigation of previous failures of the 765 kV S/C Delta configuration towers in some of the lines, it has taken up the process of strengthening of such towers in a phased manner and strengthening work was underway in this line also, however, the failed tower location was not strengthened.

g. As reported by POWERGRID, a localized wind storm prevailed in the vicinity of transmission line which has caused widespread damages in the vicinity of Satna & Rewa, M.P. Some towers of 220 kV Satna - Chhatarpur (MPPTCL) transmission line, 132 kV Satna- Satna (Prism Cement), 132 kV Satna-Majhgawan transmission line, 132 Kv Satna - Satna Cement transmission line were also reported to be collapsed during the aforementioned cyclonic wind storm. It was reported that some trees were found uprooted/broken in nearby area of the failed tower location. The details of damage occurred due to the wind storm was also got covered in the local newspaper.

h. The material tests were conducted on 10 samples selected from site at independent NABL accredited lab and various parameters in these reports were generally found to be within limits.

➢ **Committee Observations and Recommendations :**

This was the first failure incident of this transmission line. Committee noted that there were multiple incidences of tower failure in the transmission lines traversing in the same region of Madhya Pradesh on the date of failure of this transmission line, i.e., on 28.05.2020.

The Committee noticed that this transmission line was erected using same tower design as in the 765 kV Gaya-Fatehpur S/C transmission line (Wind Zone-4) with Delta configuration. The failure of these 765 kV Delta configuration suspension type towers had been investigated by the Standing Committee of Experts for investigating failure of transmission line towers in the year 2015. Design review analysis of this type of tower of PGCIL was carried out by CPRI on directions of the Standing Committee and strengthening of few members above the waist level by replacing existing members with new members were proposed. The failed tower had not been strengthened. The pattern of failure of transmission towers from the waist level, i.e. from the K-frame section, is similar to past failures of towers of similar configuration observed in previous years. The inadequacy in tower structure of 765 kV S/C Delta configuration suspension type towers coupled with the reported storm caused the failure of towers.

Committee advised POWERGRID to ensure that the strengthening mechanism adopted is in accordance with the suggestions of Standing Committee in previous meetings. Committee recommended that the transmission line utilities should avoid the use of the Delta

Configuration towers in the future.

A.14 400 kV D/C Agra-Sikar I & II Transmission line failed on 29.05.2020

[Towers at Location Nos. 12 (DA+0), 13 (DA+0), 14 (DA+0) & 15(DD+0)]

➢ **Brief Background**

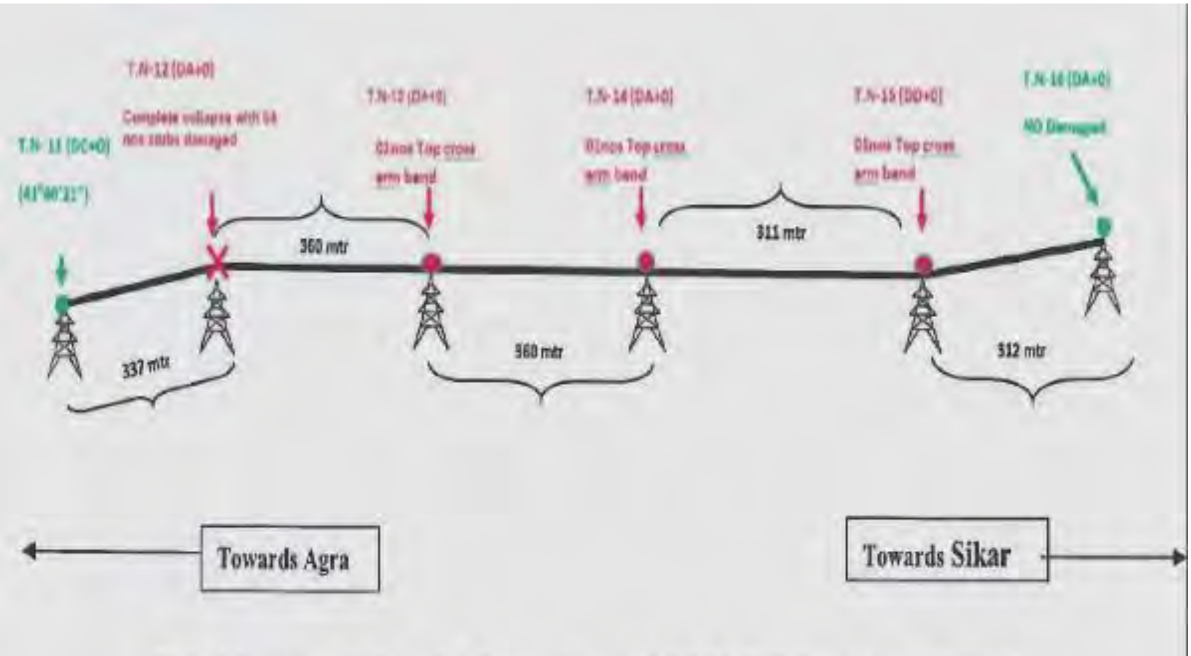
400 kV D/C Quad Agra-Sikar Transmission Line was designed by POWERGRID itself. The line was executed by M/s EMC and was commissioned in January, 2014. The length of line is 393.90 km. This line traverse through plain terrain & cultivating fields and towers were designed for wind zone 4 as per IS 802:1995 with Quad MOOSE conductor and one OPGW and one normal earth wire. The towers were designed for Reliability level 1 with vertical configuration. POWERGRID informed that in design for suspension type towers, special consideration for narrow front wind (1.5 times basic wind speed i.e. 250 kmph) and 75% full wind under security condition were considered. Porcelain Disc Insulators was used in the line at the failed tower locations. The line had previously failed on 12.06.2019 in which two suspension & one tension towers at Location Nos. 339 (DA+0), 340 (DA+0) & 341(DC+0) had failed.

➢ **Observations**

a. The details of tower spotting in the relevant sections are as follows.

Sl. No.	Loc. No.	Tower Type	Span	Angle of Dev.	Extent of damage
1	11	DC+0	337	16°4’11”(R)	Intact
2	**12**	**DA+0**	**360**		**Collapsed and all four stubs damaged**
3	**13**	**DA+0**	**360**		**01 No. top Cross arm damaged**
4	**14**	**DA+0**	**311**		**01 No. top Cross arm damaged**
5	**15**	**DD+0**	**312**	**45°45’10’’(L)**	**01 No. top Cross arm damaged & detached from tower**
6.	16	DA+0	355		Intact

b. A schematic representation indicating affected location is shown below:



Pictorial representation of collapsed tower of 400 KV D/C Quad Agra-Sikar Line

c. **Tower at location No. 12 (DA+0)** was completely collapsed to the ground in transverse direction towards ckt-I side. As reported by POWERGRID, all four stubs were damaged and no tower members/nuts & bolts were found missing at the location.

Tower at Location No. 12 (DA+0)

d. **Tower at location No. 13 (DA+0**) was in erect position. The top cross arm of the tower (ckt-II) was damaged due to the jerk developed by conductors.

e. **Tower at location No. 14 (DA+0)** was in erect position. The top cross arm of the tower (ckt-II) was damaged. As reported by POWERGRID, the conductor between location No. 14, 15 & 16 broke and crossed over ckt-I top conductor and fell on the ground. The Broken cross arm at the tower No. 14 was pulled towards location No.13.

Tower at Location No. 13 (DA+0) **Tower at Location No. 14 (DA+0)**

f. **Tower at location No. 15 (DD+0)** was in erect position and the top box cross arm (ckt-II) of the tower was almost detached from the tower body and major portions were reported to be found at the other side in the field. Some of the members of the cross arm were also reported to be hanging from the tower body. The top two panel members, leg & bracing members in longitudinal direction were also damaged due to impact of counter weight of broken insulator string. It was reported that the top conductor of the span between locations 15 to 16 had went to other side of the towers, however earth wire peaks were not damaged. As reported by POWERGRID, the conductor between location Nos. 14, 15 & 16 broke and crossed over ckt-I top conductor and fell on the ground. The Broken cross arm at the tower No. 14 was pulled towards location No.13.

Tower at Location No. 15 (DD+0)

g. POWERGRID informed that patrolling of the failed location was carried out on 30th April 2020 and no defects like missing members, missing nut & bolts were reported. Patrolling of 3-4 other towers adjacent to the affected tower were also carried out and no abnormalities were observed. Further, for collapsed tower location different foundation dimensions like back to back dimensions, diagonal distance, difference in levels etc. were found to be generally in line with approved drawing.

h. As per POWERGRID, at the time of tower collapse, localized wind storm prevailed in the vicinity of affected stretch of transmission line and the same had caused widespread damages in the vicinity. Tower failure was initiated due to this high intensity localized wind storm. POWERGRID officials informed that the above windstorm has also caused extensive wide spread damages to nearby trees and other structures. The same was also reported in local newspapers as well.

i. The material tests were conducted on 4 samples selected from failed tower structure at independent NABL accredited lab and various parameters in these reports were generally found to be within limits.

- **Committee Observations and Recommendations :**

Committee noted that this transmission line had failed in two consecutive years, i.e. 2019 & 2020. The line has been designed as per Reliability level 1 instead of Reliability level 2 which is to be adopted for quad conductor configuration lines as per Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations. Further, in the previous failure incident, committee observed that there was deficiency in the erection/O&M practices adopted by POWERGRID as number of bolts were found missing in the Leg members at some of the failed tower locations. Also, the distance of bolt hole from the edge of the members also appeared to be on lower side.

Committee noted that the high wind velocity might have prevailed in the vicinity of transmission line. However, POWERGRID could not provide wind speed data from any authenticated observatory indicating speed of wind prevailing at the failure location at the time of the failure. Committee noted that the due to the deficiency in erection/O&M of the transmission line, the tower structures were inherently weak which failed during the high wind incident observed in the area. The wind had caused failure of transmission tower at location No. 12 (DA+0) which subsequently led to failures of the towers at Location Nos. 13, 14 & 15 due to pulling force of the conductors.

Committee also noted that CEA Regulations have been drafted after detailed consultation with the stakeholders and shall be adhered to in any case. Considering the fact that there have been many failures

in Agra region in past few years, Committee advised POWERGRID to improve their operation & maintenance activities and to increase frequency of patrolling of the lines. Committee also advised POWERGRID to ensure that Reliability level to be adopted for all the future transmission lines shall be in accordance to CEA Regulations.

It was emphasized that after every failure the concerned utility needs to submit the actual wind velocity prevailed in the affected area so that the investigating team of standing committee could get reference wind speed prevailed over that area. In this matter, the respective utility may seek the help of IMD to get the wind data obtained from observatory/ Satellite/Radar.

A.15 220 kV S/C RAPP C-ANTA transmission line failed on 03.07.2020

[Tower at location No. 213 (A+0)]

➢ **<u>Brief Background</u>**

220 kV S/C RAPP C-ANTA transmission line of POWERGRID was constructed by M/s Hythro Corporation and the same was commissioned on 10.01.2000. The suspension towers used in this line are of 400 kV S/C type (Horizontal Configuration) and have been designed for medium wind zone as per IS 802-1977. The line is having polymer insulators in I-I-I configuration. This was reported as the first incidence of tower failure in this line.

➢ **<u>Observations</u>**

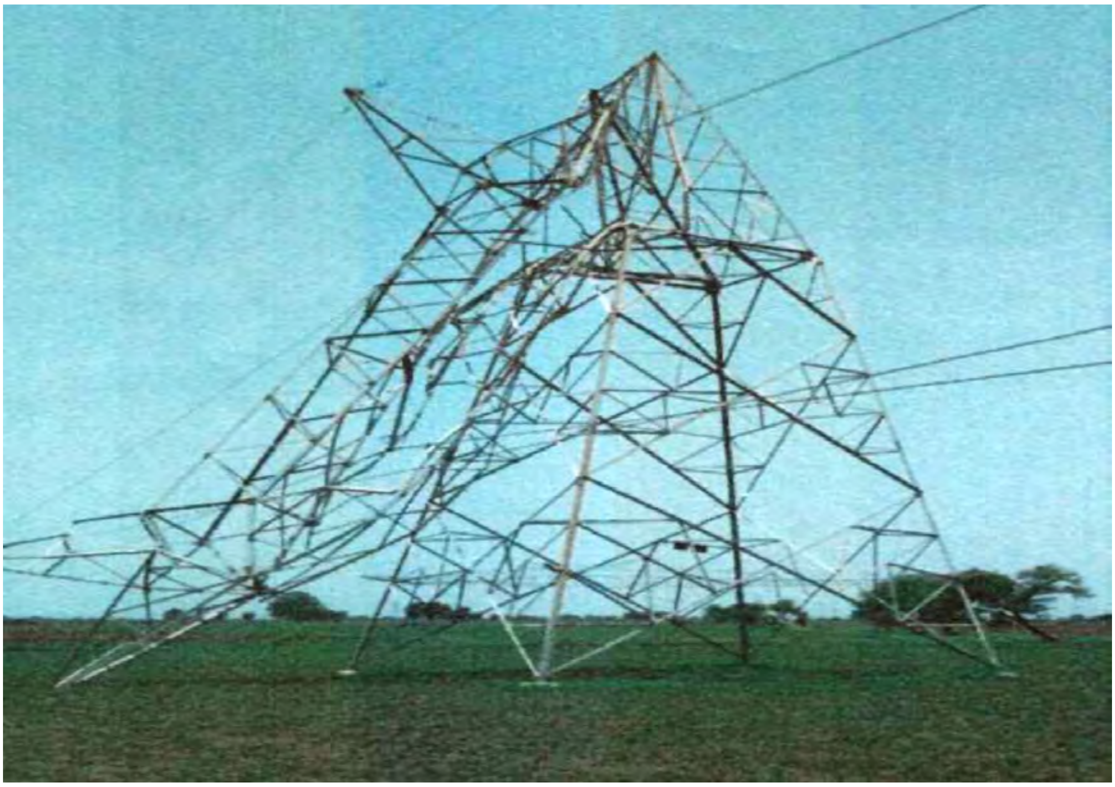
a. The affected suspension tower was situated/located in open agricultural field of Gopalpura, PostThikariya, Tahsil Anta, District Baran (Rajasthan) and was about 70 km from Kota Substation of POWERGRID. The tower was situated in plain terrain with very few low height trees around the location. Google map of failed tower stretch is shown below:

b. Tower spotting details of relevant section of the transmission line is as follows:

SI. No.	Loc. No.	Type of Tower	Forward Span	Angle of Dev.	Extent of damage

1.	207	A+3	410		
2.	208	A+0	400		
3.	209	A+0	430		Nil
4.	210	A+0	430		
5.	211	A+0	380		Nil
6.	212	A+0	420		Nil
7.	**213**	**A+0**	**420**		**Tower damaged from waist level**
8.	214	A+0	430		
9.	215	A+0	430		
10.	216	B+0	400	3°10'(LT)	Nil

c. **Tower at location No. 213 (A+0)** was bent from the waist level in the transverse direction. The lower part of the tower was in erect condition and no damage was observed to the foundation and stubs. The top portion of tower structure toppled and bent from tower waist level. As reported by POWERGRID, the tower was checked thoroughly and no tower members/nuts & bolts were found missing in the tower. Further, for collapsed tower location different foundation dimensions like back to back dimension, diagonal distance, difference in levels etc were found to be generally in line with approved drawing.



d. POWERGRID informed that patrolling of the failed location was carried out on 1st June 2020 and no defects like missing members, missing nuts & bolts were reported. Further, patrolling of 3-4 other towers adjacent to the affected tower were also carried out and no abnormalities were observed.

e. As per POWERGRID, at the time of tower collapse, heavy localized whirling wind storm prevailed in the vicinity of affected stretch of transmission line and the tower failure was initiated due to this high intensity localized wind storm. POWERGRID officials informed that the above windstorm has also caused extensive wide spread damages to nearby trees and other structures. The same was also reported in local newspapers as well.

f. The material tests were conducted on 04 samples selected from site at independent NABL accredited lab and various parameters in these reports were generally found to be within limits.

➢ **Committee Observations and Recommendations :**

Committee noted that the 220 kV transmission line has been strung on the towers designed for 400 kV voltage level. However, the spans between the towers has been increased/ optimized by POWERGRID. Committee also noted even though the transmission line was commissioned in year 2000, the line has been designed as per old IS 802:1977 instead of IS 802:1995. Committee advised POWERGRID to examine the background of adoption of old designs for these transmission lines and submit the reasons for the same to the Committee. POWERGRID subsequently informed that towers available for 400 kV S/C has been used in 220 kV RAPP C-Anta transmission line at few locations. Foundation for the failed tower location was casted in July 1999 and the line was commissioned in 2000.

Committee noted that in order to save the cost of designing & testing, transmission utilities might continue to use old designs of towers even after revision of IS codes. Committee recommended that such type of practices should not be adopted by the utilities and it should be ensured that the transmission lines are designed and erected as per latest IS codes, Regulations and recommendations of the Standing Committee and Task Force, as applicable.

Further, the committee noted that this transmission line is around 20 years old. The high wind velocity might have prevailed in the vicinity of transmission line in the transverse direction leading to failure of tower at location No. 213(A+0). However, POWERGRID could not submit wind speed data from any authenticated observatory indicating speed of wind prevailing at the failure location at the time of the failure. In absence of wind speed data from authenticated observatory, it is not possible to conclude that wind speed might have exceeded the design wind speed.

Committee noted that this was the first failure incident of this transmission line and advised POWERGRID to observe & monitor the

transmission line and in case repeated failures are observed in the line in future, the decision for adopting the strengthening of transmission line by providing hip bracing in the bottom most panels for the towers designed according to IS 802:1977, may be discussed and finalized in the meetings of the Committee.

A.16 400 kV D/C (Quad) Dulhasti-Kishenpur II & III Transmission line failed on 10.09.2020

[Towers at location No. 261 (DB+6) & 262 (DC+4.5)]

- **Brief Background**

400 kV D/C Quad Dulhasti-Kishenpur line of POWERGRID was constructed in two different packages by M/s Tata Projects and M/s R S Gill & Company and was commissioned on 19.01.2018. The total length of the transmission line is 119.438 km. The section involving the affected towers (location Nos. 261 & 262) was executed by M/s Tata Projects. The towers of the line were designed as per IS 802:1995 in vertical configuration considering wind pressure for Wind Zone 5 and Non-Snow Zone (zero ice loading). The towers were designed considering Reliability level 1. The line is having Porcelain insulators with 25 insulators in each sub-string of the quad tension string. Only one of the circuits was strung on the tower at the time of failure incident.

- **Observations**

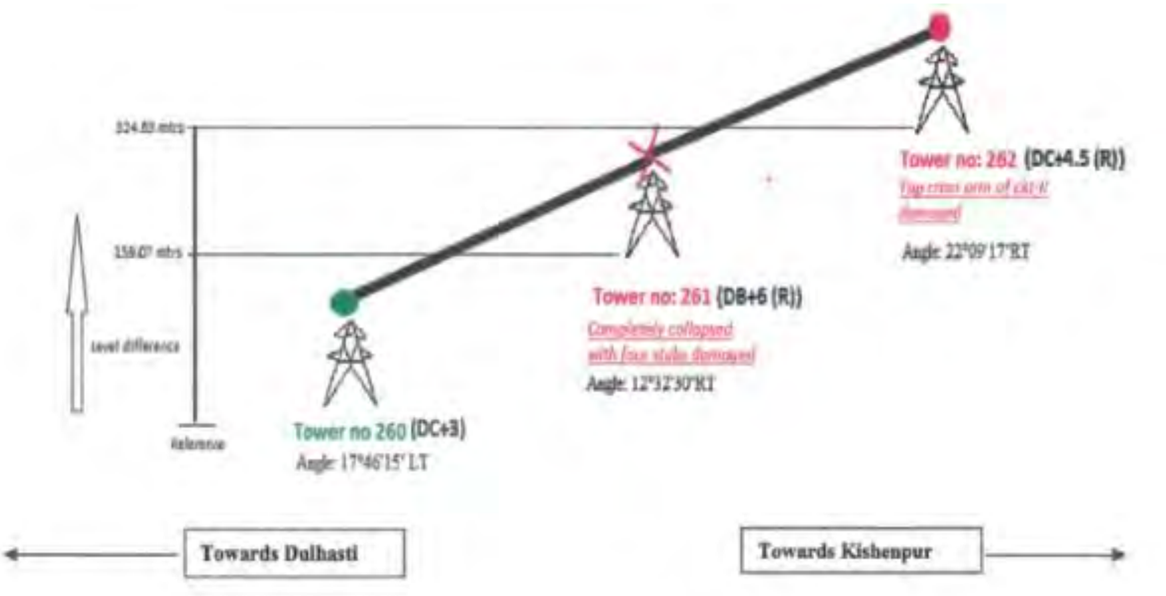
a. The affected towers were situated/located in Village Sewna of Udhampur District at around 70 km from Udhampur town in Jammu & Kashmir. The tower was situated in forest area with no local habitation present near the towers.

b. Tower spotting details of relevant section of the transmission line is as follows:

Tower No.	Type of Tower	Angle of Deviation	Span Length (m)	Level difference (m)	Remarks
260	DC+3	17°46'15" LT			L-"A" has 9 m. Leg Extn L-"B", "C" & "D" have 3 m Leg Extn.
			262	159.07	
261	**DB+6 (Rnf)**	**12°32'30" RT**			**L-"A" has 9 m Leg Extn L-"B", "C" & "D" have 6 m Leg Extn.**
			425	165.76	

262	DC+4.5 (Rnf)	22°09'17" RT			L-"A" has 7.5 m Leg Extn L-"B" has 6 m Leg Extn. L-"C"&"D" have 4.5 m LE

c. The diagram depicting the details of failed towers is shown below:



d. **Tower at location No. 261 (DB+6)** was having reinforced tower foundations. The tower had collapsed completely to the ground in almost transverse direction to the line. All the four main legs and the stubs were damaged. As reported by POWERGRID, Leg 'C' of the tower was observed to be sheared near the stub joint. Common plan bracings and some of the members in the cage section of the tower were fractured and deformed.

Tower at Location No. 261(DB+6)

e. POWERGRID informed that no major landslide/ settlement was observed at the failure site. The Level and diagonal dimensions were measured and it was observed that differential settlement seems to have occurred over a longer period of time which might have resulted in sinking of Legs A & B.

f. The measurements of Level difference with respect to leg "C" were as under:
   - Leg A - 0.667 Meter down
   - Leg B — 0.597 Meter down
   - Leg C — 0.00 Meter (Reference)
   - Leg D — 0.014 Meter Up

g. The back to back and diagonals measured by POWERGRID site officials were as under:
   - Back to Back of Stub

Leg to Leg	**As per Drawing (in m)**	**As per Actual (in m)**
A to B	17.011	16.7568 m
B to C	16.432	16.6224 m
C to D	16.432	16.0669 m
D to A	17.011	17.2671 m

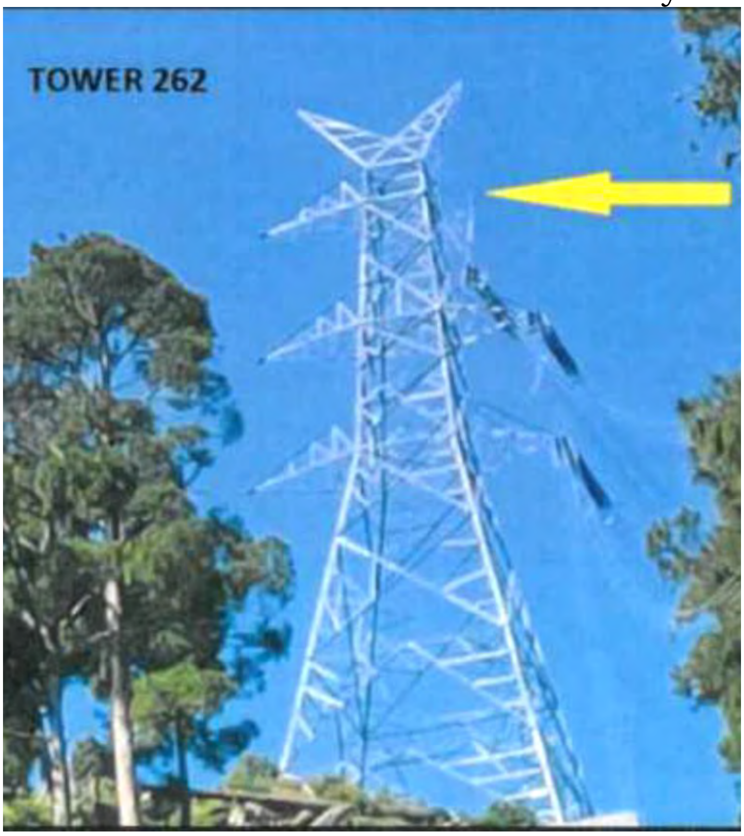
   - Diagonals (Stub 200 X 20, Length 4023 mm)

Diagonal	As per Drawing (in m)	As per Actual (in m)
A to CP (Half Diagonal)	12.416	12.783
C to CP (Half Diagonal)	11.597	11.877
A to C (Full Diagonal)	24.013	24.660
B to CP (Half Diagonal)	11.597	11.337

D to CP (Half Diagonal)	11.597	11.290
B to D (Full Diagonal)	23.194	22.627

h. As reported by POWERGRID officials, some of the Uphill Boulders were also found hitting the lower legs, however, the upper soil strata was observed to be stable.

i. **Tower at Location No. 260 (DC+4.5)** was in erect condition. The top cross arm of the tower was found to be damaged due to the pulling force of the conductors. This was observed to be a secondary failure.



Tower at Location No. 260(DC+4.5)

j. POWERGRID informed that patrolling of the failed location was carried out on 1st June 2020 and no defects like missing members, missing nuts & bolts were reported. Further, patrolling of 3-4 other towers adjacent to the affected tower were also carried out and no abnormalities were observed.

k. The material tests were conducted on 04 samples selected from site at independent NABL accredited lab and various parameters in these reports were generally found to be within limits.

l. Committee noted that single circuit was strung on the double circuit tower and enquired whether the towers were designed & tested considering the single side stringing. POWERGRID informed that the strength of tower to withstand single side stringing was verified during testing of tower at the test bed.

m. POWERGRID informed that a geo-technical investigation of the affected locations is also being carried out.

➢ **Committee Observations and Recommendations :**

Committee noted that the transmission line has been commissioned after the notification of Central Electricity Authority (Technical Standards for Construction of Electrical Plants and Electric Lines) Regulations 2010. However, the line is designed as per Reliability level 1 instead of Reliability level 2 which is to be adopted for quad conductor configuration lines as per aforementioned Regulations.

Committee observed that the failure of tower at location No. 261 (DB+6) had occurred due to buckling/deformation of tower members due to differential settlement of foundation pits. POWERGRID is required to take suitable safety measures considering the geotechnical investigation and suggested that an avalanche protection / retaining wall may also be constructed around the tower to safeguard the tower from hitting of the boulders.

Committee also noted that even though the transmission line was commissioned in year 2018, the line has been designed as per old IS 802:1995 instead of IS 802:2015.

Committee also advised POWERGRID to ensure that Reliability level to be adopted for all the future transmission lines shall be in accordance to CEA Regulations. Committee recommended that practices of using old designs of towers even after revision of IS codes should not be adopted by the utilities and it should be ensured that the transmission lines are designed and erected as per latest IS codes, Regulations and recommendations of the Standing Committee and Task Force, as applicable.

A.17 765 kV S/C Bina–Gwalior-III Transmission line failed on 05.01.2021
[Tower at Location No.611 (B+0)]

➢ **Brief Background**

765 kV S/C Quad Bina-Gwalior-III Transmission Line of POWERGRID was executed by joint venture of M/s Lanco & Unitech and was commissioned in May, 2014. Total length of the transmission line is 231.3 km. This line traverse through plain terrain and tension towers were designed for wind zone 4 as per IS 802:1995 with Quad Bersimis conductor. The towers were designed with delta configuration. This was reported to be the first failure of the transmission line.

➢ **Observations:**

a. The details of tower spotting in the affected sections is as follows:

Sr. No.	Loc. No.	Tower Type	Span	Angle of Dev.	Extent of damage
1	609	C (Delta) + 9	425	15^0 38’ 38” LT	Intact
2	610	A (Delta) + 6	340		Intact
3	**611**	**B (Delta)+0**	**300**	**1^0 44’17” RT**	**Tower Collapsed, Theft of tower members and cutting of main bracings observed.**
4	612	A (Delta) + 0	300	0	Theft of all cross bracings, three main plan members and all redundant members of bottom panel observed
5	613	A (Delta) + 0	301	0	Intact
6	614	A (Delta) + 0	420	0	Intact
7	615	A (Delta) + 0	380	0	Intact
8	616	C (Delta) + 0		16^0 06’ 01” LT	Intact

b. **Tower at Location No. 611 (B+0)** was located near village Bilauaa, Jaurasi Ghati Dabra Taluk in Gwalior district (Madhya Pradesh). The tower was completely collapsed from stub level to the ground and only one stub of the tower along with its foundation was found intact. It was observed that Leg B was bent from top of chimney level and the remaining two legs were sheared from just above concrete/chimney level. All the redundant members connected to leg A & leg B below belt level of bottom panel were stolen. In leg-C and leg-D, all redundant members from cross bracing to the main legs were missing. Removed tower member pieces, bolts and nuts were found scattered at the tower collapse site.

Tower at Loc. No.611 (B+0)


Bolts/Nuts, cutting tools & Removed tower members Found at Site

c. **Tower at Location No. 612 (A+0**) was in erect position, however it was observed that all the redundant members of bottom section and three main plans bracing of the tower had been removed. Number of tower pieces removed from bottom panel, bolts/nuts along with cutting tools were also found at location No. 612(A+0).

d. POWERGRID officials informed that as per the data available in PATROSOFT, the patrolling of above locations were carried out on 12th October 2020 and no missing tower members / nuts & bolts were observed at that time.

e. POWERGRID informed that the incidence of theft has been reported to the local police station and FIR has been lodged. In this line, incidences of theft had been observed earlier also and many communications with the local administrative bodies in this regard had been made.

Tower at Loc. No.612 (A+0)

f. To examine the chemical and material properties, samples from the affected tower location were selected from site and sent for testing at independent NABL accredited lab for testing. All the tower steel samples were found acceptable as per the relevant Indian Standards.

➢ **Committee Observations and Recommendations :**

Committee observed that the failure of towers has been caused due to theft or sabotage by miscreants in the area. This is also evident as tools used by miscreants and removed tower parts were also found lying in the vicinity of collapsed tower.

Committee discussed the issue and noted that there are many incidences of thefts/sabotage in the Gwalior region. MPPTCL informed that they are also facing these types of problems in some of their transmission lines and had adopted painting of transmission towers with Tarcoal paint. POWERGRID informed that they had increased the patrolling frequency and had installed vibration sensitive cameras at some of the locations to avoid thefts/sabotage. Committee advised POWERGRID to improve their patrolling activities in the area to ensure safe & reliable operation and to avoid theft/sabotage by miscreants.

A.18 765 kV S/C Jhatikara–Bhiwani Transmission line failed on 06.05.2021

[Tower at Location No. 33/3 (A+0)]

➢ **Brief Background**

765 kV S/C Quad Jhatikara-Bhiwani Transmission Line of POWERGRID was erected by M/s EMCO and was commissioned in October, 2012. The towers of this line were designed for Wind Zone 4 (47 m/sec) and reliability level 2 as per IS 802-1995. In addition to existing codal provisions the suspension towers have also been designed considering narrow front wind condition and with 75% wind in broken wire condition. The towers were designed with Quad ACSR Bersimis Conductor. The suspension towers of this line were designed with Double "I-V-I" Polymer insulator string in Delta configuration. The line had earlier failed in May, 2018 in which one of suspension tower at Location No. 17 (A+0) was affected.

➢ **Observations:**

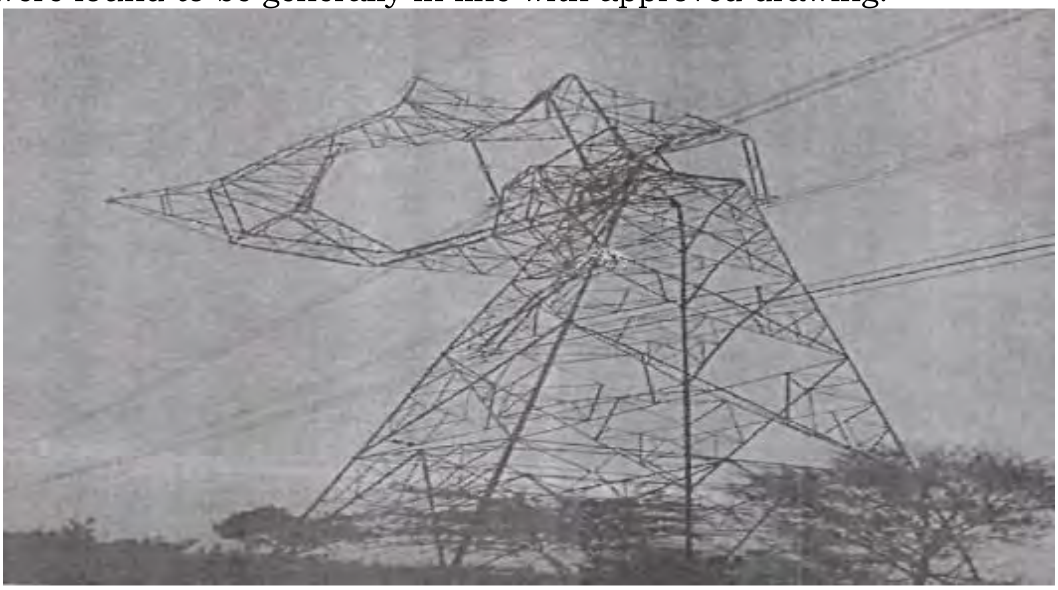
a. The details of tower spotting in the affected sections is as follows:

Sr. No.	Loc. No.	Tower Type	Span	Angle of Dev.	Extent of damage
1	33/0	C+0	390	10 11' 37" LT	Intact
2	33/1	A+0	385		Intact

3	33/2	A+0	391		Intact
4	**33/3**	**A+0**	**387**		**Collapsed**
5	33/4	A+0	381		Intact
6	33/5	A+0	396		Intact
7	33/6	A+3	400		Intact
8	33/7	A+0	390		Intact
9	33/8	A+0	396		Intact
10	33/9	A+3	400		Intact
11	34/0	C+0			Intact

b. **Tower at Location No. 33/3 (A+0)** was located in plain field with few trees in vicinity near village Jhatikara (New Delhi) at around 20 km from Jhatikara substation of POWERGRID. Tower was damaged from the waist level and damaged part was still hanging in the transverse direction. Most of the members above waist level were in jumbled condition. Bulging of tower members below the waist level and above basic tower level was observed. It was also observed that one arm of the 'V' insulator string (of middle phase) was detached from tower while the other was still connected. Insulators of outer phases were damaged and both the 'I' string (outer phases) were still attached with tower.

c. POWERGRID informed that patrolling of the failed location was carried out on 04.03.2021 and no defects like missing members, missing nuts & bolts were reported. Examination of 3-4 other towers adjacent to the affected tower were also carried out and no abnormalities were observed. Further, for collapsed tower location different foundation dimensions like back to back, diagonal distance, levels and the same were found to be generally in line with approved drawing.



Tower at Loc. No. 33/3 (A+0)

d. POWERGRID informed that at the time of tower collapse, heavy thunderstorm condition with exceptionally high wind velocity prevailed in the narrow strip in the vicinity of affected stretch of transmission line and the Tower failure was initiated due to this high intensity localized wind storm.

e. The previous failures of the 765 kV S/C Delta configuration towers had been investigated by Standing Committee and the Committee had suggested strengthening of these towers. It was informed by POWERGRID that the failed tower locations were already strengthened. POWERGRID also informed that they had got reviewed this tower design by M/s Manitoba Hydro, Canada and they have also suggested strengthening of some of the members. The strengthening suggested by M/s Manitoba Hydro was also executed at the failed tower.

f. To examine the chemical and material properties, samples from the affected tower locations were selected from site and sent for testing at independent NABL accredited lab. All the tower steel samples were found acceptable as per the relevant Indian Standards.

➢ **<u>Committee Observations and Recommendations :</u>**

Committee noted the failed tower was already strengthened by POWERGRID prior to the failure and enquired about the adequacy of strengthening mechanism adopted by POWERGRID for these structures. POWERGRID official informed that the strengthening of towers includes replacement of few tower members with large size members as well clamping of additional members to the existing members. Strengthening of towers in same manner as suggested by the Standing Committee in the previous meetings, i.e. by replacement of all members, is not possible for already erected tower members as long shutdown of transmission lines will be required. However, failed towers are always replaced by completely strengthened tower in line with the recommendations of committee. Further, strengthening of few other tower members, as suggested by M/s Manitoba Hydro is also being adopted by POWERGRID. The tower with strengthening currently being adopted by POWERGRID (i.e. clamping of few members and replacement of some members) had also been successfully tested at the CPRI test bed.

Committee noted the above and concluded that a narrow front of high intensity wind observed in the area had led to failure of the tower. Committee advised that failed tower should be replaced with already strengthened tower and POWERGRID should ensure that the strengthening mechanism adopted is in accordance with the suggestions of Standing Committee recommended in previous meetings. It was emphasized that after every failure the concerned

utility needs to submit the actual wind velocity prevailed in the affected area so that the investigating team of standing committee could get reference wind speed prevailed over that area. In this matter, the respective utility may seek the help of IMD to get the wind data obtained from observatory/ Satellite/Radar.

Committee also advised that best practices in quality control process for raw material, manufacturing, transportation, construction, storage, erection and stringing of transmission line should be adopted by utilities.

A.19 800 kV HVDC Agra–BNC-Pole-II Transmission line failed on 10.05.2021
[Tower at Location No. 3118 (A+0)]

➢ **Brief Background**

800 kV HVDC Agra-BNC Transmission Line of POWERGRID was constructed by M/s INABENSA and pole-II of the transmission line was commissioned in November, 2015. The towers of this line were designed for basic wind speed of 47 m/s corresponding to wind zone 4 as per IS 802:1995 also taking into consideration narrow front wind on tower body & 50 % wind in broken wire condition. The line was designed with Hexa ACSR Lapwing conductor with Y string glass insulators in horizontal configuration. The line had earlier failed on 02.05.2018 in which three towers at location Nos. 4328, 4347 & 4348, which were located near Agra region, were affected.

➢ **Observations:**

a. The details of tower spotting in the affected sections is as follows:

Sr. No.	Loc. No.	Tower Type	Span	Angle of Dev.	Extent of damage
1	3116	C+0	390	15°45' 12" LT	Intact
2	3117	A+0	390		Intact
3	**3118**	**A+0**	**370**		**One cross arm damaged**
4	3119	A+0	414		Intact
5	3120	B+0	415	10°13' 25" LT	Intact

b. **Tower at Location No. 3118 (A+0)** was located in plain field area near village Baraijot/Sekhpura, Kalwari Taluk in Basti district (Uttar Pradesh). The tower was in erect condition and only one cross arm of pole-II of tower was damaged. All the stubs and rest of the tower were found intact.

Tower at Loc. No. 3118 (A+0)

c. POWERGRID informed that discussion was done with nearby local village residents and it was gathered that at the time of tower collapse, heavy thunderstorm condition with exceptionally high wind velocity prevailed in the narrow strip in the vicinity of affected stretch of transmission line and the Tower failure was initiated due to this high intensity localized wind storm. It was informed that the above windstorm has also caused extensive wide spread damages to nearby trees and nearby other structures. The same was also reported in local newspapers as well.

d. POWERGRID officials highlighted that the failed transmission tower was designed for wind speed corresponding to wind zone 4, however, the tower is located at approx. 15 km from the boundary of Wind Zone 5.

e. The material tests were conducted on samples selected from affected portion of the tower at independent NABL accredited lab and various parameters in these reports were generally found to be within limits.

➢ **Committee Observations and Recommendations :**

Committee concluded that the high wind velocity might have prevailed in the vicinity of transmission line in the transverse direction leading to failure of towers. However, wind speed data received from any authenticated observatory indicating speed of wind prevailing at the failure location at the time of the failure is not provided by the transmission utility. In absence of wind speed data from authenticated observatory, it is not possible to conclude that wind speed might have exceeded the design wind speed.

It was emphasized that after every failure the concerned utility needs to submit the actual wind velocity prevailed in the affected area so that the investigating team of standing committee could get reference wind speed prevailed over that area. In this matter, the respective utility may seek the help of IMD to get the wind data obtained from observatory/ Satellite/Radar.

Committee also noted that the failed tower was in vicinity of boundary of higher wind zone 5. Committee advised that Transmission lines to be laid within 50 km of the border of the wind zones may be designed with higher of the two zones.

A.20 400 kV D/C Korba–Raipur-III & IV Transmission line failed on 11.05.2021

[Tower at Location No.303 (DA+0)]

- **Brief Background**

400 kV D/C Korba-Raipur-III & IV Transmission Line of POWERGRID was commissioned in July, 2011. Total length of the transmission line is 212.8 km. This line traverse through plain terrain and "DA" type suspension towers of this line were designed for wind speed of 39 m/s corresponding to Wind Zone 2 and reliability level 1 and also taking into consideration narrow front wind on tower body & 75% wind in broken wire condition. The towers were designed in vertical configuration with Twin ACSR Moose conductor and Single "I" Porcelain insulator string.

- **Observations:**

a. The details of tower spotting in the affected sections is as follows:

Sr. No.	Loc. No.	Tower Type	Span	Angle of Dev.	Extent of damage
1	301	DD+0	395	39˚44' 53" RT	Intact
2	302	DA+6	370		De-capping of Insulator
3	**303**	**DA+0**	**380**		**Collapsed**
4	304	DA+0	370		Intact
5	305	DA+3	395		Intact

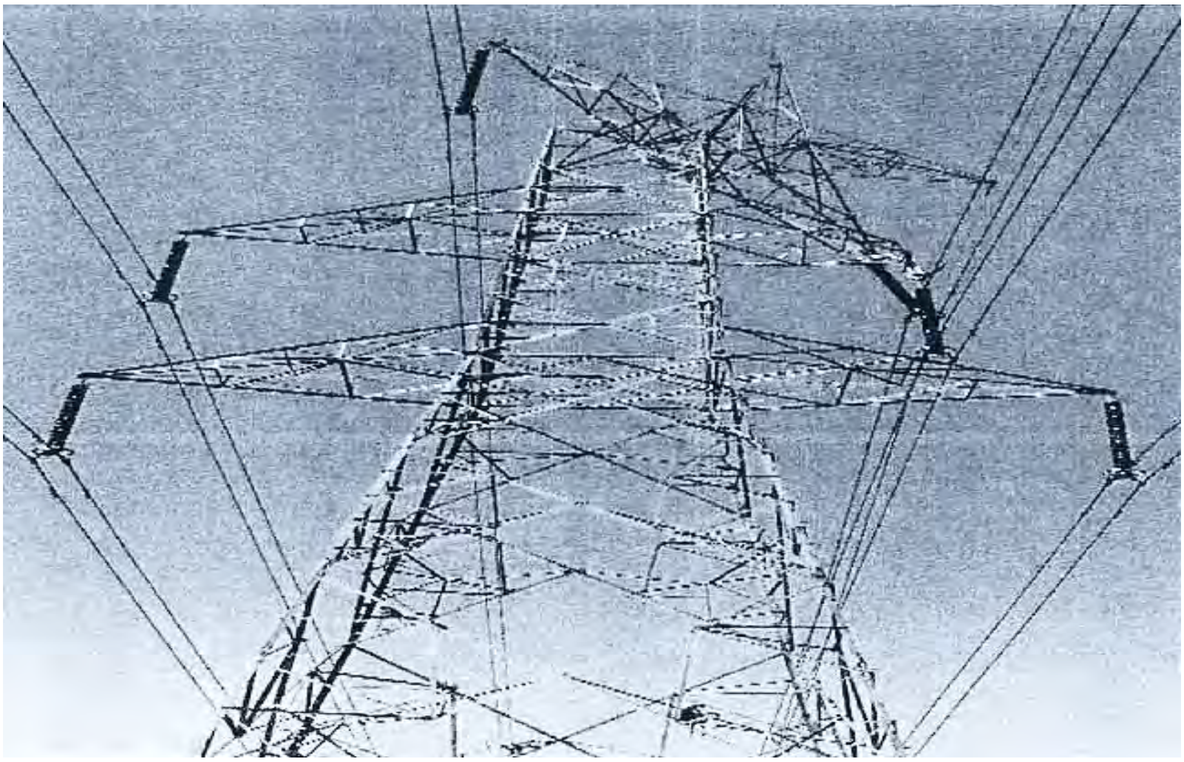
b. **Tower at Location No. 303 (DA+0)** was located in plain field with few trees in vicinity near village Khajuri, Takhatpur Taluk in Bilaspur district (Chhattisgarh) at around 40 km from Bilaspur Substation. Both of the top cross arms & one middle cross arm of the tower were damaged and rest of the tower along with stubs was intact and still standing erect. The damaged portion of the tower was resting on the tower structure. POWERGRID informed that the damaged tower was also examined for any defects like missing members, nuts & bolts etc., and no such defects were observed.

c. POWERGRID informed that patrolling of the failed location was carried out on 20.04.2021 and no defects like missing members, missing nut & bolts were reported.

d. It was informed that other towers adjacent to the affected tower location 303 were also examined and no abnormalities were observed except for Tower at Location No. 302 (DA+6) insulator de-capping was observed which might be because of sudden jerk of conductors.

e. POWERGRID officials informed that discussion was done with nearby local village residents and it was gathered that at the time of tower collapse, heavy windstorm condition with exceptionally high wind velocity prevailed in the vicinity of affected stretch of transmission line and the Tower failure was initiated due to this high intensity localized wind storm. It was informed that the above windstorm has also caused extensive wide spread damages to nearby trees and LT pole structures. The same was also reported in local newspapers as well.

f. To examine the chemical and material properties, few samples from the affected tower were selected from site and sent for testing at independent NABL accredited lab. All the tower steel samples were found acceptable as per the relevant Indian Standards except one in which percentage of Carbon composition was marginally high. (0.24% in place of allowable 0.23%), however, the mechanical properties were within limit.



Tower at Location No. 303 (DA+0)

➢ **Committee Observations and Recommendations :**

Committee observed that there was damage of the cross arm of the tower at location No. 303 (DA+0) and due to the jerk de-capping of the insulator at the tower at location No.302 (DA+6) occurred. Representative from MPPTCL also confirmed that the transmission lines of MPPTCL is also facing similar problems in this region and a pilot project considering line surge arrestors is being implemented by MPPTCL to overcome the issue.

Committee concluded that the high wind velocity might have prevailed in the vicinity of transmission line in the transverse direction leading to failure of towers. However, wind speed data received from any authenticated observatory indicating speed of wind prevailing at the failure location at the time of the failure is not provided by the transmission utility. In absence of wind speed data from authenticated observatory, it is not possible to conclude that wind speed might have exceeded the design wind speed.

It was emphasized that after every failure the concerned utility needs to submit the actual wind velocity prevailed in the affected area so that the investigating team of standing committee could get reference wind speed prevailed over that area. In this matter, the respective utility may seek the help of IMD to get the wind data obtained from observatory/ Satellite/Radar.

Committee advised that Utilities should assess the condition of structure of towers, conductors, earthwire, insulators and all associated accessories, foundation and earthing system periodically using modern techniques & diagnostic tools and should take appropriate action, wherever abnormality is noticed.

A.21 765 kV D/C Wardha–Aurangabad Transmission line failed on 27.05.2021

[Tower at Location No. 318(DA+3), 319(DA+0), 320(DA+0), 321 (DA+3), 322(DA+6)]

➢ **Brief Background**

765 kV D/C Wardha-Aurangabad Transmission Line of POWERGRID was executed by M/s Gammon India and was commissioned in July, 2014. This line traverse through plain terrain & and suspension towers of this line were designed for basic wind speed of 39 m/s corresponding to Wind Zone 2 reliability level 2 as per IS 802-1995. POWERGRID informed that narrow front wind on tower body & 75% of wind in broken wire condition was also considered in design of these towers. The line was designed with Hexa ACSR Zebra conductor with Double "I" glass insulator string in vertical configuration. This was reported as the first incident of failure in the transmission line.

➢ **Observations:**

a. The affected suspension towers were located in the plain field area near Gimbha village, Mangrulpir Tahsil of Washim District (Maharashtra) at around 116 km from Wardha substation. The details of tower spotting in the affected sections is as follows:

Sr. No.	Loc. No.	Tower Type	Span	Angle of Dev.	Extent of damage
1	323	DC+0(TP)	395	0°	Intact
2	**322**	**DA+6**	**405**		**Tip of earth wire peak of circuit-I was buckled/ damaged**
3	**321**	**DA+3**	**390**		**Collapsed**
4	**320**	**DA+0**	**354**		**Collapsed**
5	**319**	**DA+0**	**387**		**Collapsed**
6	**318**	**DA+3**	**393**		**Collapsed**
7	317	DA+0	365		Intact
8	316	DA+0	394		Intact
9	315	DA+0	360		Intact
10	314	DA+0	357		Intact
11	313	DA+0	398	15° 10’ 10” LT	Intact

b. **Tower at Location No. 322 (DA+6)** was in erect condition. The tip of earth wire peak of circuit-I was buckled/damaged. All the stubs and other tower members were intact.

Tower at Location No. 322 (DA+6)

c. **Tower at Location No. 321 (DA+3)** was damaged from stub level and was collapsed in transverse direction to the line. All the four stubs of tower were completely damaged.

Tower at Location No. 321 (DA+3)

d. **Tower at Location No. 320 (DA+0) & 319 (DA+0)** were buckled from middle cross arm level and the top portion of the towers were resting on the base structure. All the four stubs of both the towers were intact.

Tower at Location No. 320 (DA+0)

Tower at Location No. 319 (DA+0)

e. **Tower at Location No. 318 (DA+3)** was in erect condition. The top cross arm for circuit-II was damaged. All the four stubs of tower were intact.

Tower at Location No. 318 (DA+3)

a. POWERGRID informed that the damaged towers were also examined for any defects like missing members, nut & bolts etc. and no such defects were observed. Further, it was reported that different foundation dimensions like back to back, diagonal distance, levels were also examined by POWERGRID officials and the same were found to be generally in line with approved drawing and there were no missing members in the tower structure.

g. POWERGRID informed that patrolling of the failed location was carried out on 20.01.2021 and no defects like missing members, missing nuts & bolts were reported. Further, other towers adjacent to the affected tower locations were also examined and no abnormalities were observed.

h. POWERGRID officials informed that at the time of tower collapse, heavy thunderstorm activities were reported during which high wind velocity prevailed in the vicinity of affected stretch of transmission line and the same led to tower failures. It was informed that nearby trees were also damaged during the windstorm. The same was also reported in local newspapers as well.

a. To examine the chemical and material properties, 08 samples from the affected tower location No. 321 were selected from site and sent for testing at independent NABL accredited lab for testing. All the tower steel samples were found acceptable as per the relevant Indian Standards.

➢ **Committee Observations and Recommendations :**

Committee noted that this was the first incident of tower failure in the line. Committee concluded that the high wind velocity might have prevailed in the vicinity of transmission line in the transverse direction leading to failure of towers. However, wind speed data received from any authenticated observatory indicating speed of wind prevailing at the failure location at the time of the failure is not provided by the transmission utility. In absence of wind speed data from authenticated observatory, it is not possible to conclude that wind speed might have exceeded the design wind speed.

Committee emphasized that after every failure the concerned utility needs to submit the actual wind velocity prevailed in the affected area so that the investigating team of standing committee could get reference wind speed prevailed over that area. In this matter, the respective utility may seek the help of IMD to get the wind data obtained from observatory/ Satellite/Radar.

Committee advised that all transmission towers should be checked on topmost priority after major wind event to remove fatigue and distortions, if any, so as to restore the original strength and avoid failures in subsequent event of high intensity winds.

A.22 400 kV S/C Korba–Bhilai-I Transmission line failed on 30.05.2021
[Tower at Location No. 320 (A+3)]

➢ **Brief Background**

400 kV S/C Korba-Bhilai Transmission Line of POWERGRID was executed by M/s SAE and was commissioned in January, 1983. The suspension

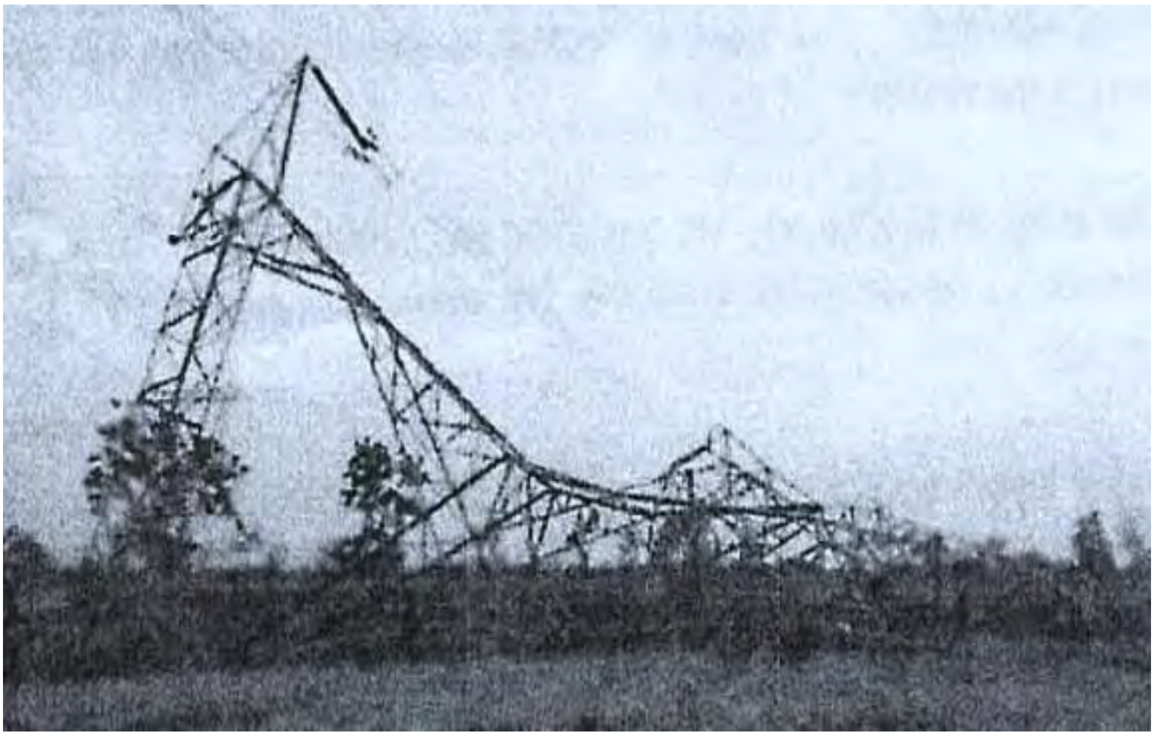
towers of this line were designed as per IS 802 – 1977 considering Medium Wind zone. The tower was designed with twin moose conductor with Single “I” insulator string in horizontal configuration. This is reported as the second instance of such tower failure in this line. Earlier in June-2009, three suspension towers at location at location Nos. 88, 89 & 90 had collapsed.

- **Observations:**

a. The details of tower spotting in the affected sections is as follows:

Sr. No.	Loc. No.	Tower Type	Span	Angle of Dev.	Extent of damage
1	312	A+0	374	0˚0’	Intact
2	313	A+0	388		Intact
3	314	A+0	412		Intact
4	315	A+3	415		Intact
5	316	A+0	395		Intact
6	317	A+0	405		Intact
7	318	A+0	395		Intact
8	319	A+0	415		Intact
9	**320**	**A+3**	**420**		**Collapsed**
10	321	A+0	390		Intact
11	322	A+0	381		Intact
12	323	B+0	380	14˚04’ RT	Intact

b. **Tower at Location No. 320 (A+3**) was located in plain field area at about 73 km from Bhilai sub-station. The tower got collapsed completely to the ground from the stub level in transverse direction to the line. All the stubs of the tower were damaged. POWERGRID informed that different foundation dimensions like back to back, diagonal distance, levels were also checked and the same were found to be generally in line with approved drawing and there were no missing members in the tower structure.



Tower at Loc. No. 320 (A+3)

b. POWERGRID informed that patrolling of the failed location was carried out on 17.02.2021 and no defects like missing members, missing nuts & bolts were reported. Further, other towers adjacent to the affected tower location were also examined and no abnormalities were observed.

c. POWERGRID officials informed that discussion was done with nearby local village residents and it was gathered that thunderstorm condition with exceptionally high wind velocity prevailed at the time of tower collapse and the Tower failure was initiated due to this high intensity localized wind observed during the storm. It was informed that the above windstorm has also caused damages to nearby trees. The same was also reported in local newspapers as well.

➢ **<u>Committee Observations and Recommendations :</u>**

Committee noted that this transmission line is around 38 years old and it had previously failed in the year 2009. Committee noted that the towers were designed as per IS 802 (1977) and narrow front wind load on these towers would not have been considered in the design. Committee concluded that the high wind velocity might have prevailed in the vicinity of transmission line in the transverse direction leading to failure of towers. However, wind speed data received from any authenticated observatory indicating speed of wind prevailing at the failure location at the time of the failure is not provided by the transmission utility. In absence of wind speed data from authenticated observatory, it is not possible to conclude that wind speed might have exceeded the design wind speed.

Committee observed that high intensity wind observed in the area may have led to failure of this old tower structure. It was emphasized that after every failure the concerned utility needs to submit the actual wind velocity prevailed in the affected area so that the investigating team of standing committee could get reference wind speed prevailed over that area. In this matter, the respective utility may seek the help of IMD to get the wind data obtained from observatory/ Satellite/ Radar.

A.23 765 kV S/C Meerut–Moga Transmission line failed on 10.06.2021

[Tower at Location No.558 (A+0), 559 (A+3), 560 (A+3)]

➢ **Brief Background**

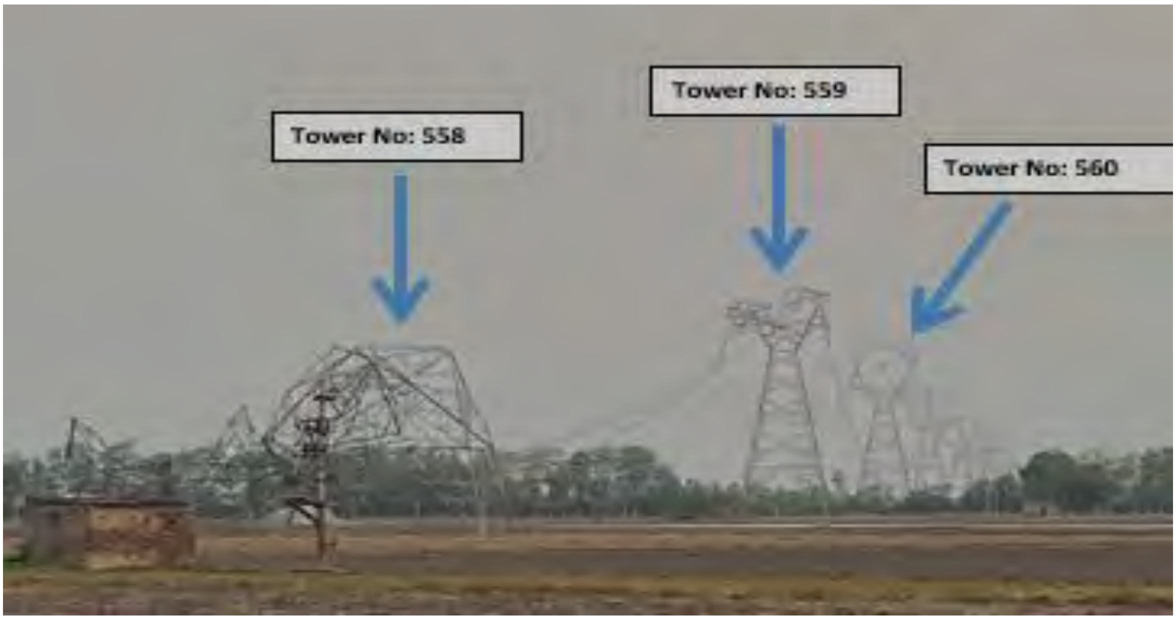
765 kV S/C Meerut-Moga Transmission Line of POWERGRID was constructed by M/s KEC India and was commissioned in May, 2015. Total length of the transmission line is 337.5 km. This line traverse through plain terrain and suspension towers of this line were designed for reliability level 2 and basic wind speed of 47 m/sec corresponding to Wind Zone 4 as per IS 802-1995, taking into consideration narrow front wind on tower body and 75% of wind in broken wire condition. The towers were designed in Delta configuration with Quad ACSR BERSIMIS Conductor. The suspension towers of this line were designed with Double "I-V-I" insulator string in Delta configuration. Polymer insulators have been used in the line at the failed tower locations. In the forest area both Horizontal configuration and delta configuration towers have been used in this Transmission Line. The line had earlier failed on 13.05.2016 in which tower at location No. 649 (A+0) had failed from above the waist level in the middle of one side of K-frame portion.

➢ **Observations:**

a. The affected suspension towers were located in the plain field area near to village Dhanetha, Tehsil Samana, District Patiala, Punjab and about 164 km from Moga sub-station. The details of tower spotting in the affected sections is as follows:

Sr. No.	Loc. No.	Tower Type	Span	Angle of Dev.	Extent of damage
1	557	C+3	375	19^0 20" 29' RT	Intact
2	**558**	**A+0**	**390**		**Tower collapsed just above the K-frame level & 1st panel level.**
3	**559**	**A+3**	**350**		**Tower failed from upper side of Delta section**

4	**560**	**A+3**	**355**		**Right Peak Damage**
5	561	A+0	375		Intact
6	562	A+0	375		Intact
7	563	A+0	385		Intact
8	564	A+9	331		Intact
9	565	C+9	371		Intact



b. **Tower at Location No. 558 (A+0)** was collapsed from the first cross bracing level in transverse direction to the line towards left side when observed facing Moga end. Tower's Leg A was found bent from just above the second panel level and other three legs were bent from just above the K-frame level. All the foundations chimneys and stubs were intact. All chimneys were covered in the soil. It was also observed that extra holes were not plugged with nuts & bolts.

Tower at Loc. No.558 (A+0)

c. **Tower at Location No. 559 (A+3**) was in erect condition. The cage portion of tower body i.e. K fame was completely distorted and buckled inwards and the same was resting on tower structure below waist level.

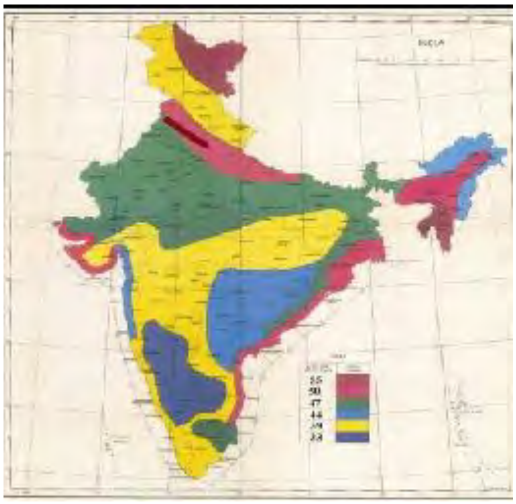
Tower at Loc. No.559 (A+3)

d. **Tower at Location No. 560 (A+3**) was in erect position. The right side peak of the tower got buckled and remaining tower structure was intact.

Tower at Loc. No.560 (A+3)

e. It was informed that the patrolling of the affected section of the transmission line was done on 29.05.2021 and no major defects like missing members, missing nuts & bolts were reported. Failed towers were examined for missing members and bolts & nuts. It was found that there were no missing members and bolts & nuts.

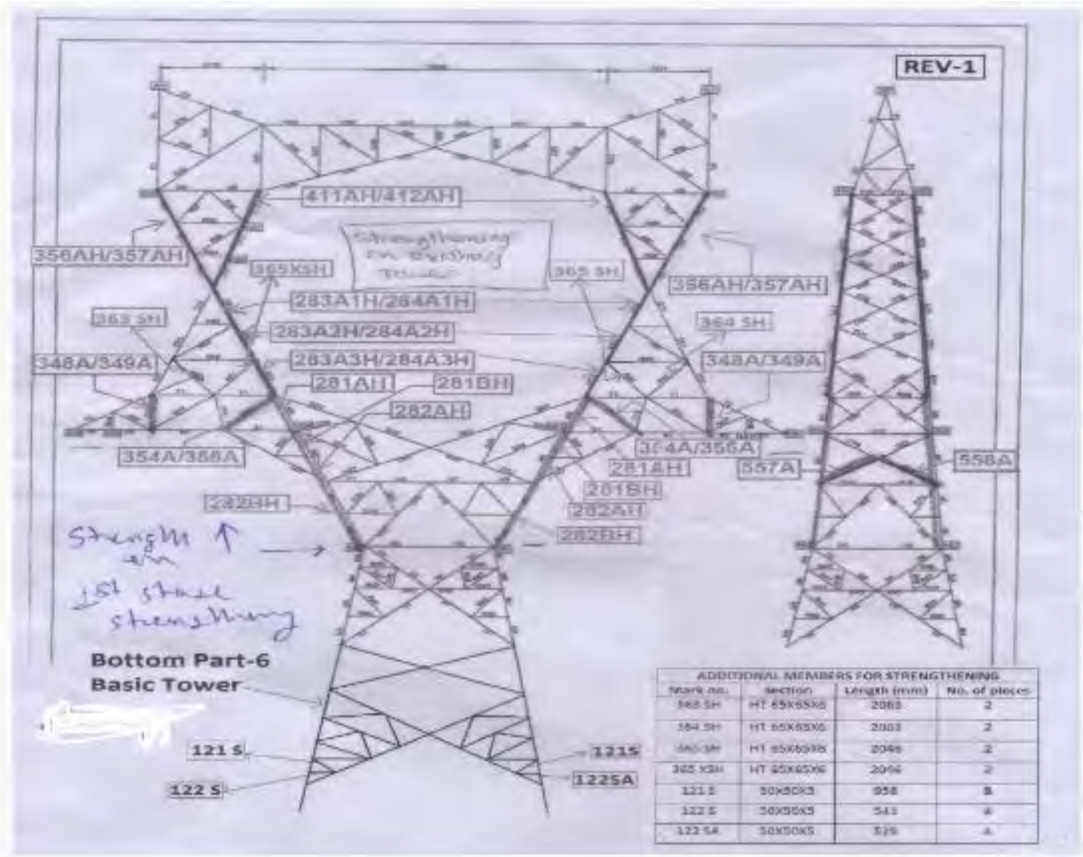
f. POWERGRID officials highlighted that the transmission line has been designed for Wind Zone 4 as per IS 802:1995. However, as per the latest wind map available in National Building Code, 2016, the affected section of the line is located under Wind Zone 5. The intensity of wind speed had increased in the affected area and the affected towers were not designed for these wind speeds.



g. It was informed that heavy thunderstorm activities were reported during which high velocity wind followed by rain were observed in the vicinity of affected stretch of transmission line. It was reported by POWERGRID that the failure of transmission towers was due to this high speed wind. Trees branches has been broken in the nearby area of the failed towers. However no major up-rooting of trees and permanent structure damaged were seen in the nearby area.

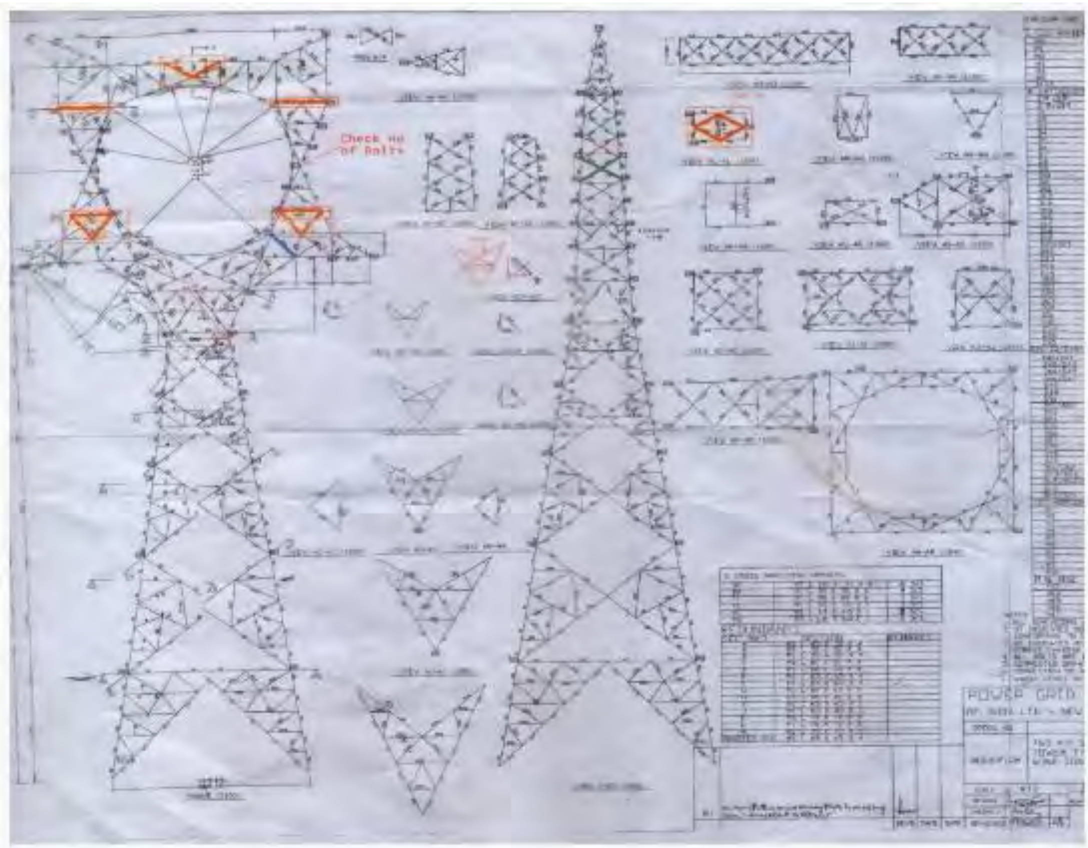
h. Strengthening of towers:

- The previous failures of the 765 kV S/C Delta configuration towers had been investigated by Standing Committee and the Committee had suggested strengthening of these towers. It was informed by POWERGRID that the failed towers were strengthened two times after commissioning. In the first stage additional members (shown as dark) for strengthening were provided as below:



First Stage Tower Strengthening Drawing

- In the Second stage, tower strengthening of cross arms/peak members and redundant members was done at these failed location towers (as highlighted in attached drawing).



Second Stage Tower Strengthening Drawing

- The above mentioned tower strengthening in both the stages was done with clamping of additional members rather than replacing old members with new one.

b. To examine the chemical and material properties, samples from the affected tower locations No. 558 & 559 were selected from site and sent for testing at independent NABL accredited lab. All the tower steel samples were found acceptable as per the relevant Indian Standards.

➢ **Committee Observations and Recommendations :**

Committee noted the failed tower was already strengthened by POWERGRID prior to the failure and enquired about the adequacy of strengthening mechanism adopted by POWERGRID for these structures. POWERGRID official informed that the strengthening of towers includes replacement of few tower members with large size members as well clamping of additional members to the existing members. Strengthening of towers in same manner as suggested by the Standing Committee in the previous meetings, i.e. by replacement of all members, is not possible for already erected tower members as long shutdown of transmission lines will be required. However, failed towers are always replaced by completely strengthened tower in line with the recommendations of committee. Further, strengthening of few other tower members, as suggested by M/s Manitoba Hydro is also being adopted by POWERGRID. The tower with strengthening currently being adopted by POWERGRID (i.e. clamping of few members and replacement of some members) had also been successfully tested at the CPRI test bed.

Committee further noted that the wind map of India has been revised and as per the latest wind map available in the National Building Code, 2016, the wind zone of the area in which the failed towers are located has been changed from Wind Zone 4 to Wind zone 5.

Committee concluded that the high wind velocity might have prevailed in the vicinity of transmission line in the transverse direction leading to failure of towers. However, wind speed data received from any authenticated observatory indicating speed of wind prevailing at the failure location at the time of the failure is not provided by the transmission utility. In absence of wind speed data from authenticated observatory, it is not possible to conclude that wind speed might have exceeded the design wind speed.

Committee advised POWERGRID to ensure that the strengthening mechanism adopted is in accordance with the suggestions of Standing Committee recommended in previous meetings. It was

emphasized that after every failure the concerned utility needs to submit the actual wind velocity prevailed in the affected area so that the investigating team of standing committee could get reference wind speed prevailed over that area. In this matter, the respective utility may seek the help of IMD to get the wind data obtained from observatory/ Satellite/Radar.

Committee also advised POWERGRID to monitor the failure of already strengthened towers and in case repeated failure of such towers is observed, than POWERGRID should review the strengthening mechanism adopted for such structures.

A.24 765 kV S/C Moga-Bhiwani Transmission line failed on 12.06.2021
[Tower at Location No.292 (C+0), 293 (B+25), 294 (C+9)]

- **Brief Background**

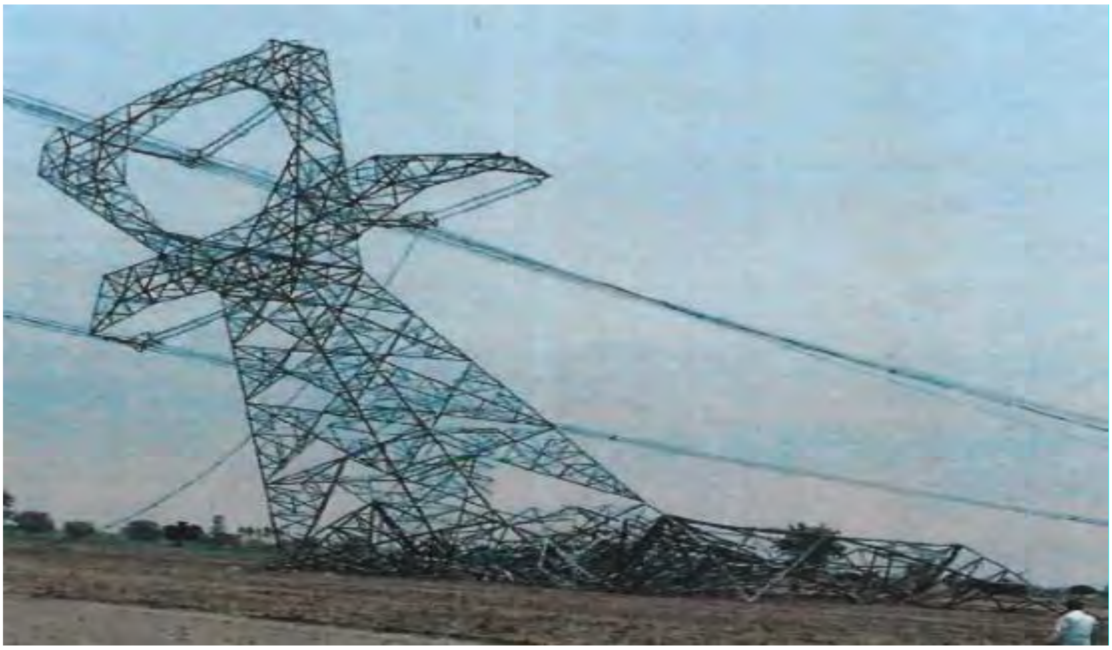
765 kV S/C Moga-Bhiwani Transmission Line of POWERGRID was constructed by M/s EMCO and was commissioned in June, 2012. This line traverse through plain terrain. The 'B' type towers of this line were designed considering 15° angle of deviation and basic wind speed of 47 m/sec corresponding to Wind Zone-4 and reliability level 2 as per IS 802-1995, and also taking into consideration narrow front wind on tower body and 75% wind in broken wire condition. The towers were designed in Delta configuration with Quad ACSR BERSIMIS Conductor. This was reported as the first incident of tower failure in the line.

- **Observations:**

c. The affected towers were located in plain field with few trees in vicinity near village Gajuwala, Bhiwani Taluk in Fatehabad district (Haryana) and about 100 km from Bhiwani sub-station. The details of tower spotting in the affected sections is as follows:

Sr. No.	Loc. No.	Tower Type	Span	Angle of Dev.	Extent of damage
1	290	A+0	370		Intact
2	291	A+0	385		Intact
3	**292**	**C+0**	**365**	**29°09' 52" LT**	**1 No. Earth wire peak damaged**
4	**293**	**B+25**	**230**	**0°**	**Tower Collapsed**
5	**294**	**C+9**	**393**	**15°45' 47" RT**	**1 No. Earth wire peak damaged**
6	295	A+0	394		Intact
7	296	A+3	394		Intact

d. **Tower at Location No. 293 (B+25)** was spotted at 0° angle of deviation with +25M extension for Power line crossing of 220 kV D/C Kirori-Samain transmission line of HVPNL. The tower was observed to be hanging and tilted in the transverse direction to the line and tower portion above 0 M level, i.e. basic body of tower was intact. The tower body portion below 0 M level, i.e. the body extension part, was severely damaged and most of the tower members in this portion were jumbled. Due to the collapse of tower, the stubs of all four legs were also damaged. There was superficial damage to the chimney concrete as well.



Tower at Loc. No.293 (B+25)

e. **Towers at Location No. 292 (C+0) & at location No. 294 (C+25)** were in erect position. One side earth wire peak of the towers was damaged. POWERGRID informed that the towers had damaged due to the sudden jerk caused by collapsed tower at location No. 293.

Tower at Loc. No.292 (C+0) **Tower at Loc. No.294 (C+25)**

f. POWERGRID informed that the damaged towers were also examined for any defects like missing members, missing nuts & bolts etc and no such defects were observed. Further, it was reported that different foundation dimensions like back to back, diagonal distance, levels were also examined by POWERGRID officials and the same were found to be generally in line with approved drawing.

g. POWERGRID informed that their team of officials also checked the records of line patrolling of this line. As per the data furnished by site, patrolling of the failed location was carried out on 19.03.2021 and no defects like missing members, missing nuts & bolts were reported. Further, other towers adjacent to the affected tower locations were also examined and no abnormalities were observed.

h. POWERGRID officials informed that discussion was done with nearby local village residents and it was gathered that at the time of tower collapse, heavy thunderstorm condition with exceptionally high wind velocity prevailed in the narrow strip in the vicinity of affected stretch of transmission line and the Tower failure was initiated due to this high intensity localized wind storm. It was informed that the above windstorm has also caused extensive wide spread damages to nearby trees and LT poles. The same was also reported in local newspapers as well.

i. To examine the chemical and material properties, 05 samples from the affected tower locations were selected from site and sent for testing at independent NABL accredited lab. All the tower steel samples were found acceptable as per the relevant Indian Standards.

➢ **<u>Committee Observations and Recommendations :</u>**

Committee noted that only the +25 m Body extension part was damaged and basic body structure of the failed tower was intact. Committee also noted that the failed tower at location No. 293 was of B type tower with +25 m body extension and was spotted with a lower span

Committee observed that case of +25 m body extension, normally the stub setting templates are not available and props are used for this purpose. Special precaution is required to be taken to ensure the correct slope of stubs in addition to the correct back to back distance between the stubs.

Committee noted that in this case the B type tower have been spotted with lower span values and with zero degree deviation angle and hence, have inherent safe margin. In case failure was due to high speed wind as reported by POWERGRID, the nearby suspension type towers would have collapsed instead of this tower. Further, as only the extension part had collapsed and basic body structure is intact,

it indicates that there must have been some erection deficiency in erection of extension part which had led to collapse of tower.

Committee advised POWERGRID to review the design & erection practice adopted by them for the construction of +25m body extension parts of the tower to avoid similar incidences of failure in future.

A.25 400 kV D/C Kaithal-Baghpat Transmission line failed on 08.07.2021
[Towers at Location No. 388 (DA+0), 389 (DA+0), 390 (DA+0), 391 (DA+0)]

➢ **Brief Background**

400 kV D/C (Quad) Kaithal-Meerut Transmission Line of POWERGRID was commissioned in November, 2010. LILO of this line was done at Baghpat Substation in May 2016. The LILO portion of this line was constructed by M/s Jyoti Structures Limited. The tower collapsed in the Loop-in portion of 400 kV D/C (Quad) Kaithal-Baghpat Transmission line.

The suspension towers of this line were designed for basic wind speed of 47 m/s corresponding to Wind Zone 4 and reliability level 1 as per IS 802-1995. Also narrow front wind on tower body and 75% of wind in broken wire condition were considered. The towers were designed with Quad ACSR Moose conductor with double I string having porcelain disc insulators. At present, the line is having polymer insulators.

Observations:

a. The affected towers were located in plain field with few trees in vicinity near village Bijraul in Baghpat district (Uttar Pradesh). The details of tower spotting in the affected sections is as follows:

Sr. No.	Loc. No.	Tower Type	Span	Angle of Dev.	Extent of damage
1	386	DD+18	393	26˚44' 01" LT	Intact
2	387	DA+0	325		Intact
3	**388**	**DA+0**	**275**		**One Earthwire Peak damage**
4	**389**	**DA+0**	**211**		**Collapsed**
5	**390**	**DA+0**	**317**		**Both Earthwire Peak damage**
6	**391**	**DA+0**	**350**		**One middle crossarm damage**
7	392	DB+0	242	07˚59' 04" RT	Intact

b. **Tower at Location No. 389 (DA+0)** was located in the agricultural field. The tower was collapsed from the first panel level in transverse direction to the line. One of the stubs was bent and three stubs were found to be intact. The coping of the chimneys were cracked.

Tower at Loc. No.389 (DA+0)

c. **Tower at Location No. 388 (DA+0) & 390 (DA+0)** were in erect condition. The earth wire peak of the circuit-I side of the tower at location No. 388 (DA+0) was damaged, whereas at location No. 390 (DA+0) both the earth wire peaks were damaged.

Tower at Loc. No.388 (DA+0) **Tower at Loc. No.390 (DA+0)**

d. **Tower at Location No. 391 (DA+0)** was located in agricultural field and all the foundations/legs of the tower were covered with vegetation/crops. The tower was in erect condition. The middle cross arm of circuit-II of the tower was damaged.

Tower at Loc. No.391 (DA+0)

e. The affected towers were also examined for any defects like missing members, missing nuts & bolts etc and no such defects were observed. However, the foundations of the towers were covered with vegetation/crops. Few of the extra holes in tower structures were also not plugged with nuts & bolts.

f. The trees/vegetation located near the towers were damaged, however, there was no visible uprooting of the trees.

g. POWERGRID officials informed that as per the revised wind map published in the National Building Code 2016, the affected area was now covered in Wind Zone 5.

h. As reported by POWERGRID officials, from the discussion with nearby local village residents, it was gathered that at the time of tower collapse, heavy thunderstorm condition with exceptionally high wind velocity prevailed in the narrow strip in the vicinity of affected stretch of transmission line and the Tower failure was initiated due to this high intensity localized wind storm. The wind event was widely reported in the local print media and as per the newspaper reports, heavy damage occurred in the area on 08-07-2021 due to high intensity localized thunderstorm. HT & LT lines were also found fallen in nearby area.

a. POWERGRID informed that the last patrolling of the failed location was carried out on 23.06.2021 and no defects like missing members, missing nuts & bolts were reported.

j. To examine the chemical and material properties, samples from the affected tower locations were selected from site and sent for testing at independent NABL accredited lab. All the tower steel samples were found acceptable as per the relevant Indian Standards.

- **Committee Observations and Recommendations :**

The towers had failed within 6 years from the date of commissioning. It was also noted that the transmission line has been commissioned after the notification of CEA Regulations, 2010. However, the line is designed as per Reliability level 1 instead of Reliability level 2 which is to be adopted for quad conductor configuration lines as per aforementioned Regulations.

Committee further noted that that at the time of erection, the towers were designed considering wind zone 4 as per the wind map applicable at that time, however, the wind zone of the area has been updated to wind zone 5 in the latest wind map published in National Building Code.

Committee observed that although print media published about heavy wind in the area, no uprooting of trees was observed at the site. It is very difficult to ascertain whether wind speed exceeded the design speed for which towers were designed. It appears that failure of the tower at location No. 289 (DA+0) led to its collapse in transverse direction of line and subsequently due to jerk during collapse, peak of tower at locations No. 388, 390 and cross arm at location No. 391 were also damaged.

Committee emphasized that after every failure the concerned utility needs to submit the actual wind velocity prevailed in the affected area so that the investigating team of standing committee could get reference wind speed prevailed over that area. In this matter, the respective utility may seek the help of IMD to get the wind data obtained from observatory/ Satellite/Radar.

Committee advised that the transmission lines should be designed and erected as per latest IS codes, Regulations and recommendations of the Standing Committee / Task Force, as applicable.

A.26 400 kV D/C Kishenpur-Wanpoh (ckt-III & IV) Transmission line failed on 23.10.2021

[Tower at Location No.145 (DC+3R)]

- **Brief Background**

400 kV D/C Kishenpur-Wanpoh (ckt-III & IV) Transmission Line of POWERGRID was constructed by M/s Tata Projects Limited and was commissioned in July, 2017. The towers of this line were designed for basic wind speed of 39 m/s corresponding to wind zone-2 and reliability

level-1 as per IS 802:1995. The towers were designed with Twin ACSR Moose conductor and are having porcelain disc insulator string in vertical configuration. This was reported as the first incident of tower collapse in this transmission line.

➢ **Observations:**

a. The details of tower spotting in the affected sections is as follows:

Sr. No.	Loc. No.	Tower Type	Span	Angle of Dev.	Extent of damage
1	143	DD+6		26˚24' 11" LT	Intact
			305		
2	144	DB+0		7˚14' 31" RT	Bulging of tower members
			354		
3	**145**	**DC+3R**		**23˚54' 38" LT**	**Tower Collapsed**
			273		
4	146	DB+6R		2˚51' 33" LT	Intact
			254		
5	147	DB+6		3˚32' 43" LT	Intact

b. **Tower at Location No. 145 (DC+3R)** was located in hilly terrain near village Kathar (Upparmadha), Chenaini Taluk in Udhampur district (Jammu & Kashmir), around 47.3 km from Kishenpur substation. The tower was completely collapsed and all four stubs of the tower were bent/damaged.

c. POWERGRID officials informed that there was a drifting of foundation at location No. 144 towards tower No. 143, which resulted in tightening of conductors between Tower Nos. 144 & 145 and increase in sag of conductors between towers at location Nos. 144 & 143.

d. POWERGRID informed that the similar occurrence was observed by POWERGRID site officials in April 2020. At that time also, there was loosening & tightening of conductors between spans 143-144 and 144-145 respectively due to sinking of foundation at location No. 144 and in order to reduce the tensile load on towers from 145 to 144 during the month of April-2020, POWERGRID site officials had put additional polymer insulators in some of the phases to reduce the tension in the section 144-145 and back stays at tower 145. Further, as a result of sliding of location 144 towards 143, sag of the conductors in section 144-143 was visibly more due to reduction in tension in the conductors. In order to stabilize tower No. 144, back stay at tower No. 144 was also provided.

e. POWERGRID informed that patrolling of the failed location was carried out on 07.07.2021 and no defects like missing members, missing nuts & bolts were reported. Further, examination of tower at location No. 146, adjacent to the affected tower, was also carried out and no abnormalities were observed. For collapsed tower location different foundation dimensions like back to back, diagonal distance, stub levels and the same were found to be generally in line with approved drawing.

f. POWERGRID informed that their officials also visited tower at location No. 144 and a wide crack in the land and bulging of soil near to the tower location was found. It was informed that the bulging of soil indicates gradual land sliding in the near vicinity of the towers.

Tower at Loc. No.145 (DC+3R)

Tower at Loc. No.145 (DC+3R): Leg-A, B, C, D

Bulging of Soil in the Vicinity of Tower at Loc. No.144 (DB+0)

g. Due to this sliding of foundation, many tower members of tower of location 144 were seen bent. Bracing of the lower panel was also observed bulging outward.

Bulging of Tower at Loc. No.144 (DB+0)

Insertion of Extra Polymer Insulators for Tower at Loc. No.144 (DB+0)

h. POWERGRID informed that their discussion with the local people in the nearby villages revealed that there was hailstorm at the time of tower collapse in the area and felling of trees in nearby village, snapping of conductors, breaking of electric poles etc had also occurred during this heavy hailstorm. The event was widely reported in the local print media and it was mentioned in newspaper reports that the heavy hailstorm occurred in the area on 23-10-2021 due to sudden change of temperature.

i. According to POWERGRID, it was evident that there has been sliding tendency in the whole land mass surrounding the foundation of tower No. 144 downhill towards location No. 143. The gradual sliding of landmass at location 144 led to increased tension in span 144-145 causing excess loading on tower No. 145. During the hailstorm, heavy winds and contraction of conductor due to sudden fall in temperature on 23-10-2021(day of incident) further aggravated the stress on tower No. 145 which caused its failure.

j. The material tests were conducted on samples selected from site at independent NABL accredited lab and these reports were generally found to be within limits.

- **Committee Observations and Recommendations :**

Committee noted the above and concluded that due to land slide the tower located at lower height was shifted due to which the tension in the conductor had increased which had led to failure of adjacent tower located at higher location i.e. tower at location No.145 (DC+3 (R)).

Committee advised POWERGRID to ensure that the geological investigation of the land mass is carried out and based on the report, take the necessary strengthening measures required for tower foundations and/or for the hill slope, so that such incidences do not repeat.

B. MADHYA PRADESH POWER TRANSMISSION COMPANY LTD. (MPPTCL)

The towers of following Transmission Lines of MPPTCL had failed during above mentioned period:

S. No.	Name of the Transmission Line	Name of Utility	Date of Failure	Year of Commissioning	Wind Zone	No. of Towers Failed			Conductor
						Suspension	Tension	Total	
1.	400 kV D/C Malwa (TPH)- Pithampur transmission line	MPPTCL	16.04.2019	2013	Medium	2	-	2	Vertical/ Twin ACSR Moose
2.	220 kV Omkareshwar Barwaha tap to Nimrani line	MPPTCL	16.04.2019	1982	Medium	1	-	1	Vertical/ ACSR ZEBRA
3.	400 kV D/C Malwa (TPH)- Pithampur transmission line	MPPTCL	02.06.2019	2013	Medium	20	4	24	Vertical/ Twin ACSR Moose
4.	400 kV D/C Rajgarh- Sardar Sarovar DCDS line	MPPTCL	11.06.2019	2002	Medium	4	1	5	Vertical/ Twin ACSR Moose
5.	220 kV D/C Jabalpur-Narsinghpur transmission line	MPPTCL	13.06.2019	Line commissioned in 1962 Failed tower erected on 07.06.2019	Line as per Old Design Failed tower designed for wind zone 4	1	-	1	Vertical/ ACSR Zebra
	Total (2019) Transmission lines failed : 5					**28**	**5**	**33**	
6.	220 kV Malanpur-Auriya & 220 kV Mehgaon-Adani transmission line	MPPTCL	28.05.2020	1993	Medium	11	-	11	Vertical/ AAAC Zebra
7.	220 kV Malanpur-Morena (ckt I & II) transmission line	MPPTCL	29.05.2020	2017	4	3	-	3	Vertical/ ACSR Zebra
8.	220 kV Malanpur-PGCIL (ckt I & II) transmission line	MPPTCL	29.05.2020	2010	4	3	2	5	Vertical/ ACSR Zebra
9.	400 kV S/C Malwa TPH Pithampur Transmission line of MPPTCL	MPPTCL	26.03.2020	2013	Medium	6	1	7	Vertical/ Twin ACSR Moose

	Total (2020) **Transmission lines failed : 4**					23	3	26	
10.	400 kV D/C Malwa TPH -Pithampur ckt I&II line	MPPTCL	29.05.2021	2013	Medium	5	-	5	Vertical/ Twin ACSR Moose
11.	220 kV Amarkantak-Panagar/SGTPS Birsinghpur transmission line	MPPTCL	21.09.2021	1996	Medium	2	-	2	Vertical/ ACSR ZEBRA
	Total (2021) **Transmission lines failed : 2**					7	-	7	
	TOTAL: **Transmission lines failed: 11*** **Towers failed: 66**								

*In the subject period, the 400 kV D/C Malwa (TPH)- Pithampur transmission line of MPPTCL failed four times

B.1 400 kV D/C Malwa (TPH)- Pithampur transmission line

➢ **Brief Background**

400 kV D/C Malwa (TPH)-Pithampur transmission line of MPPTCL was commissioned in 2013. Total length of the transmission line is 93.44 km. This line traverses through plain terrain. The towers of this line were designed by MPPTCL for medium wind zone as per IS 802:1977. The line has vertical configuration with ACSR Twin Moose conductor.

The transmission line failed four times in the period from April 2019 to December 2021. The details of each of the failure incident is produced below:

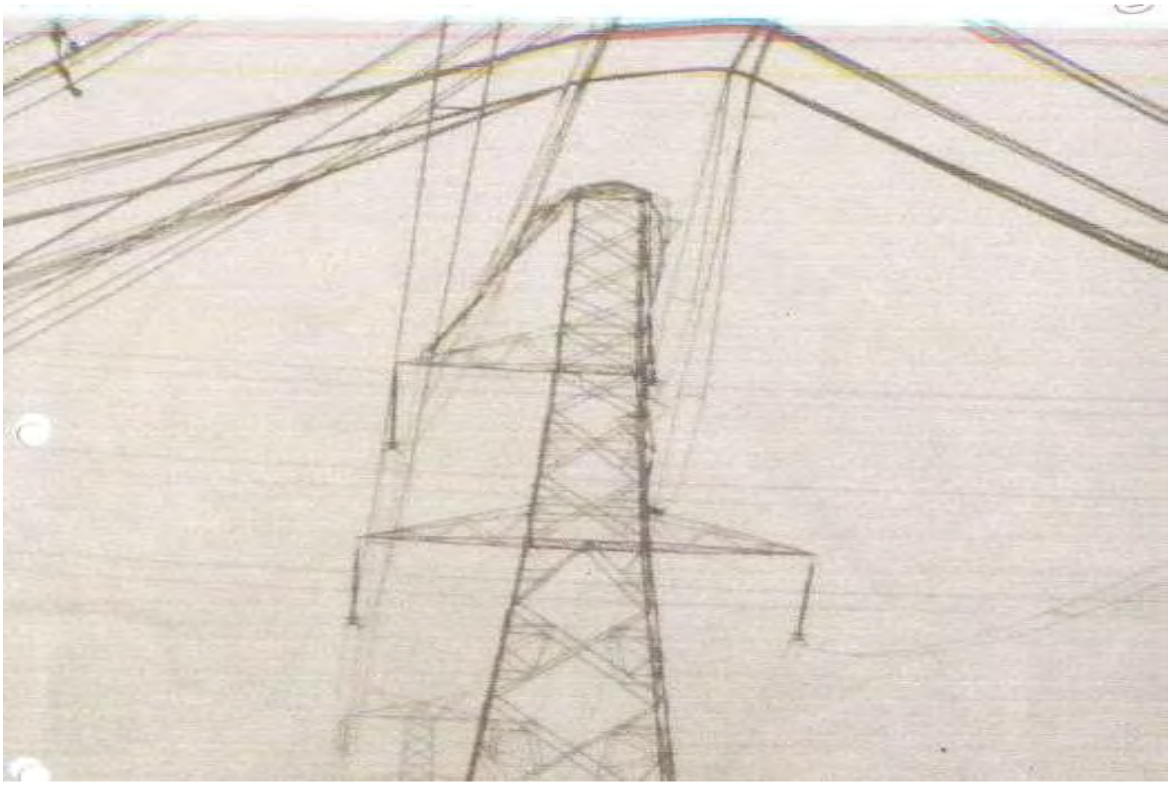
B.1.1. Failure of transmission line on 16.04.2019
[Towers at location No. 216 (FD0) & 217 (FD0)]

➢ **Observations:**

a. 400 kV D/C Malwa (TPH)- Pithampur transmission line of MPPTCL was crossed over by the 765 kV Khandwa-Dhule D/C transmission line of M/s Sterlite Power. At the time of failure incident, the 765 kV Khandwa-Dhule D/C transmission line having Hexa AAAC Moose conductor per bundle configuration was under construction, however, the stringing of span crossing over the line of MPPTCL was complete.

b. As reported by MPPTCL, there was high speed wind conditions on 16.04.2019 in the affected area during which the towers of 765 kV D/C Khandwa-Dhule line of M/s Sterlite collapsed due to which the conductors of this line fell over MPPTCL's 400 kV D/C Malwa (TPH)- Pithampur transmission line resulting into damage of towers at locations No. 216 (FD0) & 217 (FD0).

c. Falling of Hexa AAAC Moose conductor on the span resulted into excessive loading and damaged the towers at locations No. 216 (FD0) & 217 (FD0). The top portion of the tower at location No. 216 (FD0) was damaged and at location No. 217 (FD0) peak, top cross arm & middle cross arm of one of the circuits were damaged. The conductor in the span and insulators were also damaged.



Tower at location No. 217 (FD0)

B.1.2. Failure of transmission line on 02.06.2019

[Twenty (20) suspension type towers at location Nos. 126 to 131, 133 to 137, 139 & 160 to 167, and four (4) tension towers at location Nos. 132, 138, 159 & 168]

➢ **<u>Observations:</u>**

a. MPPTCL representative informed that the failed transmission towers were located in plain terrain in Maheshwar tehsil of Khargone District Madhya Pradesh. As reported by MPPTCL, during the high wind incident that occurred on 02.06.2019, twenty (20) suspension type towers and four (4) tension towers were affected. The details of damages observed in the failed towers is as follows:

SI. No.	Loc No.	Tower Type	Observations/ Extent of damage
1	126	FD0	Tower was partially damaged and was in erect condition. The top part of the tower, above the bottom cross arm level, was damaged & buckled and was resting on lower tower body. One of the stubs was reported to be bent.

2	127	FD0	Tower was collapsed from second panel level in transverse direction. Two of the stubs were bent. The chimneys were reported to be intact.
3	128	FD0	Tower was collapsed from second panel level in transverse direction. All the four stubs and chimneys were reported to be intact.
4	129	FD0	Tower was collapsed completely to the ground in transverse direction from first panel level. All four stubs were bent/damaged. Chimneys were observed to be intact.
5	130	FD0+3	Tower was collapsed completely to the ground in transverse direction from stub level. All four stubs along with chimneys were bent/damaged.
6.	131	FD0	Tower was collapsed from second panel level in transverse direction. All the four stubs & chimneys were reported to be intact.
7.	132	FD 60	Tower was collapsed completely in transverse direction from stub level. All four stubs were bent/ damaged. Chimneys were observed to be intact.
8.	133	FD0+3	Tower was collapsed completely to the ground from the first panel level in the transverse direction. One of the stubs was reported to be bent and all the chimneys were reported to be intact.
9.	134	FD0	Tower was collapsed completely to the ground in transverse direction from stub level. All four stubs were bent/damaged.
10.	135	FD0	Tower was collapsed completely to the ground from the first panel level in the transverse direction. All of the stubs the chimneys were reported to be intact.
11.	136	FD0	Tower was collapsed completely in transverse direction from stub level. All four stubs were bent/damaged. Two of the Chimneys were reported to be damaged and two were intact.
12.	137	FD0	Tower was collapsed completely in transverse direction from stub level. All four stubs and one chimneys were reported to be bent/damaged.
13.	138	FD 30	Tower was partially damaged and was in erect condition. The top part of the tower, above and including the top cross arm was damaged & buckled and was resting on lower tower body. All of the stubs the chimneys were reported to be intact.
14.	139	FD0+6	Tower was partially damaged and was in erect condition. The top part of the tower upto the middle cross arm level was damaged & buckled and was resting on lower tower body. All of the stubs the chimneys were reported to be intact.
15.	159	FD 30+3	Tower was in erect condition. The middle cross arms of the tower were damaged. All of the stubs and the chimneys were reported to be intact.
16.	160	FD0	Tower was in erect condition. The peak of the tower was damaged. The conductor of one of the middle cross arms also got detached and was lying on the ground. All of the stubs and the chimneys were reported to be intact.
17.	161	FD0	Tower was collapsed from second panel level in transverse direction. All the tower members above the second level were buckled, got twisted and jumbled with

			each other. All the four stubs were reported to be damaged. The chimneys were reported to be intact.
18.	162	FD0	Tower was collapsed from the first panel level in transverse direction. All the four stubs & three of the chimneys were reported to be damaged.
19.	163	FD0+3	Tower was collapsed completely in transverse direction from stub level. All the four stubs were damaged/bent. Crack were observed in three of the chimneys.
20.	164	FD0	Tower was collapsed completely in transverse direction from stub level. All the four stubs were damaged/bent. Crack were observed in two of the chimneys.
21.	165	FD0	Tower was collapsed completely in transverse direction from stub level. All the four stubs and the four chimneys were damaged.
22.	166	FD0+6	Tower was collapsed completely in transverse direction from stub level. All the four stubs were damaged/bent and one of the chimneys was damaged.
23.	167	FD0+10	Part of the tower structure above the first panel level got bent and sheared from the lower tower body and was lying on the ground in transverse direction. The lower part of the tower structure was twisted and jumbled. Three of the stubs were observed to be damaged and cracks were observed in one of the chimneys.
24.	168	FD 30	Tower was in erect condition. One of the peaks and all the three cross arms of one of the circuits were damaged. All of the stubs and the chimneys were reported to be intact.

Tower at loc. No. 126 (FD0)

Tower at loc. No. 127 (FD0)

Tower at loc. No. 128 (FD0)

Tower at loc. No. 129 (FD0)

b. MPPTCL representative informed that the towers at the location Nos. 159 to 168 failed in transverse direction towards the south direction from the line whereas towers at the location Nos. 126 to 139 failed in transverse direction towards the north direction from the line.

Tower at loc. No. 130 (FD0+3)

Tower at loc. No. 131 (FD0)

Tower at loc. No. 132 (FD 60)

Tower at loc. No. 133 (FD0+3)

Tower at loc. No. 134 (FD 0)

Tower at loc. No. 135 (FD0)

c. MPPTCL representative informed that on 02.06.2019 heavy thunderstorm with cyclonic wind was observed in the area which resulted in the failure/ collapse of these towers in transverse direction to the line. To examine the failure, a Team of Experts was constituted by MPPTCL. The team along with Expert of Design of towers visited the tower failure site to investigate the cause of failure of structures and had opined that these structures had failed due to heavy cyclonic circulation in the area.

Tower at loc. No. 136 (FD 0)

Tower at loc. No. 137 (FD0)

Tower at loc. No. 138 (FD 30)

Tower at loc. No. 139 (FD0+6)

d. MPPTCL representative informed that these towers were designed as per old IS code i.e. IS 802:1977 and they had taken up the matter with Designer for strengthening the designs as per IS 802: 1995 and

MPPTCL will take up the strengthening work of all suspension towers of this design in a phased manner.

Tower loc. No. 159 (FD 30+3)

Tower at loc. No. 160 (FD0)

Tower loc. No. 161 (FD 0)

Tower at loc. No. 162 (FD0)

Tower loc. No. 163 (FD 0+3)

Tower at loc. No. 164 (FD0)

Tower loc. No. 165 (FD0)

Tower at loc. No. 166 (FD0)

e. MPPTCL representative informed that the high speed wind also caused uprooting of various trees and severe damage to structures located in the vicinity. The same was also covered in the local newspaper and was confirmed by the residents of the nearby villages.

Tower loc. No. 167 (FD0+10)

Tower at loc. No. 168 (FD 30)

f. To verify the mechanical strength and chemical composition of failed tower members, material tests were conducted on samples collected from failed towers at independent NABL accredited lab. As per the test report some of the members failed to conform to desired specifications/values of the tensile strength, yield stress and elongation parameters.

B.1.3. Failure of transmission line on 26.03.2020

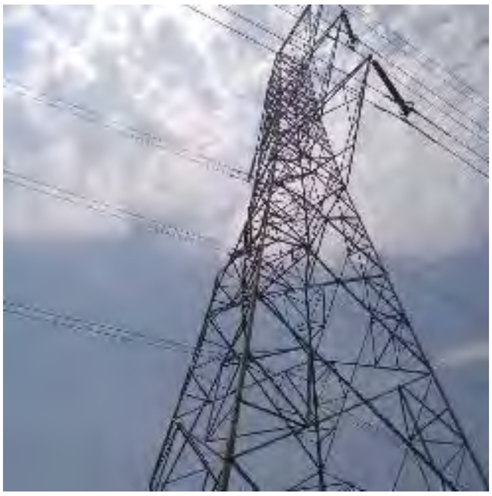
[Towers at location No. 13(FD0), 14(FDT 30), 15(FD0), 16(FD0), 17(FD0), 18(FD0) & 19 (FD0)]

➢ **<u>Observations:</u>**

a. The failed transmission towers were located in plain terrain in Pithampur tehsil of Dhar District in Madhya Pradesh. As reported by MPPTCL, a high wind speed incident occurred on 26.03.2020 in the area during which six (6) suspension towers and one tension tower were damaged/collapsed. The details of damages observed in the failed towers is as follows:

SI. No.	Loc No.	Tower Type	Observations/ Extent of damage
1	13	FD0	Tower was partially damaged and was in erect condition. Some of the leg members & cross bracings at the top part of the tower structure got bent. The stubs and chimney were reported to be intact.
2	14	FTP 30	The tower structure got twisted, deformed, and jumbled up and was lying on the ground. All of the stubs & chimneys were reported to be damaged.
3	15	FD0	Tower was observed to be twisted from middle of the structure and collapsed to the ground in transverse direction. Two of the stubs and their chimneys were reported to be bent/damaged.
4	16	FD0	Tower was observed to be twisted from middle of the structure and collapsed from the second panel level to the ground in transverse direction. One of the stub and its chimney were reported to be bent/damaged.
5	17	FD0+6	Tower was collapsed completely to the ground in transverse direction from stub level. All the four stubs were damaged and two of the chimneys were damaged.
6.	18	FD0+3	Tower was collapsed completely to the ground in transverse direction. All the four stubs and chimneys were reported to be damaged.
7	19	FD0	Tower was collapsed completely to the ground in transverse direction. All the four stubs and chimneys were reported to be damaged.

b. As reported by MPPTCL, on the date of failure heavy thunderstorm and high speed wind were observed in the area and the affected towers failed during this thunderstorm. The high speed wind also caused uprooting of various trees and severe damage to LT lines and other structures located in the vicinity. However, due to first lockdown period of Covid-19, the same was not covered in the local newspaper.



Tower at location No. 13 (FD0)

Tower at location No. 14 (FTP 30)

Tower at location No. 15 (FD0)

Tower at location No. 16 (FD0)

Tower at location No. 17 (FD0+6)

Tower at location No. 18 (FD0+3)

Tower at location No. 19 (FD0)

c. MPPTCL representative informed that they had requested IMD to provide the data of speed of wind observed at the location and at the time of tower failure. IMD informed that they do not have departmental meteorological observatory situated at Dhar District, M.P and the nearest observatory was in Indore. However, the continuous record of wind was not available with observatory and maximum wind data could not be provided.

d. MPPTCL representative informed that these towers were designed as per old IS code i.e. IS 802:1977 and they had taken up the matter for strengthening the designs as latest IS codes and MPPTCL will take up the strengthening work of all suspension towers of this design in a phased manner.

e. MPPTCL informed that theft of tower members and any shortage of tower parts was not observed in the failed tower structures.

f. To verify the mechanical strength and chemical composition of failed tower members, material tests were conducted on samples collected from failed towers at independent NABL accredited lab. The reports of these tests were found to be within limits as per relevant IS codes.

B.1.4. Failure of transmission line on 29.05.2021

[Towers at location No. 148(FD0), 149(FDT 30), 150(FD0), 151(FD0+6) & 152 (FD0+3)]

➢ **<u>Observations:</u>**

a. MPPTCL representative informed that the failed transmission towers were located in plain terrain near Akhipura Village in Maheshwar tehsil of Khargone District Madhya Pradesh. As reported by MPPTCL, Five towers (suspension type) damaged/collapsed during the high wind incident on 29.05.2021. The details of damages observed in the failed towers is as follows:

SI. No.	Loc No.	Tower Type	Observations/Extent of damage
1	148	FD0	Tower was completely collapsed to the ground in transverse direction from the stub level. All the four stubs and two of the chimneys were reported to be damaged. All the hardware fittings were damaged.
2	149	FD0	Tower was completely collapsed to the ground in transverse direction from the stub level. All of the four stubs & chimneys were reported to be damaged.
3	150	FD0+6	Tower was collapsed from the second panel level in the transverse direction and was lying on the ground.. All of the four stubs and two of the chimneys were reported to be bent/damaged.
4	151	FD0	Tower was collapsed from the second panel level in the transverse direction and was lying on the ground. All of the stubs and chimneys were reported to be intact.
5	152	FD0+3	Tower was partially damaged and was in erect condition. The peak of the tower was damaged. All of the cross arms of one circuit and top cross arm of second circuit were also damaged. All of the stubs and chimneys were reported to be intact.

Tower at location No. 148 (FD0)

Tower at location No. 149 (FD0)

Tower at location No. 150 (FD0+6)

Tower at location No. 151 (FD0)

Tower at location No. 152 (FD0+3)

b. The failed towers were located in the similar area/stretch of the transmission line in which the failure of towers was observed in the year 2019. The towers located on both sides of the failed towers, i.e. from tower locations No. 126 to 139 and between tower locations No.

159 to 168 were affected in the previous tower failure incident.

c. MPPTCL informed that at the time of failure, both the circuits of the transmission line were under shutdown condition for carrying out the modifications/shifting work of the transmission line.

d. MPPTCL representative informed that on the date of failure heavy thunderstorm and high speed wind were observed in the area. The wind observed was of whirling nature and the affected towers were failed during this thunderstorm. The high speed wind also caused uprooting of various trees and severe damage to LT lines and other structures located in the vicinity and the same was also covered in the local newspaper.

e. MPPTCL representative informed that these towers were designed as per IS 802:1977 for medium wind zone. As per IS 802:2015, the area of the subject incident comes under Wind Zone 2. As per calculations of MPPTCL, the wind pressure load corresponding to wind zone 2 comes around 49.12 kg/m^2 , whereas the towers were designed for medium wind zone as per IS 802-1977 with wind pressure load of 45 kg/m^2 with F.O.C. of 2 for normal conditions and 1.5 for Broken wire conditions. Further, the net transverse load for these towers comes around net transverse load calculated as per IS 802:2015.

f. MPPTCL representative informed that they will take up the strengthening work of all suspension towers as per latest IS codes in a phased manner.

g. To verify the mechanical strength and chemical composition of failed tower members, material tests were conducted at independent NABL accredited lab on samples collected from failed towers. The reports of these tests were found to be within limits as per relevant IS codes. However, the Mass of Zinc observed on some of the samples were lower than the prescribed values mentioned in relevant IS.

➢ **<u>Committee Observations and Recommendations :</u>**

1. ***Committee noted that this transmission line had failed four times in the period from April 2019 to December 2021.***

2. ***400 kV D/C Malwa (TPH)- Pithampur transmission line of MPPTCL was crossed over by the 765 kV Khandwa-Dhule D/C transmission line of M/s Sterlite Power. Committee concluded that the failure of towers 216 (FD0) & 217 (FD0) of 400 kV transmission line on 16.04.2019 was due to the sudden impact of Hexa Bundle conductors of 765 kV D/c line of M/s Sterlite Power falling on it. Committee suggested that in order to minimize the chances of secondary failure of transmission lines due to snapping of conductors of transmission lines crossing overhead, minimum two sets of insulators per phase per circuit shall be adopted by the utilities.***

3. ***Committee observed that though the transmission line has been commissioned in 2013, towers designed as per old code IS 802:1977 were used in the transmission line. Committee noted that as these towers were designed as per old IS 802:1997, diaphragm bracing members are not present in the towers near the cross bracings and as such oblique wind loads and narrow front wind loads are not considered in design of these towers.***

4. ***Committee recommended that practices of using old designs of towers even after revision of IS codes should not be adopted by the utilities and it should be ensured that the transmission lines are designed and erected as per latest IS codes, Regulations and recommendations of the Standing Committee and Task Force, as applicable.***

5. ***Committee noted that repetitive failure incidents have been observed in two of the transmission lines (400 kV Katni-Damoh transmission line & 400 kV Malwa-Pithampur transmission line) and MPPTCL had created a plan to strengthen the suspension towers of these transmission lines in a phased manner. Committee suggested MPPTCL that in case multiple tower failures are observed in the other transmission lines, towers of those lines can also be considered for strengthening.***

   Committee also suggested that as there is huge capital investment involved in the strengthening procedure, MPPTCL may consider a third party vetting of proposed design modifications which are to be adopted for strengthening of the transmission lines.

6. ***Committee suggested MPPTCL to ensure that whenever failure of transmission towers occurs, the failed towers should be replaced by towers designed as per latest IS codes.***

7. ***Committee also noted that as per the material test reports submitted by MPPTCL, some of the tower members had failed in the chemical and mechanical tests. Committee also observed that some of the tower structures appeared to be heavily rusted & Further, mass of zinc in some of the failed samples appeared to be lower than values specified in IS codes.***

   Committee noted that due to these deficiencies, the tower structures becomes vulnerable and advised MPPTCL to increase the scrutiny of material testing to ensure good quality raw material is used in erection of transmission lines. Further, Committee advised MPPTCL to review the procedure currently adopted by MPPTCL and ensure that all the necessary steps are taken to avoid rusting of tower members.

B.2 220 kV Omkareshwar Barwaha tap to Nimrani transmission line of MPPTCL failed on 16.04.2019

[Tower at location No. 22 (DA+0)]

➢ **Brief Background**

220 kV D/C Omkareshwar Barwaha tap to Nimrani transmission line of MPPTCL was commissioned in 1982. Total length of the transmission line is 93.44 km. This line traverse through plain terrain. The towers of this line were designed by MPPTCL for medium wind zone as per IS 802:1977. The line has vertical configuration with ACSR Zebra conductor.

➢ **Observations:**

d. 220 kV Omkareshwar Barwaha tap to Nimrani transmission line of MPPTCL was crossed over by the 765 kV Khandwa-Dhule D/C transmission line of M/s Sterlite Power. At the time of failure incident, the 765 kV Khandwa-Dhule D/C transmission line with hexa AAAC Moose conductor per bundle configuration was under construction. However, the stringing of the span crossing over 220 kV Omkareshwar Barwaha tap to Nimrani transmission line of MPPTCL, was complete.

e. As reported by MPPTCL, on 16.04.2019 there was high speed wind conditions in the affected area during which the towers of 765 kV D/C Hexa Khandwa-Dhule line of M/s Sterlite collapsed due to which the conductors of this line fell over MPPTCL's 220 kV Omkareshwar Barwaha tap to Nimrani transmission Line. This resulted into damage of Tower No. 22.

f. Falling of Hexa AAAC Moose conductor on the span resulted into excessive loading and damaged the tower at Location No. 22. The top portion of the tower was bent and rested on the lower tower body. The conductor in the span & insulators attached were also damaged.

Tower at location No. 22 (DA+0)

➢ **Committee Observations and Recommendations :**

220 kV Omkareshwar Barwaha tap to Nimrani transmission line of MPPTCL was crossed over by the 765 kV Khandwa-Dhule D/C transmission line of M/s Sterlite Power. Committee concluded that the failure of transmission tower of MPPTCL located at location No. 22 was due to the sudden impact of Hexa Bundle conductors falling on it.

Committee suggested that in order to minimize the chances of secondary failure of transmission lines due to snapping of conductors of transmission lines crossing overhead, minimum two sets of insulators per phase per circuit shall be adopted by the utilities.

B.3 400 kV D/C Rajgarh-Sardar Sarovar transmission line of MPPTCL failed on 11.06.2019

[Towers at location No. 562(DA+0), 563(DA+6), 564(DA+0), 565(DA+6) & 566(DC+10)]

➢ **Brief Background**

220 kV D/C Rajgarh- Sardar Sarovar transmission line of MPPTCL was commissioned in 2002. Total length of the transmission line is 178 km, of which 114 km length of the line is in Madhya Pradesh and rest is in Gujarat. The line traverses through hilly terrain. The towers of this line were designed by MPPTCL for medium wind zone as per IS 802:1977 and the line was erected by M/s RPG. The line has vertical conductor configuration with Twin ACSR Moose conductor and Porcelain insulators.

➢ **Observations:**

a. The failed transmission towers were located in hilly terrain near the village Chhatkala, M.P. As reported by MPPTCL, four suspension type towers and one tension tower were affected in the high wind incident that occurred on 11.06.2019. The details of damages observed in the failed towers is as follows:

SI. No.	Loc. No.	Tower Type	Extent of damage
1	562	DA+0	Tower was partially damaged and was in erect condition. One Earthwire peak and one top cross arm damaged. All stubs were intact.
2	563	DA+6	Tower was partially damaged and was in erect condition. One Earthwire peak, top cross and canopy portion damaged. All stubs were intact.

3	564	DA+0	Tower was completely collapsed in transverse direction from stub level. All four stubs were damaged/bent.
4	565	DA+6	Tower was completely collapsed in transverse direction from first panel level. All four stubs were bent.
5	566	DC+10	Tower was partially damaged and was in erect condition. One of the earthwire peak was damaged. One of the top phase conductor was snapped and rested on bottom phase conductor of second circuit.

Tower at loc. No. 562

Tower at loc. No. 563

Tower at loc. No. 564

Tower at loc. No. 565

Tower at loc. No. 566

b. MPPTCL representative informed that the transmission line failed during the period of effect of Vayu Cyclone which affected Gujarat and western parts of M.P. It was also gathered from the discussion with nearby villagers that at the time of tower collapse, heavy whirling wind prevailed in the affected area which led to collapse of the towers. The above windstorm has also caused extensive damages to nearby trees and other structures.

c. MPPTCL representative informed that the samples were collected from the failed tower structures and were sent to NABL accredited lab for strength and material testing. The values of tested parameters were found to be within limits.

d. MPPTCL representative informed that they had initiated the project of strengthening of the suspension type towers of this design and suspension towers of this line will also be strengthened in second phase of the project.

- **Committee Observations and Recommendations :**

Committee noted that the tower failure incident occurred during the Vayu cyclone which affected western part of Madhya Pradesh and state of Gujarat. The failed towers were located in hilly/ undulated terrain which had also amplified the high wind effect on the tower structures. Committee also noted that tough the transmission line was commissioned in year 2002, the line was designed as per old IS 802:1977 instead of IS 802:1995. Committee concluded that the aforementioned factors led to collapse of towers at location No. 564 & 565 which subsequently led to partial damage of nearby towers due to cascading effect.

Committee recommended that practices of using old designs of towers even after revision of IS codes should not be adopted by the utilities and it should be ensured that the transmission lines are designed and erected as per latest IS codes, Regulations and recommendations of the Standing Committee and Task Force, as applicable.

B.4 220 kV D/C Jabalpur-Narsinghpur transmission line of MPPTCL failed on 13.06.2019

[Tower at location No. 11A (DA+10)]

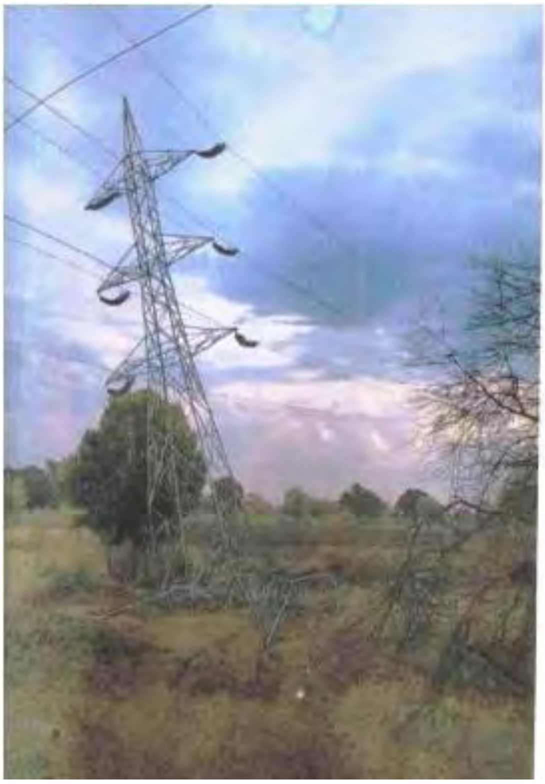
- **Brief Background**

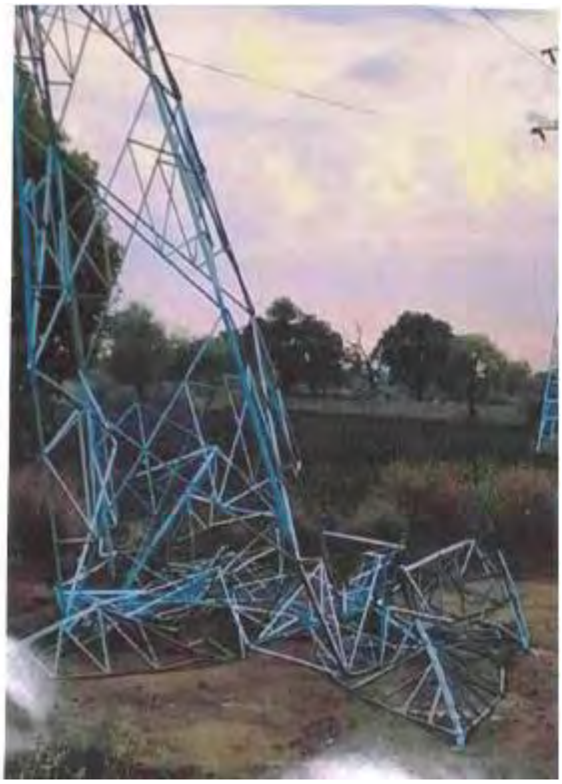
220 kV D/C Jabalpur-Narsinghpur transmission line of MPPTCL was commissioned in year 1962. Total length of the transmission line is 74.65 km. The line traverses through plain terrain. The towers of this line were designed as per old codes applicable at that time. The line has vertical conductor configuration with ACSR Zebra conductor and Porcelain insulators.

- **Observations:**

a. It was reported by MPPTCL that for raising the road clearance between towers at location No. 11 & 12, which was affected due to widening of National Highway 7 by NHAI, the tower at location No. 11A(DA+10) was erected. This tower was designed and constructed by MPPTCL. The tower was designed for wind zone 4 as per IS 802:1995 and was of suspension type with +10 m body extension.

b. The failed tower at location No. 11A (DA+10) was damaged from the bottom portion of the structure. All the four stubs of the tower were bent. Approximately 15 m (including +10 m body extension) bottom portion of the tower was damaged and rest of the tower structure was connected to the conductors and was in slanted position as can be seen in the picture given below.





Tower at location No. 11A

c. As reported by MPPTCL, on the date of failure a thunderstorm with high speed wind and rains was observed in the area. The tower at location No. 11A failed during this thunderstorm which also caused uprooting of various trees and severe damage to structures located in the vicinity.

d. MPPTCL representative informed that a tower failure investigation committee was constituted by MPPTCL to investigate the failure incident. This committee observed that back to back distance of foundations was in order and no member was missing.

➢ **Committee Observations and Recommendations :**

Committee noted that the transmission line is almost 50 years old. However, failed tower was newly erected at location No. 11A on 07.06.2019 and the same had failed on 13.06.2019, i.e. within a period of one week. Committee observed that as the basic tower structure of failed tower is intact and only the body extension part had failed, it appears there might be some deficiencies in the erection of tower which had led to failure of tower structure in the high wind speed event observed in the area on 13.06.2019.

Committee advised MPPTCL to ensure that good erection practices are adopted for construction of transmission lines and special precaution is taken while erecting the towers with body extension so that the slope of stubs and back to back distance between the stubs are correctly maintained as per approved drawings.

B.5 220 kV Malanpur-Auriya & 220 kV Mehgaon-Adani transmission line of MPPTCL on same tower failed on 28.05.2020

[Eleven (11) suspension Towers at location Nos. 14 to 24]

- **Brief Background**

220 kV Malanpur-Auriya & 220 kV Mehgaon-Adani transmission line of MPPTCL was constructed in year 1993. Total length of the 220 kV Malanpur-Auriya transmission line is 145.8 km and that of 220 kV Mehgaon-Adani transmission line is 37.88 km. The line traverses through plain terrain. The towers were designed by MPPTCL for medium wind zone as per IS 802:1977 and as per present wind map of India, this area falls under Wind Zone 4. The line has vertical conductor configuration with AAAC Zebra conductor and Porcelain insulators. The line had previously failed in year 2015 in which eight towers (loc. Nos. 107 to 113 and 305) were damaged/collapsed.

- **Observations:**

a. The failed towers were located in plain terrain. All the failed eleven towers were suspension type (DA+0) towers. All the affected towers were collapsed completely to the ground in transverse direction from stub level. The details of damaged towers is as follows:

SI. No.	Loc. No.	Tower Type	Extent of damage
1.	14	DA+0	Tower was completely collapsed from the stub level. All the stubs and chimneys were damaged.
2.	15	DA+0	Tower was completely collapsed from the stub level. Two of the stubs and chimney were damaged.
3.	16	DA+0	Tower was completely collapsed from the stub level. One of the stubs and chimney were damaged
4.	17	DA+0	Tower was completely collapsed from the stub level. Three of the stubs and chimney were damaged
5.	18	DA+0	Tower was completely collapsed from the stub level. One of the stubs and chimney were damaged
6.	19	DA+0	Tower was completely collapsed from the stub level. Two of the stubs and chimney were damaged.
7.	20	DA+0	Tower was completely collapsed from the stub level. One of the stubs and chimney were damaged

8.	21	DA+0	Tower was completely collapsed from the stub level. One of the stubs and chimney were damaged
9.	22	DA+0	Tower was completely collapsed from the stub level. Two of the stubs and chimney were damaged.
10.	23	DA+0	Tower was completely collapsed from the stub level. Two of the stubs and chimney were damaged.
11.	24	DA+0	Tower was completely collapsed from the stub level. One of the stubs and chimney were damaged

Tower at location No. 14

Tower at location No. 15

Tower at location No. 17

Tower at location No. 18

Location No. 19

Location No. 20

Location No. 21

Tower at location No. 22

Tower at location No. 23

b. As reported by MPPTCL, on the date of failure heavy thunderstorm and high speed winds were observed in the area in the vicinity of failed tower locations. The high speed wind also caused uprooting of various trees and severe damage to structures located in the vicinity. The same was also covered in the local newspapers.

c. It was observed that non-galvanized towers had been used in transmission lines. The transmission towers were heavily rusted and some of the nuts/bolts were observed to be missing in these structures.

d. MPPTCL representative informed that they had requested IMD to provide the data of speed of wind observed at the location at the time of tower failure. IMD informed that they had Meteorological observatory situated at Gwaliar, M.P. However, the continuous record of wind was not available with observatory and maximum wind data could not be provided.

e. As reported by MPPTCL, to verify the mechanical strength and chemical composition of failed tower members, material tests were conducted at independent NABL accredited lab on samples collected from failed towers. The reports were generally found to be within limits except for one of the samples which had failed in tensile strength test.

➢ **Committee Observations and Recommendations :**

Committee noted that multiple incidents of tower failure have been reported of the transmission lines traversing in the same region of M.P. on the date of failure of this transmission line, i.e., on 28.05.2020.

Committee also noted that as per the material test reports submitted by MPPTCL, the yield strength of one of the samples was not as per Indian Standard. Further, non-galvanized black towers had been used by MPPTCL for erection of the line which were observed to be rusted. Some of the bolts were also found to be missing in the structures. Committee noted that due to these deficiencies, the tower structures were vulnerable which failed during the high speed wind event observed on 28.05.2020.

Committee advised MPPTCL to enhance the scrutiny of material testing to ensure that good quality raw material is used in erection of transmission lines. Committee highlighted that the strength of tower structures gets compromised due to missing bolts and utilities should be highly cautious to ensure that erection deficiencies are avoided in the tower structures. Further, the Committee decided that black (un-galvanized) towers should not be used by the utilities in the erection of future transmission lines.

B.6 220 kV Malanpur-Morena ckt I & II transmission line of MPPTCL failed on 29.05.2022

[Towers at location No. 31 (DA+0), 32 (DA+3) & 33 (DA+3)]

➢ **Brief Background**

220 kV Malanpur-Morena ckt I & II transmission line of MPPTCL was commissioned in year 2017. Total length of the transmission line is 29.8 km. The line was designed by MPPTCL and executed by M/s Varrsana Ispat Limited Gujarat. The towers of this line were designed corresponding to wind zone 4 as per IS 802:1995. The line has vertical conductor configuration with ACSR Zebra conductor and Polymer insulators. It was reported as the first incidence of failure of the line.

➢ **Observations:**

a. The failed transmission towers were located in plain terrain with few trees in the vicinity. The towers were located near village Bamour Tehsil, Morena District, M.P. All the affected towers were suspension type. The details of damaged towers is as follows:

SI. No.	Loc. No.	Tower Type	Extent of damage
1	31	DA	Tower was completely collapsed to the ground in transverse direction. All the four stubs were damaged. The portions of chimneys, above the ground level, were also damaged.
2	32	DA+3	Tower was partially damaged above the bottom cross arm level. The portion of tower structure above the lowest cross arm level got bent & sheared from the tower. The lower tower structure was erect. All the stubs were intact.
3	33	DA+3	Tower was in erect condition and was partially damaged. One of the bottom cross arms of the tower of ckt-II was damaged and got bent. All of the stubs were intact.

Tower at loc. No. 31 (BO)

Tower at loc. No. 31 (BO +3)

Tower at loc. No. 32 (B0 +3)

b. MPPTCL representative informed that on the date of failure heavy thunderstorm and high speed winds were observed in the area. The high speed wind also caused uprooting of various trees and severe damage to structures located in the vicinity. The same was also covered in the local newspaper.

c. MPPTCL representative informed that they had requested IMD to provide the data of speed of wind observed at the location and at the time of tower failure. IMD informed that they had Meteorological observatory situated at Gwaliar, M.P. However, the continuous record of wind was not available with observatory and maximum wind data could not be provided.

d. As reported by MPPTCL, to verify the mechanical strength and chemical composition of failed tower members, material tests were conducted at independent NABL accredited lab on samples collected from failed towers. The reports of these tests were found to be within limits as per relevant IS codes.

➢ **Committee Observations and Recommendations :**

Committee noted that even though the transmission line was commissioned in year 2017, the line has been designed as per old IS 802:1995 instead of IS 802:2015. Committee further noted that multiple towers had failed in the region on 28.05.2021 and on 29.05.2021.

Committee concluded that the high wind velocity might have prevailed in the vicinity of transmission line in the transverse direction leading to failure of towers. However, wind speed data received from any authenticated observatory indicating speed of wind prevailing at the failure location at the time of the failure is

not provided by the transmission utility. In absence of wind speed data from authenticated observatory, it is not possible to conclude that wind speed might have exceeded the design wind speed. However, Committee observed that during the high wind speed event that occurred on the previous day, residual stresses might have developed in the tower structures which led to failure of these towers in the high wind speed event observed on 29.05.2021.

Committee advised that the transmission lines should be designed and erected as per latest IS codes, Regulations and recommendations of the Standing Committee and Task Force, as applicable. Committee advised MPPTCL that if failure of transmission towers occurs, the failed towers should be replaced by towers designed as per latest IS codes.

B.7 220 kV Malanpur-PGCIL ckt. I & II transmission line of MPPTCL failed on 29.05.2020

[Towers at location No. 90, 91, 92, 93 & 94]

- **Brief Background**

220 kV Malanpur-PGCIL ckt. I & II transmission line of MPPTCL was commissioned in year 2010. Total length of the transmission line is 39 km. The line traverses through plain terrain and was designed & executed by MPPTCL. The towers of this line were designed corresponding to wind zone 4 as per IS 802:1995. The line has vertical conductor configuration with ACSR Zebra conductor and Porcelain insulators. This was reported as first incidence of failure in the line.

- **Observations:**

a. The failed towers were located in plain terrain with few trees in the vicinity. As reported by MPPTCL, three suspension towers were collapsed and two tension towers were partially damaged in the high wind incident that occurred on 29.05.2020. The details of damages observed in the failed towers is as follows:

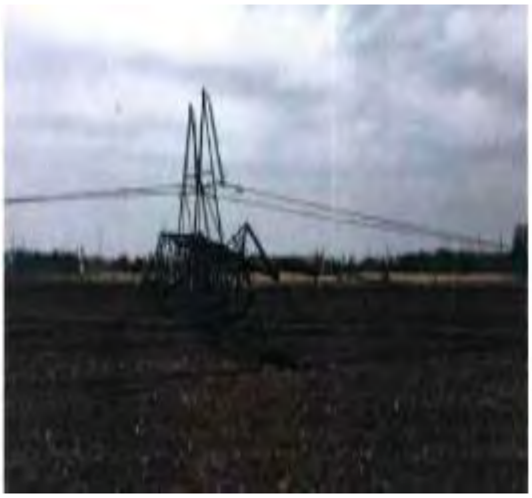
SI. No.	Loc. No.	Tower Type	Extent of damage
1	90	Tension	Tower was in erect condition. The tower was partially damaged and buckled from the bottom cross arm level. All stubs & chimneys were intact
2	91	Suspension	Tower was completely collapsed to the ground in transverse direction. One of the stubs was damaged.

3	92	Suspension	Tower was completely collapsed to the ground in transverse direction. Three of the stubs were damaged.
4	93	Suspension	Tower was completely collapsed in transverse direction from first panel level. Two of the stubs were damaged.
5	94	Tension	Tower was partially damaged and was in erect condition. The Middle phase cross arm of ckt-I was damaged and was found lying on the ground. The peak portion of the tower was buckled. One of the earthwire peaks was damaged.

Tower at location No. 90

Tower at loc. No. 94

Tower at location No. 91



Tower at loc. No. 92

Tower at loc. No. 93

b. As reported by MPPTCL, on the date of failure heavy thunderstorm and high speed winds were observed in the area which caused the failure of towers. The high speed winds also caused uprooting of various trees and severe damage to structures located in the vicinity. The same was also covered in the local newspaper and was confirmed by the residents of the nearby villages.

c. MPPTCL representative informed that they had requested IMD to provide the data of speed of wind observed at the location and at the time of tower failure. IMD informed that they had Meteorological observatory situated at Gwalior, M.P. However, the continuous record of wind was not available with observatory and maximum wind data could not be provided.

d. As reported by MPPTCL, to verify the mechanical strength and chemical composition of failed tower members, material tests were conducted at independent NABL accredited lab on samples collected from failed towers. The reports of these tests were found to be within limits as per relevant IS codes.

➢ **Committee Observations and Recommendations :**

Committee observed that the transmission towers used in the line were heavily rusted. Committee further noted that multiple towers had failed in the region on 28.05.2021 and on 29.05.2021.

Committee concluded that the high wind velocity might have prevailed in the vicinity of transmission line in the transverse direction leading to failure of towers. However, wind speed data received from any authenticated observatory indicating speed of wind prevailing at the failure location at the time of the failure is not provided by the transmission utility. In absence of wind speed

data from authenticated observatory, it is not possible to conclude that wind speed might have exceeded the design wind speed. However, Committee observed that during the high wind speed event occurred on the previous day, residual stresses might have developed in the tower structures which led to failure of these towers in the high wind speed event observed on 29.05.2021.

Committee advised that black (un-galvanized) towers should not be used by the utilities in the erection of future transmission lines. Committee observed that rusting of tower members severely compromises the strength of these structures and advised that the best practices in quality control process for raw material, manufacturing, transportation, construction, storage, erection and stringing of towers should be adopted by utilities. Committee also advised that all transmission towers should be checked on topmost priority after major wind event to remove distortions, if any, so as to restore the original strength and avoid failures in subsequent event of high intensity winds.

B.8 220 kV Amarkantak-Panagar/SGTPS Birsinghpur transmission line of MPPTCL failed on 21.09.2021

[Towers at location No. 84 (A0) and 85 (NB0)]

- **<u>Brief Background</u>**

220 kV Amarkantak-Panagar/SGTPS Birsinghpur transmission line of MPPTCL was commissioned in year 1996. Total length of the transmission line is 230 km. The line traverses through plain terrain. The line was designed and erected by MPPTCL. The towers were designed as per IS 802:1977 and for medium wind zone. As per latest wind map of India these areas fall under Wind Zone 4. The line has vertical conductor configuration with ACSR Zebra conductor and Porcelain insulators.

- **<u>Observations:</u>**

a. The failed towers were located in plain terrain near Village Pipariya, Budhar Tehsil, Shahdol District, M.P. As reported by MPPTCL, a high wind incident was observed on 29.05.2020, during which two suspension type towers were damaged. The details of damaged towers are as follows:

SI. No.	Loc. No.	Tower Type	Extent of damage
1.	84	suspension	The tower was damaged from the second panel level and collapsed in transverse direction of the line. The upper portion of the tower got sheared and was lying on the ground. All the stubs and chimneys were intact. The members were heavily rusted.
2.	85	suspension	The tower was damaged from the second panel level and collapsed in transverse direction of the line. The stubs and chimneys were intact. The members were heavily rusted.

b. As reported by MPPTCL, on the date of failure high intensity storm was observed in the area which caused the failure of towers. The high speed winds also caused uprooting of various trees and severe damage to structures located in the vicinity. The same was also covered in the local newspaper and was confirmed by the residents of the nearby villages.

Tower at location No. 84

Tower at location No. 85

c. MPPTCL representative informed that they had requested IMD to provide the data of speed of wind observed at the location and at the time of tower failure. IMD had informed that their wind observatory is not present at Shahdol Disrict, M.P and the record of wind velocity at the time of incident is not available with them.

d. To verify the mechanical strength and chemical composition of failed tower members, material tests at independent NABL accredited lab on the samples collected from failed towers were conducted. The reports of these tests were found to be within limits as per relevant IS codes.

➢ **Committee Observations and Recommendations :**

Committee observed that the transmission towers used in the line were heavily rusted and noted that rusting of tower members severely compromises the strength of these structures. Committee also noted that though the transmission line has been commissioned in year 1996, the transmission towers were designed considering old IS 802:1977 in which oblique wind & narrow front wind were not considered. Committee observed that the high speed wind have prevailed in the area on the failure date and caused the failure of these towers.

Committee advised that as a precautionary measure, MPPTCL may review the design of these towers with respect to latest code of IS 802:2015, Regulations and recommendations of the Standing Committee and Task Force, as applicable, and whenever failure of transmission towers occurs, the failed towers should be replaced by towers designed as per latest IS codes.

B. UTTAR PRADESH POWER TRANSMISSION CORPORATION LTD. (UPPTCL)

C.1 765 kV Lalitpur-Fatehabad (Agra) ckt-I Transmission line of UPPTCL failed on 03.05.2020

[Towers at Location No.146 (A+0) & 147 (A+6)]

➢ **Brief Background**

765 kV D/C Lalitpur-Fatehabad (Agra) ckt-I Transmission Line of UPPTCL was executed by M/s POWERGRID and was commissioned in October, 2016. This line traverse through plain terrain. Towers of this line were designed for wind zone-4 with Quad Bersimis ACSR conductor in Horizontal configuration.

➢ **Observations:**

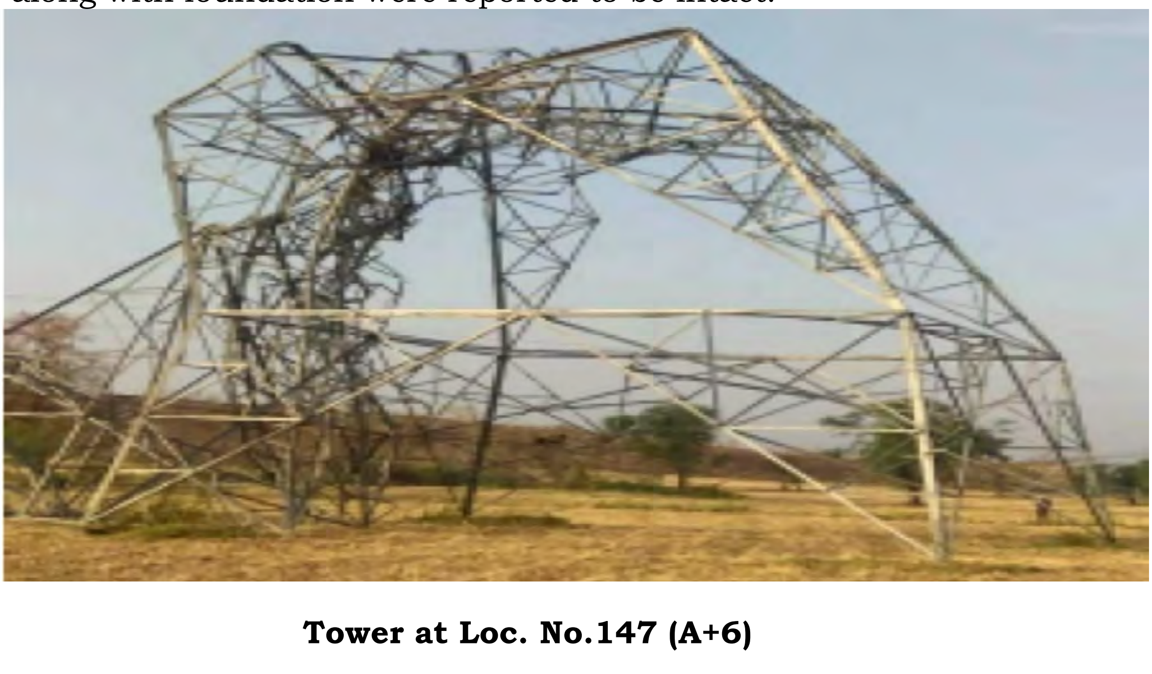
a. It was informed by representative of UPPTCL that on 03.05.2020 a high speed localized thunderstorm was observed and following suspension type towers were affected during the storm:

Sr. No.	Loc. No.	Tower Type	Extent of Damage
1	146	A+0	Peak Damaged
2	147	A+6	Collapsed

b. Tower at Location No. 146 (A+0) was reported to be in erect condition. One of the peaks of this tower supporting OPGW link was damaged.

Tower at Loc. No.146 (A+0)

c. **Tower at Location No. 147 (A+6)** was located in plain field with few trees in vicinity. The tower was collapsed in the transverse direction to the transmission line from 1st panel level. All the four stubs of the tower along with foundation were reported to be intact.



Tower at Loc. No.147 (A+6)

d. UPPTCL officials informed that high speed localized thunderstorm condition with exceptionally high wind velocity was observed in the vicinity of failed transmission towers on 03.05.2020. Further, the towers are located in valley portion having small hills at both sides. Due to these conditions the wind load acting on the towers was increased which ultimately caused failure of tower at location No. 147 (A+6). The peak at location No. 146 was damaged due to pulling load/jerk of earthwire/OPGW developed due to failure of tower at location No. 147.

e. UPPTCL representative informed that IIT Kanpur had been requested to examine the root cause of failure of towers of the line and IIT Kanpur, in its preliminary analysis had highlighted that twenty two (22) members of A type tower and sixteen (16) members of D type tower have slenderness ratio greater than unity and had recommended strengthening of these towers. However, the final report is still awaited.

f. POWERGRID officials informed that the POWERGRID in its 765 kV Delhi-Meerut transmission line have used towers of same design and as such no incidences of tower failure have been observed in the same.

➢ **Committee Observations and Recommendations :**

Committee noted that the towers were located in valley portion having small hills at both sides and due to the tunnelling effect, the intensity of wind might have increased. The high intensity wind was observed in the area on 03.05.2020 which had led to failure of the tower at location No. 147 and subsequently due to cascading effect, damage of earthwire peak at location No. 146.

Committee further deliberated influence of topography of the location on the wind loads acting on the transmission towers. Representative from CPRI highlighted that topographical factor [of upto 30%] is included in the IEC 60826 for transmission lines located in mountains/complex topographical areas, however, at present the same is not considered in the design of transmission towers as per IS codes and this issue will be taken up in the next meeting of BIS.

Committee noted that UPPTCL had approached IIT Kanpur for design review of the towers and IIT Kanpur, in its preliminary analysis had highlighted that twenty two (22) members of A type tower and sixteen (16) members of D type tower have slenderness ratio greater than unity and had recommended strengthening of these towers. However, the final report is still awaited. Committee advised UPPTCL to take necessary precautionary actions based on the final report of IIT Kanpur to avoid similar failures in the line. UPPTCL was also advised to share the report with the Committee.

C.2 765 kV Lalitpur-Fatehabad (ckt-II) Transmission line of UPPTCL failed on 03.05.2020 & 28.05.2020

[Towers at Location No. 161 (A+6), 162 (A+6), 163 (A+0) & 164 (D+3) failed on 03.05.2020 and Towers at location No. 179 (A+3), 180 (A+3), 181 (A+9), 182 (B+6) failed on 28.05.2020]

➢ **Brief Background**

765 kV D/C Lalitpur-Fatehabad (Agra) ckt-II Transmission Line of UPPTCL was executed by M/s POWERGRID and was commissioned in April, 2017. This line traverse through plain terrain. Towers of this line were designed for wind zone-4 with Quad Bersimis ACSR conductor in Horizontal configuration. It is highlighted that ckt-I of 765 kV Lalitpur-Fatehabad Transmission line of UPPTCL had also failed on 03.05.2020.

➢ **Observations:**

a. The details of tower spotting in the affected sections is as follows:

Sr. No.	Loc. No.	Tower Type	Extent of Damage
Failed on 03.05.2020			
1	161	A+6	Collapsed
2	162	A+6	Collapsed
3	163	A+0	Collapsed
4	164	D+3	Collapsed
Failed on 28.05.2020			
1	179	A+3	One Earthwire peak damaged
2	180	A+3	Cross arm damaged
3	181	A+9	Collapsed
4	182	B+6	K Portion of tower Collapsed

b. UPPTCL officials informed that high speed localized thunderstorm condition was observed in the affected area on 03.05.2020 in which four (4) towers of the line at location No. 161 to 164, were collapsed.

c. **Towers at Location No. 161 (A+6) & 162 (A+6)** were located in hilly field with few trees in vicinity. The towers were collapsed from basic body level above the +6 m body extension portion in the direction of transmission line. All the four stubs of the towers along with foundations were reported intact.

Tower at Loc. No.161 (A+6)

Tower at Loc. No.162 (A+6)

d. **Tower at Location No. 163 (A+0)** was collapsed completely from the first panel, in the transverse direction perpendicular to the transmission line. All the four stubs of the tower were reported to be damaged.

Tower at Loc. No.163 (A+0)

e. **Tower at Location No. 164 (D+3)** was collapsed in the transverse direction. One out of four stubs of the tower was reported to be damaged.

Tower at Loc. No.164 (D+3)

f. UPPTCL representative informed that the restoration work of the failed towers was under execution and subsequently on 28.05.2020, in another high wind speed condition developed in the area and failure of four (4) towers at location No.179 to 182 were observed. The towers of the affected sections were located in valley portion having small hills at both sides.

g. **Towers at Location No. 179 (A+3) & 180 (A+3)** were in erect condition. The Earth Wire peak of the tower at Location No. 179 (A+3) & the Cross Arm of the tower at Location No. 180 (A+3) was damaged. The remaining tower structures and all the four stubs along with foundation of the tower were intact in both the towers. UPPTCL representative informed that these were secondary failures occurred due to pulling force/ jerk of conductor/ Earthwire developed due to failure of nearby tower at location No. 181.

Tower at Loc. No.179 (A+3) **Tower at Loc. No.180 (A+3)**

h. **Tower at Location No. 181 (A+9)** was collapsed form the first cross arm bracing level in the transverse direction to the transmission line. All the four stubs along with foundation of the tower were found reported to be intact.

Tower at Loc. No.181 (A+9)

i. **Tower at Location No. 182 (B+6)** was in erect condition. The tower portion above waist level i.e. K portion of the tower was damaged. All the four stubs along with foundation of the tower were intact. UPPTCL representative informed that this was the secondary failure occurred due to pulling force/ jerk of conductor developed due to failure of nearby tower at location No. 181.

Tower at Loc. No.182 (B+6)

j. UPPTCL representative informed that IIT Kanpur had been requested to examine the root cause of failure of towers of the line and IIT Kanpur, in its preliminary analysis had highlighted that twenty two (22) members of A type tower and sixteen (16) members of D type tower have slenderness ratio greater than unity and had recommended strengthening of these towers. However, the final report is still awaited.

k. UPPTCL representative highlighted that the on the date of 28.05.2020, the failure of transmission lines of MPPTCL had also occurred. The subject transmission towers are located in the nearby area to MPPTCL transmission line and high velocity incident have been observed in the complete area. The towers are located in passage like terrain having small hills at both sides and the failure have been observed in this passage area. Both side hilly terrain and Valley portion causes tunneling effect

➢ **Committee Observations and Recommendations :**

Committee noted that the towers were located in valley portion having small hills at both sides and due to the tunnelling effect, the intensity of wind might have increased. The committee noted that the high intensity wind was observed in the area on 03.05.2020 which had led to failure of the towers. Committee also noted that there were multiple incidents of tower failure in the transmission lines traversing in the same region of M.P on the date of failure of this transmission line, i.e., on 28.05.2020 which indicates a high speed wind was observed in the area. Committee observed that the tower at location No. 181 (A+9) had collapsed in this high speed wind and led to secondary failure of nearby towers.

Committee noted that UPPTCL had approached IIT Kanpur for design review of the towers and IIT Kanpur, in its preliminary analysis had highlighted that twenty two (22) members of 'A' type tower and sixteen (16) members of 'D' type tower have slenderness ratio greater than unity and had recommended strengthening of these towers. However, the final report is still awaited. Committee advised UPPTCL to take necessary precautionary actions based on the final report of IIT Kanpur to avoid similar failures in the line.

C. RAJASTHAN RAJYA VIDYUT PRASARAN NIGAM LTD. (RVPN)

D.1 765 kV S/C Anta-Phagi (ckt-II) transmission line of Rajasthan Rajya Vidyut Prasaran Nigam Ltd.,(RVPN) failed on 04.06.2020

[Towers at location No. 355 (61/0 (TTC+3)) & 394 (72/1 (TTA+3))]

➢ **Brief Background**

765 kV S/C Anta-Phagi (ckt-II) Transmission line of RVPN was designed

by M/s PGCIL and was executed by M/s L&T. The line was commissioned in 2014. The line was initially charged at 400 kV voltage level on 04.01.2014 and subsequently at 765 kV voltage level on 08.01.2015. The line traverse through plain terrain and Delta configuration towers designed by M/s PGCIL. These towers were designed as per IS: 802:1995 for wind zone-4 with Quad ACSR Bersimis Conductor and porcelain insulators. The line had earlier failed in March, 2015 in which seven (7) towers (six suspension and one tension type) at location No. 18/0 to 18/6 were collapsed.

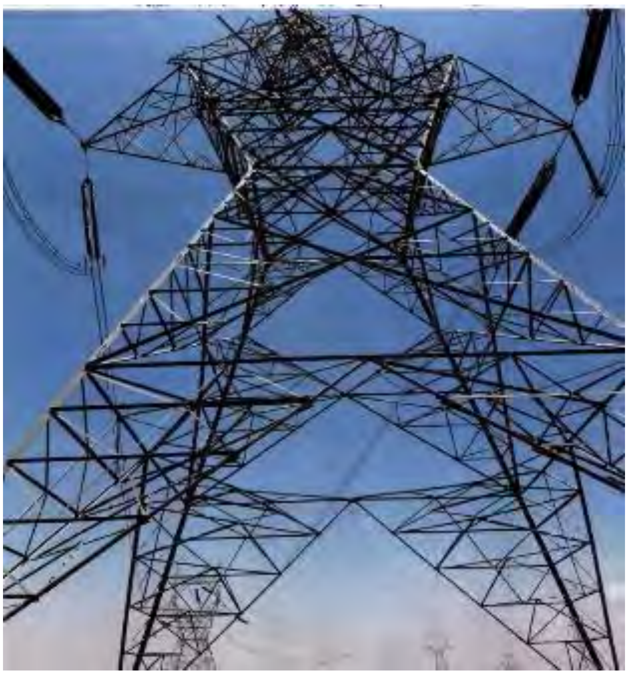
➢ **Observations:**

a. Representative from RVPN informed that a high wind storm was observed in the area on 04.06.2020 during which two towers at separate sections/ locations of the line were observed damaged/ collapsed. However, no information regarding the wind speed observed during the incident is available with RVPN.

b. **Tower at location No. 394 (72/1(TTA+3))** was located in the plain field with few trees in the vicinity. The tower was completely collapsed to the ground. Two No. of stubs were reported to be damaged and two No. stubs were buckled.

Tower at location No. 394 (72/1(TTA+3))

c. **Tower at location No. 355 (61/0(TTC+3))** was located in the plain field with few trees in the vicinity. The tower was in erect condition. The members of the tower in the delta portion were bent & buckled inwards. The lower portion of the tower & the stubs/foundations were intact. All four conductors of Y-phase with tension strings, extension links and connecting plates with two members detached from tower main body and fell down towards location No. 356. Due to this detachment, top portion of tower bent in opposite direction towards location No. 354).



Tower at location No. 355 (61/0(TTC+3))

d. RVPNL representative informed that some of the erection deficiencies like unplugged holes, loose nuts & bolts etc. were observed in the affected tower locations. Further, the material tests were conducted on the samples collected from failed tower locations and the reports were observed to within limits.

e. Representative from RVPN informed that the previous failure of incidence of failure of seven (7) towers of this line was discussed in the earlier meeting of the Standing Committee. Standing Committee of Experts had recommended for strengthening of suspension type delta configuration towers of this line in similar way as suggested for 765 kV Gaya-Fatehpur transmission line of POWERGRID. However, the strengthening was not executed by RVPN and after the recurrence of failure incident in the line, RVPN had consulted POWERGRID and had adopted the same procedure as currently adopted by POWERGRID for strengthening of delta configuration towers and at present, the strengthening process is under bidding stage.

➢ <u>**Committee Observations and Recommendations :**</u>

Committee noted that in the incident one tension and one suspension type tower of two different sections had failed. The Committee noted that the transmission line has been erected with Delta configuration towers designed by POWERGRID similar to that of 765 kV Gaya-Fatehpur S/C transmission line (Wind Zone-4) and it has been suggested to RVPNL in the previous meeting of Standing Committee to carry out strengthening of these towers. However, the strengthening has not been completed by RVPN.

Committee also noted that at some locations deficiencies like, unplugged holes, loose nut& bolts, etc. were observed in the failed towers. Due to the above, it was observed that the towers were

structurally weak and the occurrence of high speed wind incident led to failure of the towers.

Committee suggested RVPN to strengthen their towers as suggested in the previous meeting of Standing Committee. Committee also suggested RVPNL to plan and conduct a Structural quality Audit of towers of this line at random basis.

D. KARNATAKA POWER TRANSMISSION CORPORATION LTD. (KPTCL)

E.1 220 kV D/C Bagalkot-Vajjramatti Transmission line failed on 09.08.2019.

[Tower at Location No. 319 (DB+6)]

➢ **Brief Background**

220 kV D/C Bagalkot Vajjramatti transmission line of KPTCL was erected by KPTCL and was commissioned in year 2001. The towers were designed with vertical configuration having ACSR Drake Conductor and Porcelain Disc insulator strings. As reported by KPTCL, this was the first incidence of failure in the transmission line.

➢ **Observations**

a. As reported by KPTCL representative, due to heavy rains observed in the area, flash flood was observed in the Ghataprabha River on 8th & 9th August 2019. The length of the 220 kV Bagalkot-Vajjramatti transmission line which was damaged in the incident was 2.5 km.

b. Due to increase water level in the vicinity, the foundations of towers at location No. 318 to 326, located near Bhantanur and Machakanur villages were submerged in water. Subsequently, the tower at location No. 319 (DB+6), which was the river crossing tower, collapsed and top portion of nearby tower was damaged.

c. The conductor of the transmission line was snapped at multiple places and some portion of the conductor was flooded away in the forced water flow in the flash floods leading to damage of insulators and hardware fittings of the transmission line.

d. KPTCL representative informed that normal type foundations were considered at the failed tower location. These foundations were observed to be intact however, the stubs were bent from base level leading to collapse of the tower.

➢ **Committee Observations and Recommendations :**

Committee noted that the failed tower was erected using normal type foundations. However, the foundation of the tower was reported to be

intact. Committee observed that the failure of tower at location No. 319 (DB+6) was due to increased flow of water caused by the flash floods in the Ghataprabha river. The damage to the upper portion of the nearby tower was secondary failure caused due to pull of conductor towards collapsed tower at loc. No. 319/0 (DB+6)

Committee recommended that routing of transmission lines few kilometres away from the river bank/ anticipated future river course, use of pile foundation/additional piles etc. should be adopted by utilities especially for the river crossing tower locations. Committee also recommended that Pile type foundation may be considered for all towers in flood prone area based on soil investigation report and latest high flood data, to avoid this type of failure. Providing proper Protection (retaining wall, Gabion wall etc.), proper revetment and use of geo-synthetic material in foundation, concrete encasing & painting of stub in water logging areas etc may also be considered, wherever required.

E.2 220 kV D/C Shahapur/Shahabad to Kapnoor transmission line of KPTCL failed on 17.04.2020.

[Towers at Location Nos. 389(DB+18), 390(DB+15) & 391 (DA+3)]

➢ **Brief Background**

220 kV D/C Shahapur/Shahabad to Kapnoor transmission line of KPTCL was designed by M/s L&T and was executed and commissioned by M/s Deepak Cable (India) Limited in year 2003. The length of 220 kV Shahapur to Kapnoor transmission line is 101.94 km and that of 220kV Shahbad-Kapnoor line is 52.6 km. The towers used in this line were designed for medium wind zone as per IS 802-1977 with vertical configuration having ACSR Drake Conductor. The towers were designed for Reliability level 1. Porcelain Disc insulator string was used in the line. As reported by KPTCL, the transmission line had earlier failed on 21.05.2010 in which four (4) towers at Location Nos. 522 to 526 were failed. Further, the line had also failed on 10.04.2012 in which two towers (location Nos. 404 & 405) were affected.

➢ **Observations**

a. KPTCL representative informed that on the date of failure i.e.17.04.2020, rainy and stormy weather with whirl wind were observed in the area in which the failed towers are located and during the above mentioned high wind conditions following towers were affected:

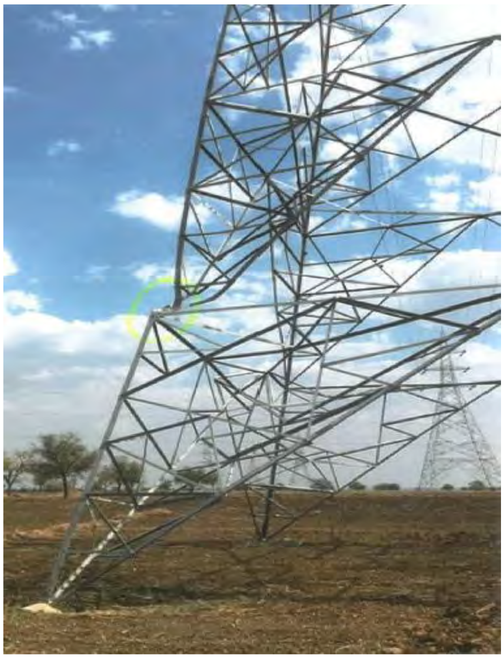
Sr. No.	Loc. No.	Tower Type	Span	Extent of Damage
1	388	DC+15		Intact

2	**389**	**DB+18**		**Leg Members and Bracings Buckled**
			155	
3	**390**	**DC+15**		**Collapsed**
			340	
4	**391**	**DA+3**		**Peak members buckled.**

b. Tower at location No. 390 (DC+15) was collapsed from the stub level. All the foundations were reported to be intact. The conductors of the line were intact and the upper portion of the collapsed tower was hanging in tilted position by the conductors.

Tower at location No. 390 (DC+15)

c. **Tower at location No. 389 (DB+18) & 391 (DA+3)** were in erect condition. The leg members and bracing members of the tower at location No. 389 were buckled. At location No. 391, the peak members were buckled. There was no damage to the foundations of these towers. These were reported as secondary failures caused due to pulling forces/ jerk of conductors/earthwires.



Tower at location No. 389 (DB+18)

d. Representative from KPTCL highlighted that the towers of this line were designed as per old IS code (IS 802:1977) in which only transverse load (wind at 0 degree) was considered for calculation of wind load on conductor, insulator, ground wire and tower body and these towers were vulnerable to high wind as oblique wind was not considered.

e. KPTCL representative informed that the wind speed data on the date of failure was gathered from the nearby observatory located at about 15 km from the tower location. However, the measurements of instantaneous wind speed were not recorded at the observatory and the wind speed was recorded in an interval of every 15 minutes and hence the wind data could not be used to deduce the wind speed at the tower site. Further, the data recorded by observatory indicates a slight increase in the speed of wind at the time of failure, however the recorded wind speed value at this site was very low. This may be due to the localized nature of the windstorm which affected the tower site. The localized windstorm had also caused extensive damages to nearby trees.

f. KPTCL representative informed that the investigation of failure was also done by technical committee of KPTCL and the committee had observed that the Span length between location Nos. 389 (DB+18) to 390 (DB+15) was 155 m and between location Nos. 390 (DB+15) to 391 (DA+3) was 340 m. In case of towers with higher body extensions such as +15 m, +18 m & +24 m, the wind load is the major governing factor under normal condition. Hence in order to compensate for the higher wind pressure, the wind spans are generally reduced such that the total wind load (wind on conductor, insulator string) on the tower remains same as original design. As long as the wind is within permissible limits, the tower sustains the load. In the instant case, the wind span is on the higher side and hence more wind loads have acted on the tower No. 390. Heavy whirl wind which passed through this stretch acted on the tower which could not resist the heavy wind.

g. KPTCL representative informed that the transmission line has been restored and the failed “DB+15” tower was replaced by 220 kV “DD+15” at location No. 390.

- **Committee Observations and Recommendations :**

Committee noted that this was the third incident of failure of tower observed in the transmission line. It was further noted that even though the transmission line was commissioned in year 2003, the line was designed as per old IS 802:1977 instead of IS 802:1995.

Committee observed that as the failed tower at location No. 390 was spotted with a zero degree deviation angle, there was sufficient safety margin available for B type tower even with considered span of 390 m.

Committee concluded that the high wind velocity might have prevailed in the vicinity of transmission line in the transverse direction leading to failure of towers. KPTCL had gathered the wind speed data from nearby wind observatory located at around 15 km from the tower failure site, however, the measurements of instantaneous winds are not available. In absence of required wind speed data, it is not possible to conclude that wind speed might have exceeded the design wind speed.

Committee noted that the towers were designed as per old IS codes, the narrow front wind factor and oblique wind load on tower structure would not have been considered in the design of towers and advised KPTCL to review the design of towers with respect to latest codes.

Committee recommended that practices of using old designs of towers even after revision of IS codes should not be adopted by the utilities and all transmission towers should be checked on topmost priority after major wind event to remove fatigue and distortions, if any, so as to restore the original strength and avoid failures in subsequent event of high intensity winds.

E. STERLITE POWER

F.1 765 kV D/C Khandwa Pool-Dhule transmission line of M/s Sterlite Power failed on 16.04.2019

[Towers at location No. 3/0 (DD+30+RC3), 3/1 (DC+9), 3/2(DA), 3/3(DA), 4/0(DD+30), 5/0 (DD+30), 6/0 (DD+30), 7/0 (DD+18) & 7/1]

➢ **Brief Background**

The 765 kV D/C Khandwa Pool-Dhule transmission line of M/s Sterlite was under construction/erection at the time of failure incident. The transmission towers of the line were designed by M/s Sterlite and the erection of the line was being executed by M/s KEC. The towers of the line were designed for wind zone 4 with vertical configuration. Hexa AAAC Zebra conductor per phase and Polymer type insulators were used in the line.

➢ **Observations**

a. The transmission line was under construction/ erection at the time of failure of the towers. However, the stringing of the affected tower section was completed.

b. As reported by the M/s Sterlite representative, the failed towers were located in plain field in Toksar and Aali Village in Sanawad Tehsil of Khargone District, Madhya Pradesh. The details of damaged towers is as follows:

SI. No.	Loc. No.	Tower Type	Observations/Extent of damage
1	**3/0**	DD+30+ RC 3	• Tower was erected with raised chimney of +3 m. • The tower collapsed completely to the ground in transverse direction to the line, towards left when observed watching towards Dhule substation. • The stubs were bent at the chimney level.
2	**3/1**	DC+9	• Tower was in erect condition.

			• Both of the top cross arms of the tower were damaged and tower structure above top cross arms was buckled. • Stubs along with foundation & chimney were intact.
3	**3/2**	Suspension type	• Both the towers were of suspension type. The towers were in erect condition. • The earthwire peaks of the towers were damaged. • The insulators were under tension due to the load of conductors. • All the four stubs of the tower along with foundation and chimney were intact.
4	**3/3**	Suspension type	
5	**4/0**	DD+30	• The towers collapsed completely to the ground in transverse direction to the line, towards right when observed watching towards Dhule substation. • The Stubs were observed to be bent at the chimney level. • All the hardware fittings were observed to be completely damaged.
6	**5/0**	DD+30	
7	**6/0**	DD+30	
8	**7/0**	DD+18	
9	**7/1**	Suspension type	• Tower was in erect condition. • The cross arms tower were observed to be damaged. • Stubs along with foundation & chimney were intact.

Tower at location No. 3/0 (DD+30+RC 3)

Tower at location No. 3/1 (DC+9)

c. The affected section of the 765 kV D/C Khandwa Pool-Dhule transmission line was crossing over the 400 kV D/C Khandwa-Indore I & II transmission line of POWERGRID and 400 kV Malwa-Pithampur line (ckt-1 & 2) and 220 kV Omkareshwar Barwaha tap to Nimrani transmission lines of MPPTCL. Due to collapse of the transmission towers of 765 kV D/C Khandwa Pool-Dhule line, the conductor fell and impacted the underlying transmission lines of POWERGRID and MPPTCL.

d. Representative from Sterlite informed that on 16.04.2019, a heavy thunderstorm like weather conditions prevailed in the vicinity of transmission lines. Strong winds and heavy rainfall were observed during the thunderstorm which led to collapse of the towers. The high wind incident was also covered by the local newspapers.

e. Sterlite representative also highlighted that four of the failed towers of 765 kV D/C Khandwa Pool-Dhule transmission line had collapsed towards right side of the center line of transmission line and one had failed towards its left indicating that a circular rotation of the movement of wind was observed in the area at the time of tower failure incident and as most of the failed towers were provided with body extensions, the effect of this rotating wind would have been higher on these towers which led to their collapse.

i. Sterlite representative informed that to ascertain the quality of material used in the transmission line, samples from the affected tower locations were sent for testing at independent NABL accredited lab and these test reports were generally found to be within limits.

➢ **Committee Observations and Recommendations :**

Committee observed that the 765 kV voltage level D type towers of M/s Sterlite, which are generally considered inherently strong towers as are designed with reliability level 2 and are used as anti-cascading towers, had failed in the wind event however, no damage has been observed in the lines of POWERGRID & MPPTCL which were also in the vicinity of the 765 kV D/C Khandwa Pool- Dhule transmission line.

Committee noted that failure of towers of this line of M/s Sterlite power led to cascading failure of 400 kV Khandwa-Indore transmission line of POWERGRID and 400 kV Malwa(TPH)-Pithampur and 220 kV Omkareshwar-Barwaha tap to Nimrani transmission lines of MPPTCL, which were passing below the 765 kV D/C Khandwa pool-Dhule transmission line.

Committee observed that as the failed towers had collapsed on both the sides of the transmission line indicates that a circular rotation of the movement of wind was observed in the area at the time of tower failure incident. However, wind speed data received from any

authenticated observatory indicating speed of wind prevailing at the failure location at the time of the failure is not provided by the transmission utility.

Committee concluded that in the absence of wind speed data from authenticated observatory, it is not possible to conclude that wind speed might have exceeded the design wind speed. Further, D type towers are considered inherently strong and should not have failed in the high speed wind event and advised M/s Sterlite to ensure that best practices in construction, erection and stringing of towers should is adopted. Committee also advised that material tests should be conducted on the failed tower members as well as on the Nut & Bolts to ensure the chemical & mechanical properties.

F.2 765 kV S/C Jabalpur–Bina transmission line of M/s Sterlite Power failed on 07.06.2019

[Towers at location No. 17/8 (SA+0), 17/9 (SA+3), 17/10 (SA+3), 17/11 (SA+0), 17/12 (SA+9) & 18/0 (SD+0)]

- **Brief Background**

765 kV S/C Jabalpur-Bina transmission line of M/s Sterlite Power was commissioned in June 2015. Total length of the transmission line is 235.19 km. The line was designed by M/s Sterlite Power and was executed by M/s C&C Constructions Limited. The line traverse through plain terrain and towers were designed for wind zone-2 as per IS 802:1995 with Quad Bersimis conductor in vertical configuration. Long Rod Polymer type Double-I suspension insulator strings were used in the line with suspension towers.

- **Observations**

a. Sterlite representative informed that the affected towers were located in plain terrain with few towers in the vicinity. Details of towers is given below:

Sr. No.	Loc. No.	Tower Type	Span (m)	Angle of Dev.	Extent of damage
1	17/7	A+3			Intact
			420.88		
2	**17/8**	**A+0**			**Partially damaged**
			413.75		
3	**17/9**	**A+3**			**Collapsed**
			416.57		
4	**17/10**	**A+3**			**Collapsed**

			424.28		
5	**17/11**	**A+0**			**Collapsed**
			415.62		
6	**17/12**	**A+9**			**Collapsed**
			403.92		
7	**18/0**	**D+0**		**45°55’ 55” RT**	**Partially damaged**

b. The towers at location No. 17/9 to 17/12 were all suspension towers and were completely collapsed to the ground in perpendicular direction to the line. The tower at location No. 17/8 (A+0) was in erect condition and was partially damaged.

c. The cascading impact was controlled by the consecutive angle type tower. However, the top portion of the angle type tower above the top cross arm got damaged.

Tower at location No. 18/0 (SD+0)

d. Sterlite representative highlighted that all the failed towers were of suspension type. Some of the towers failed in the direction perpendicular to the direction of line and subsequently, nearby suspension towers were damaged/collapsed as cascading failure due to pulling force of conductors/earthwires.

e. It was reported by Sterlite representative that no missing members/ missing nuts and bolts were observed in the affected towers. Further, the material tests were conducted on the tower members and nuts/bolts and the reports were found to be satisfactory.

f. As reported by Sterlite Power, discussion with the local people in the nearby villages revealed that high wind condition prevailed for some time in the area and tower had collapsed during high wind conditions. The high wind incident was also covered by the local newspapers.

- **<u>Probable Cause of Failure</u>**

Committee observed that a high intensity wind was observed in the area which had led to collapse of the one of the tower in the transverse direction which subsequently led to failure of nearby suspension towers due to the cascading effect. The effect of the pull force/jerk developed due to the conductors got reduced along the distance and the cascading failure was stopped by the next tension tower spotted in the line.

Committee emphasized that after every failure the concerned utility needs to submit the actual wind velocity prevailed in the affected area so that the investigating team of standing committee could get reference wind speed prevailed over that area. Committee concluded that in the absence of wind speed data from authenticated observatory, it is not possible to conclude that wind speed might have exceeded the design wind speed.

Further, the failed towers were located in the open field areas with very few trees/vegetation around the towers, however, these were designed considering Terrain Category-II. Committee highlighted that Utilities should pay utmost care in adopting the design parameters as per the terrain category faced along the route of transmission lines and adopt requisite measures, such as reduction of span length, accordingly.

Committee concluded that the high wind velocity might have prevailed in the vicinity of transmission line in the transverse direction leading to failure of towers. However, wind speed data received from any authenticated observatory indicating speed of wind prevailing at the failure location at the time of the failure is not provided by the transmission utility. In absence of wind speed data from authenticated observatory, it is not possible to conclude that wind speed might have exceeded the design wind speed.

Committee advised that best practices in quality control process for raw material, manufacturing, transportation, construction, storage, erection and stringing of towers should be adopted by utilities. Committee also advised that material tests should be conducted on the failed tower members as well as on the Nut & Bolts to ensure the chemical and mechanical properties.

F. DARBHANGA-MOTIHARI TRANSMISISON COMPANY LTD. (DMTCL)

400 kV D/C Motihari-Gorakhpur Transmission line failed on 15.08.2019 and 25.09.2019, and
[Towers at Location No.26/5 (DA+0) & 27/0 (DD+0)]

400 kV D/C Barh-Motihari Transmission line failed on 04.09.2019 and 07.10.2019
[Tower at Location No.25/5 (DA+3) & 26/0 (DD+0)]

- **Brief Background**

400 kV D/C Barh-Motihari and 400 kV D/C Motihari-Gorakhpur transmission lines of M/s Darbhanga Motihari Transmission Company Limited (DMTCL) were designed and executed by M/s Jyoti Structures.

Both of the transmission lines were commissioned in August 2017. The affected towers of these lines were part of the Line-in-Line-Out (LILO) of 400 kV Barh-Gorakhpur transmission at Motihari Substation. The total length of 400 kV Barh-Motihari transmission line is 37.5 km and that of 400 kV D/C Motihari-Gorakhpur transmission line is 38 km. The transmission lines passes through plain terrain and the towers of both of these lines were designed for wind zone 4 as per IS 802:1995 with Quad AAAC Moose conductor in vertical configuration.

It was reported that, one of the legs of the tower at location No. 26/1 of 400 kV D/C Barh-Motihari transmission line, which is part of the LILO section, was washed away due to sudden release of water from Valmikinagar barrage on 13.08.2017 and impact of hitting of rock to the pile foundation of the tower in the year 2017.

- **Observations:**

a. Two towers of each of the 400 kV D/C Barh-Motihari and 400 kV D/C Motihari-Gorakhpur transmission lines, which were part of the Line-in-Line-Out (LILO) of 400 kV Barh-Gorakhpur transmission line at Motihari Substation, were reported to be damaged and washed away due to change in the course of river Gandak. All the four towers were located in close proximity to each other on the Gopalganj side of the river bank.

b. As reported by DMTCL, both of the transmission lines were affected due to change in the course of river Gandak. The details of failure of the towers, in chronological order, is produced below:

Date of Failure	Tower Location	Tower Type	Details of Failure	Consideration taken in Foundation design
15.08.2019	27/0 of 400 kV D/C Motihari-Gorakhpur transmission line	DD+0	Foundation was washed away by flowing water of river Gandak. Tower was collapsed.	The foundation of the tower was Open cast type foundation, designed for fully submerged condition. As per M/s DMTCL officials, Three (3) numbers of pile (500 mm dia, 2.0 m long) were additionally provided under each leg of location No. 27/0 during construction.
04.09.2019	26/0 of 400 kV D/C Barh-Motihari	DD+0	Foundation was washed away by flowing water of river Gandak.	The foundation was Open cast type foundation, designed for fully submerged

	transmission line		Tower was collapsed.	condition. Three (3) numbers of pile (500 mm dia, 2.0 m long) were additionally provided under each leg of location No. 26/0 during execution as an additional protection measure
25.09.2019	26/5 of 400 kV D/C Motihari-Gorakhpur transmission line	DA+0	Foundation was washed away by flowing water of river Gandak. Tower was collapsed.	The foundation was Open cast type.
07.10.2019	25/5 of 400 kV D/C Barh-Motihari transmission line	DA+3	Foundation was washed away by flowing water of river Gandak. Tower was collapsed.	The foundation was Open cast type.

c. Details of tower spotting of the relevant portions of the line are produced below. All of these towers were located in between a 9 km bund that was set up to protect the villages in case the region is impacted by floods:

- 400 kV D/C Barh–Motihari Transmission Line (Line in)

Sl. No.	Location No.	Type of Tower	Forward Span (m)	Angle of Deviation	Foundation Type
71	25/0	DC+0	387	3°02'18"R	Open cast
72	25/1	DA+0	414		Open cast
73	25/2	DA+0	402		Open cast
74	25/3	DA+0	395		Open cast
75	25/4	DA+0	425		Open cast
76	**25/5**	**DA+3**	**424**		**Open cast foundation**
77	**26/0**	**DD+0**	**314**	**20°40'39"L**	**Open cast foundation designed for fully submerged condition**

78	26/1	DC+9	525		Pile foundation
79	26/2	DC+9	291		Pile foundation
80	26/3	DC+0	359		Open cast designed for fully submerged condition

- 400 kV D/C Motihari-Gorakhpur Transmission Line (Line Out)

Sl. No.	Loc. No.	Type of Tower	Forward Span (m)	Angle of Dev.	Foundation Type
73	26/0	DC+0	390	2°30'20"R	Open cast
74	26/1	DA+0	420	-	Open cast
75	26/2	DA+3	430	-	Open cast
76	26/3	DA+3	400	-	Open cast
77	26/4	DA+0	380	-	Open cast
78	**26/5**	**DA+0**	**387**	**-**	**Open cast foundation**
79	**27/0**	**DD+0**	**304**	**22°38'40"L**	**Open cast foundation designed for fully submerged condition**
80	27/1	DC+9	523	-	Pile foundation
81	27/2	DC+9	303	-	Pile foundation
82	27/3	DC+0	365	-	Open cast designed for fully submerged condition

d. The team which visited the failure site and interacted with local villagers and gathered the following regarding the change in course of River Gandak in the past:

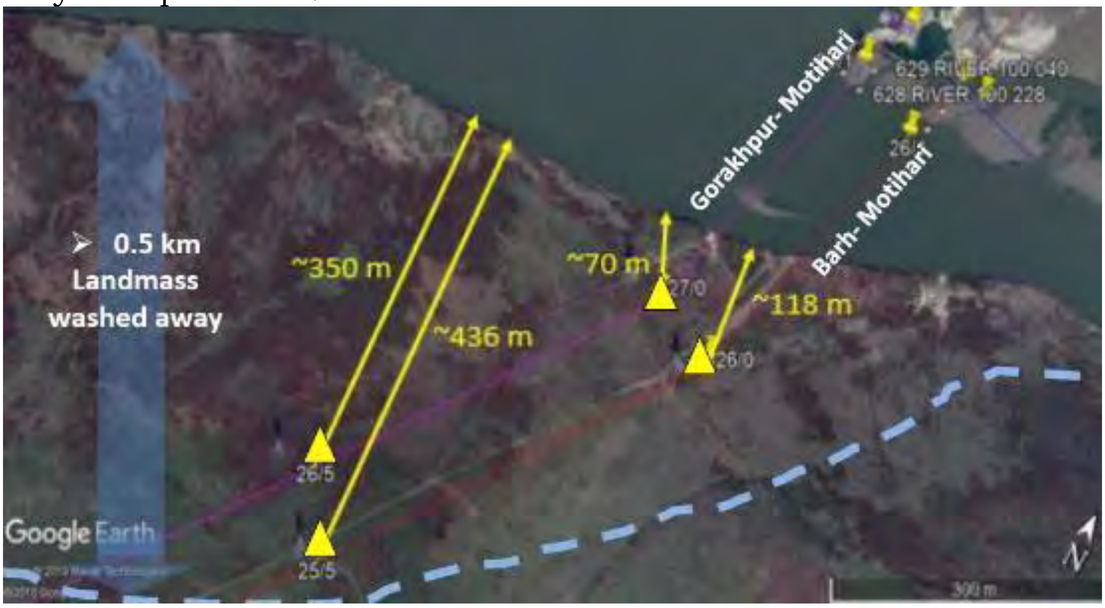
- The river was flowing as a stream near village Sareya (towards left bank of the river) around 25-30 years ago.

- Later the river was understood to be flowing as a stream between village Rupan Chhap and Semaria (approximately 5 to 6 km away from pile locations towards right bank of the river).
- In the year 2012-13, in order to ensure that the river flows away from the villages referred above, the flood control department of Bihar Government widened a small passage between Rupan Chhap and Sareya and since then the river has been flowing through this passage.

e. In the floods that ravaged the region in 2017, the pile foundations at location No. 26/1 (of Barh-Motihari line-one pile leg got washed away) and location No. 27/1 (of Motohari-Gorakhpur line - one pile leg got settled and pile cap got tilted) were affected. As informed by DMTCL representative, a new pile foundation, with 40 meter depth, for tower at location No. 26/1 (Barh-Motihari line) was constructed and line was restored using this tower. A new pile foundation, with 40 m depth was also planned for location No. 27/1 (Motihari-Gorakhpur line) and the same was under construction at the time of failure. The team which visited the tower failure site observed that the tower at location No. 27/1 (Motihari-Gorakhpur line) was still in tilted position and has not been restored and the same is prone to failure. However, despite flooding of the river banks and high water levels, this already tilted tower was not affected further in 2019. DMTCL representative informed that the tower has been shifted to new pile foundations in March, 2020.

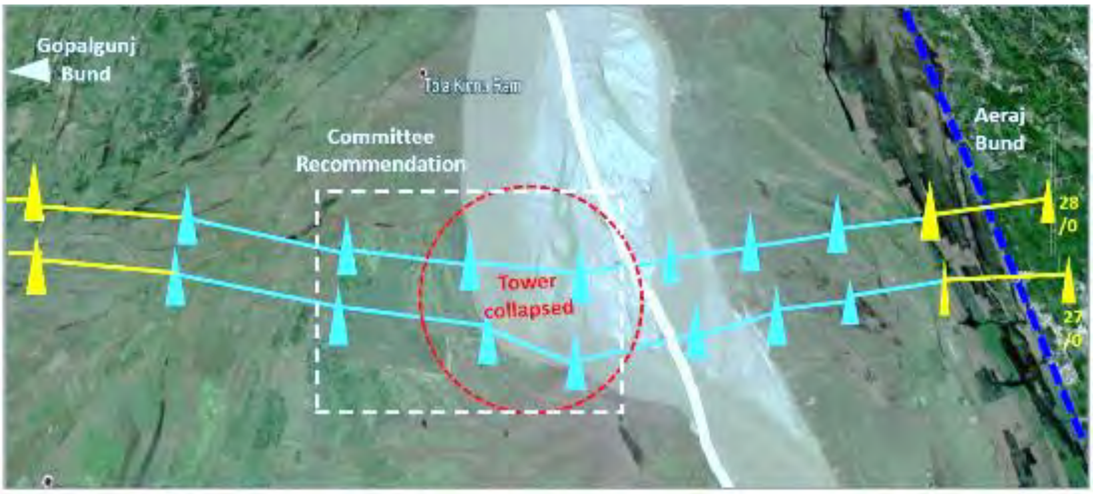
f. As reported by DMTCL representative, at the time of planning & erection of transmission lines, the towers at location nos. 26/1 and 26/2 (of Barh–Motihari 400 kV D/C line) and location nos. 27/1 and 27/2 (of Motihari–Gorakhpur 400 kV D/C line) were located in the river and pile foundations were used for these locations. The towers at locations next to these towers which have failed in 2019, were located on the river bank and were designed as normal foundations on ground as they were away from the river. As an additional measure they were designed for fully submerged condition.

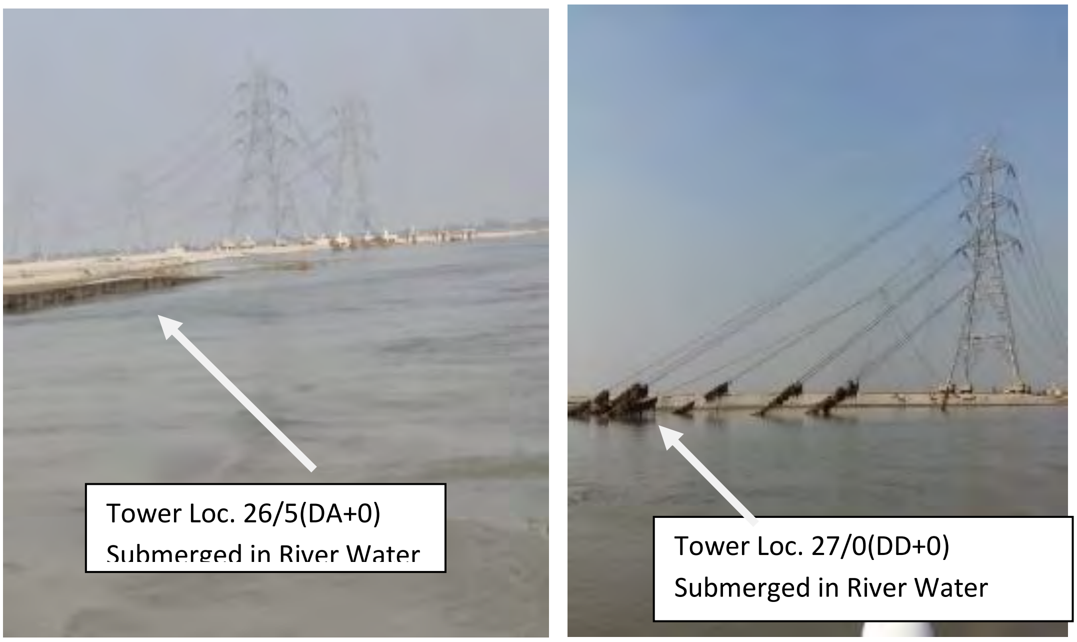
g. DMTCL representative informed that in the monsoon season of 2019, due to heavy rains in the region and continuous change in discharge from Valmiki barrage located upstream of river, the Gandak River changed its course and caused unprecedented floods in the Bihar State. Due to change in course of river and continuous cutting of the right bank of the river, a complete land mass up to the distance of 0.5 km from the original passage of river was washed away. The towers located in this land mass were originally away from the river and were not designed with pile foundation and due to change in course of river, these towers had failed. DMTCL also submitted the copy of Press release issued by IMD stating the high amount of rainfall received in July to September 2019.



h. DMTCL representative informed that as a preventive measure, the river banks near the tower locations were protected by DMTCL using sand and Geo bags prior to the monsoon season to prevent soil erosion or washing out of the banks. Also, after the first incident of tower failure, as a precautionary measure to avoid failure of nearby towers, DMTCL tried to save the towers by mounting a massive protection effort using the experience of the Gandak Authorities and District Administration in flood control measures. However, given the floods and the water current, the protective measures could not prevent the towers from getting washed away.

i. DMTCL was requested to share the Soil investigation reports used for design and construction of the tower foundations. However, DMTCL representative informed that they are not the original developers who designed and developed the transmission line project and the line was transferred to them by the original owner. The data regarding the soil investigation report is not available with them.





Tower at Loc. No.26/5 (DA+0)   Tower at Loc. No.27/0 (DD+0)
of Motihari-Gorakhpur Line

Tower at loc No. 26/0 of Barh-Motihari Line (after failure)

j. DMTCL representative informed that to avoid the failure of transmission line in future and to take extra precaution in respect of change of course of river, in addition to the collapsed four towers, six more towers had been shifted to the pile foundations as per the recommendations of the team which visited the tower failure site. Further, DMTCL had also increased the span within these towers from earlier 450 m to 650 m, due to which the first towers with open cast type foundations had moved further upto 2 km away from river on the both bank sides.

➢ **<u>Committee Observations and Recommendations :</u>**

Committee noted that the towers were designed and erected on normal open cast foundation and pile type foundations were not considered at these locations. A new water course was created due to high floods & the foundation of towers could not withstand against scouring effect/action of the river and transmission lines had failed due to the change in the river course.

Committee highlighted that adoption of Pile type foundation should be envisaged by the transmission utilities on the basis of river flow data of previous years & previous changes in the course of river observed in the region and, additional precautions like, routing of transmission lines few kilometers away from the river bank/ anticipated future river course, Providing proper revetment & use of geo-synthetic material in foundation, concrete encasing & painting of stub in water logging areas, etc. should be adopted by utilities, wherever required.

G. RAICHUR SHOLAPUR TRANSMISSION COMPANY PRIVATE LIMITED (RSTCL)

H.1 765 kV S/C Raichur-Sholapur transmission line of M/s RSTCL failed on 03.06.2019

[Towers at location No. 431 (A+3), 432 (A+3), 433 (A+0), 434 (A+0), 435 (A+3), 436 (A+0) & 437 (B+0)]

➢ **Brief Background**

765 kV S/C (Quad) Raichur-Sholapur transmission line was constructed by M/s RSTCL and was commissioned in July 2014. The line connected 765/400 kV substation of POWERGRID located near Askihal Village, Raichur District, Karnataka State with 765/400 kV substation of POWERGRID located near Limbi Chincholi Village, Solapur District, Maharashtra State. The length of the transmission line is 208.083 km. Around 180 km of the line lies in Karnataka, while the balance line portion is in Maharashtra. The transmission line towers were designed by M/s Trucon Associates as per IS 802: 1995 considering wind zone 2. In addition, additional loading of narrow front wind in horizontal directions of 0^0,45^0 & 90^0 was also considered in the design. The towers were designed in Vertical delta configuration with Quad ACSR Bersimis conductor. Polymer type insulator were used in the line and it was reported as the first incident of failure in the transmission line.

➢ **Observations:**

a. As informed by RSTCL, whirl wind followed by thunderstorm was observed in the vicinity of transmission line on 3rd June 2019. During patrolling, RSTCL team observed that six (6) suspension towers and one tension tower (B type) were collapsed/damaged. The details of damaged/collapsed towers is as follows:

Sr. No.	Loc. No.	Tower Type	Damage
1.	431	A+3	Towers fully collapsed, foundation damaged
2.	432	A+3	
3.	433	A+0	
4.	434	A+0	Tower collapsed from mid portion
5.	435	A+3	Top cross arm damaged
6.	436	A+0	
7.	437	B+0	

b. **Towers at location No. 431(A+3), 432 (A+3) & 433 (A+0)** were collapsed in transverse direction to the line. The foundations of these towers were observed to be damaged.

Tower at location No. 431 (A+3)

Tower at location No. 432 (A+3)

Tower at location No. 433 (A+0)

c. **Tower at location No. 434 (A+0)** was collapsed from mid portion of the tower structure. The bottom cage portion of the tower was in erect condition and the top portion of the tower structure got sheared away from the lower tower body and was lying on the ground. The foundations of the tower were reported to be intact.

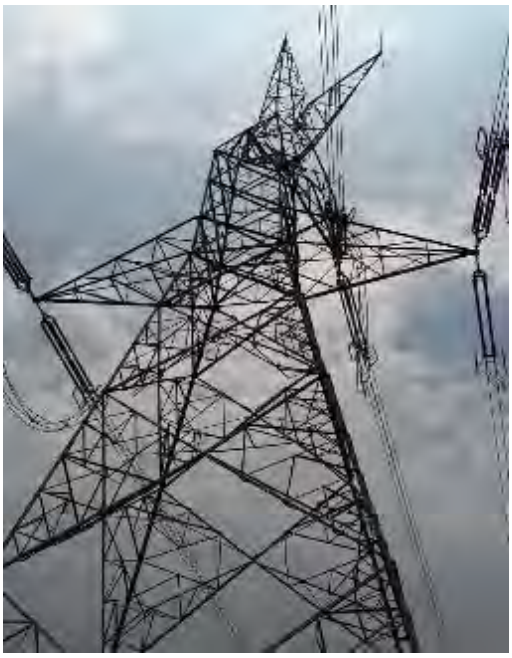
Tower at location No. 434 (A+0)

d. Towers at location No. 435(A+3), 436 (A+0) & 437 (B+0) were in erect position. The top cross arm of the tower at location No. 435 (A+3) was sheared away and was lying near the tower structure. Whereas in case of towers at location No. 436 (A+0) & 437 (B+0), the top cross arms were twisted and resting on the tower structure. The lower portions of the tower structures were observed to be intact.

Tower at location No. 435 (A+3)

Cross arm Lying near tower

Tower at location No. 436 (A+0)



Tower at location No. 437 (B+0)

e. RSTCL representative informed that collapsed towers were located at a distance of 38 km from Solapur substation. On the date of tower failure incident, RSTCL's representative were not able to reach the tower failure sites due to heavy rain, wind, and lightning prevalent at the site location. The approach to failure site was further restricted due to black cotton soil & water logging.

f. To check the chemical composition and mechanical strength of the tower members, material tests were conducted at CPRI lab on samples selected from site and yield and ultimate strength of these members were found to be within limits. However, the one member (member 2) had more carbon content than the prescribed limit, two members (member 10 & 11) had silica content more than prescribed limit and three members (members 6, 10 & 11) had Phosphorous content more than prescribed limit. RSTCL representatives highlighted that these tower members are satisfying the minimum yield strength criteria required as per IS codes.

g. RSTCL representative informed that at the failed tower locations, certain cracks in the top of the chimney of failed towers were observed. However, no members were found missing from the tower structures.

h. RSTCL representative informed that to as per their Patrolling report, there was no missing member or missing nuts and bolts observed in the last patrolling executed by their team in the month of March 2019.

i. RSTCL submitted the analysis report of M/s Trucon Associates regarding the design of these towers. The parameters considered in the designing of these towers were examined and found to be in order.

j. RSTCL highlighted that no wind speed observatory was present near the tower failure site and their attempts for gathering of the actual wind speed data were unproductive. Subsequently, they had consulted M/s

Reconnect Energy Solutions Pvt. Ltd. Bengaluru, for the same which provide the wind speed data by simulating the same environment in their lab. On the basis of the report prepared by M/s Reconnect Energy, RSTCL highlighted that the failure of towers was because of the two factors deduced in the study namely, Nocturnal shear prevalent over the tower failure site across the temporal window spanning from 23:30 hours IST 02/06/2019 to 23:30 hours IST 03/06/2019. And also the thunderstorm and associated hazard called mesocyclone observed around 17:40 hours IST 03/06/2019 adjacent to tower collapse. RSTCL also highlighted that some sudden un-natural updraft/downdrafts rapid movement of winds are the reason behind the tower collapse.

- **<u>Committee Observations and Recommendations :</u>**

Committee discussed the failure pattern observed in the case and noted that the chemical composition of some of the failed tower members was not as per IS codes. Due to higher percentage of Carbon, and Phosphorous observed in the samples, the material might have become prone to brittle fracture.

Committee noted that speed of wind prevailing at the failure location at the time of the failure could not be gathered from any authenticated observatory by transmission utility. The high speed wind event indicated in the report of the M/s Reconnect Energy is based on the simulations. Committee further noted that due to the improper chemical composition of the steel used in tower members, the towers were prone to brittle fracture which failed during the high wind incident observed in the area.

Committee suggested that Best practices in quality control process for raw material, manufacturing, transportation, construction, storage, erection and stringing of towers should be adopted.

ANNEXURE A

COMPOSITION OF STANDING COMMITTEE OF EXPERTS

Central Electricity Authority
Office of the Secretary

No.5-41/98/Secy/CEA / 809

Date 24/9/99 30

(Technical Committee No 16)

Office Memorandum

Subject: **Constitution of Standing Committee of Experts to investigate the Failure of Towers.**

Because of transmission line tower failures taking place in the country, resulting in disruption of power on large scale for long periods, it has been decided as per chapter-II, para 3 (viii) of the Electricity (Supply) Act. No 54 of 1948 to constitute a Standing Committee, consisting of experts in the field of EHV Transmission lines from CEA, Power Grid, CPRI, IIT Delhi, & SEB (of the State, where tower failure has taken place). In the event of any failure of towers for transmission lines of 220kV and higher voltages of power utilities, members of the committee should immediately visit the site to have first hand information and ascertain the causes of failure and give recommendations to prevent such recurrences in future.

2. The scope and terms of reference of the committee shall be as follows:

   (i) To investigate the causes of failure of towers.

   (ii) Recommendations to avert recurrences, of such failures in future.

3. Committee will submit its report within three months, from the date of failure.

4. Concerned power utility will provide all assistance, required by the committee in carrying out the meetings, make arrangements for immediate site visit after failure of towers by providing transport and travel facilities and preparation of the report.

5. All the Organisations/Power Utilities are requested to nominate their officers/alternate as their representative, and intimate to Chief Engineer STE, C

Every incident of Tower failure must be immediately reported to Chairman, CEA and Members of the Standing Committee.

8. This issues with the approval of Chairman, CEA.

3/9/9

(VIJOY KUMAR)
Secretary (CEA)

O/C

CMD Power Grid, New Delhi.

DG CPRI, Bangalore.

Head of Civil Engg. Deptt., IIT Delhi

Chairman of SEBs/Transmission Corporation/Grid Companies

PS to Chairman, CEA

PS to Member (PS), CEA

As per list Enclosed.

Copy to: Chief Engineer (GM), CEA
PS to Secy CEA

SS(M)CE
1/10/99

भारत सरकार
केन्द्रीय विद्युत प्राधिकरण
सचिव का कार्यालय
सेवा भवन, आर० के० पुरम्,
नई दिल्ली - 110 066
****

(आइ.एस.ओ.: 9001.2000)

o.CEA/5-41(18)/Secy-2012 / 166

Dated: 06.08.2012

OFFICE ORDER

ubject: Re-composition of the Standing Committee of Experts to investigate failure of towers-Amendment - Reg.

Standing Committee of Experts was constituted vide this Office Memorandum Techincal Committee No. 16) of even no. dated 30.09.1999 to investigate the causes of failure f towers. After the enactment of Electricity Act, 2003, it is felt necessary to re-compose the bove said Committee. The revised Compostion of the Standing Committee of Experts to nvestigate failure of towers is given below:

1. Chief Engineer, SETD, CEA - Chairperson
2. Additional Director, (CPRI) - Member
3. Head, Deptt. of Civil Engg, Delhi Technological University - Member
4. Representative from Power Utility where Power failure occurred - Member
5. Member Secretary, Regional Power Committee where Power failure occurred - Member
6. Director (Transmission), SETD, CEA - Member Secretary

The other terms of reference shall remain the same as indicated in the above referred Office Memorandum.

(M.S. Puri)
Secretary, CEA
Tel. No.26108476

To:

1. Chief Engineer, SETD, CEA
2. Director (Transmission), SETD, CEA
3. Additional Director, Mechanical Enginering Division, Central Power Research Institute (CPRI), C.V. Raman Road, Banglore
4. Head, Deptt. of Civil Engineering, Delhi Technological University, Shahbad Daulatpur, Bawana Road, Delhi

Sh [illegible]

7/8/12

5. Representative from Power Utility (as per list enclosed)
6. Member Secretary, Regional Power Committee (NRPC, WRPC, SRPC, ERPC & NERPC)

Copy for information to:

1. SA to Chairperson, CEA
2. SA to Member (PS), CEA

Copy for kind information to:

1. Secretary, Ministry of Power, Sharam Shakti Bhawan, Rafi Marg, New Delhi
2. Chairman and Managing Director, Powergrid Corporation of India Ltd., Saudamini, Plot No.2, Sector-29, Gurgaon

(M.S. Puri)
Secretary, CEA
Tel. No.26108476

ANNEXURE B

Minutes of the Meeting

भारत सरकार
Government of India
विद्युत मंत्रालय
Ministry of Power
केन्द्रीय विद्युत प्राधिकरण
Central Electricity Authority

विद्युत प्रणाली अभियांत्रिकी एवं प्रौद्योगिकी विकास प्रभाग
Power System Engineering & Technology Development Division

सेवा में,

As per attached list

विषय: Minutes of the Meeting of Standing Committee of Experts to investigate the failure of various transmission lines failed during the period April, 2019 to December 2021, held on 11.01.2022 & 12.01.2022-reg

महोदया/महोदय,

As you may be aware that an e-meeting of Standing Committee of Experts was held on 11th and 12th January 2022 to investigate the causes of failure of various transmission lines failed during the period April, 2019 to December 2021.

The minutes of the meeting are attached herewith for information and further necessary action please.

संलग्न/ Encl. – ऊपरोक्त/ as above

भवदीय

मोहित मुदगल

(मोहित मुदगल)
उप निदेशक

Address List:

1.	Director General, Central Power Research Institute, Mechanical Engineering Division, CPRI Post Box No.8066, Prof. Sir C.V. Raman Road, Sadashivnagar, Bangalore -560 080
2.	Member Secretary, NRPC, Shaheed Jeet Singh Marg, Katwaria Sarai, New Delhi-110 016 **(Fax No.91-11-26865206)**
3.	Member Secretary, ERPC, Gold Club Road, ERPC Building, Tollygunge, Kolkata-700033 **(Fax No. 033-24171358)**
4.	Member Secretary, WRPC, F-3, MIDC Area, Andheri(East), Mumbai-400093 **(Fax No.022-28370193)**
5.	Member Secretary, SRPC, CEA, No.29, Race Course Road, Bangalore-560009 **(Fax:080-22352616)**
6.	Member Secretary, North Eastern Regional Power Committee, NERPC Complex, Dong Parmaw, Lapalang, Shillong – 793006 (Meghalaya). **email: nerpc@ymail.com**
7.	Director, TCD, CEA, Sewa Bhawan, R.K. Puram, New Delhi
8.	Head of the Department, Civil Engg., Delhi Technological University, Shahbad Daulatpur, Bawana Road, Delhi-110 042 (Fax No.011-27852188)

9.	Director, Structural Engineering Research Centre, CSIR Campus, Taramani, Post Box No.8287, Chennai–600 113 **(Fax No.044-22641734).**
10.	Director General, India Meteorological Department, Mausam Bhawan, Lodhi Road, New Delhi- 110 003 **(Ph.011-24616051)**
11.	Chairman & Managing Director, POWERGRID, Saudamini, Plot No.2, Sector 29, Near IFFCO Chowk, Gurgaon – 122 001
12.	Chief General Manager (Engg-TL), POWERGRID, Saudamini, Plot No.2, Sector 29, Near IFFCO Chowk, Gurgaon – 122 001
13.	Shri E.V. Rao, KEC International Limited, RPG House, 463, Dr. Annie Besant Road, Worli, Mumbai-4000 030
14.	Chairman Sterlite Power The Mira Corporate, Suit, Plot No. 1&2, C Block, 2nd Floor, Ishwar Nagar, Mathura Road, New Delhi – 110065
15.	Shri Kaushal Thakkar, Manager, Kalpataru Power Transmission Ltd., Plot No. 101, Part III, GIDC Estate, Sector 28, Gandhinagar-382028, Gujarat
16.	Shri P.G. Suresh Kumar, Director, L&T IDPL, Kudgi Transmission Ltd., 1st Floor, TCTC Building, Mount Poonamallee Road, Manapakkam, Chennai-600 089
17.	Dr. Deepak Lakhpati, Chief Design Officer, Sterlite Power

	F-1, Sterlite Power, The Mira Corporate Suits,1 & 2, Ishwar Nagar, Mathura Road, New Delhi-110 065
18.	Mr. Bipin B. Shah, Vice President–Transmission, Torrent Power Limited, 3rd Floor, Jubilee 2. House, Shahpur, Ahmedabad380001
19.	Managing Director, Karnataka Power Transmission Corporation Limited No. 82, Shakti Bhawan, Race Course Road, Bengaluru – 560001
20.	Chairman & Managing Director, Madhya Pradesh Power Transmission Co. Ltd. Block No.2, Shakti Bhawan, Rampur, Jabalpur (M.P.) – 482008.
21.	Chief Engineer (EHT-M&I), Madhya Pradesh Power Transmission Co. Ltd., 3rd Floor, Block No.2, Shakti Bhawan, Rampur, Jabalpur (M.P.) – 482008. (0761-2702270, 2660757)
22.	Chairman & Managing Director, Rajasthan Rajya Vidyut Prasaran Nigam Ltd. Vidyut Bhawan, Janpath, Jyoti Nagar, Jaipur (Rajasthan) - 302005
23.	Chairman & Managing Director, Uttar Pradesh Power Transmission Corporation Ltd. Shakti Bhawan, 14-A, Ashok Marg, Lucknow – 226001
24.	Director, Darbhanga – Motihari Transmission Co. Ltd. 6th Floor, Plot No. 19 & 20, Film City, Sector 16 –A, Noida, Uttar Pradesh – 201301
25.	Chairman & Managing Director, Raichur Sholapur Transmission Company Private Limited, Plot No 6. Sy No. 20/A Above VKG TATA Show Room Gunj Area, Hyderabad Road, YADGIR 585-201 Karnataka

Minutes of Meeting of the Standing Committee of Experts on Failure of Transmission Line Towers held through Video Conferencing on 11.01.2022 & 12.01.2022 to Analyse failure of towers in EHV transmission Lines during the period April, 2019 to December 2021.

The list of Participants is enclosed as Annex -II.

1. Chief Engineer (PSE&TD) & Chairman of the Standing Committee welcomed all the participants and informed that during the period of April, 2019 to December 2021, failure of 174 Nos. of transmission towers in 48 transmission lines of 220kV, 400 kV and 765 kV AC and ±800 kV HVDC voltage class has been reported to CEA. Out of these 174 Nos. of failed towers, 29 nos. of towers were of tension type while the rest were suspension type (List of failed transmission lines is provided at Annex-I.). He stated that the number of towers collapsed have gradually decreased in the past few years. He requested all the utilities to intimate the tower failure incidents in a prompt manner so that a visit of team to tower failure site can be planned. He further requested utilities to provide all the relevant details/documents including images, duly filled CEA proforma, wind speed data, coordinates of failed towers, material test reports, etc., so that a proper investigation of cause of failure may be carried out. He requested Indian Meteorological Department (IMD) to provide the wind speed data of the tower failure location(s) so that detailed analysis of the failure of the transmission tower with respect to wind as a cause of failure can be carried out. He further requested Director (PSE&TD) to take up the agenda of the meeting.

2. Director (PSE&TD) welcomed all the participants and highlighted that transmission towers are important asset for the transmission systems and failure of transmission tower can cause havoc in the grid. Therefore, it is important to analyze and find out the causes which led to the failure of transmission towers and requested participants to actively participate in the deliberation to arrive at a conclusive cause of failure of transmission towers and suggest remedial measures to avoid the recurrence of such incidents in future. He highlighted that number of failure cases remains unreported to CEA as many of the Power Transmission utilities (State Transmission utilities, Private Transmission utilities /licensees) in the country neither report the failure of towers of transmission line nor participate in such national level meeting and requested all the utilities to intimate the failures of transmission line timely so that a proper investigation may be carried out. Also, he informed that there is a tower failure intimation format available on the CEA website through which utilities can intimate tower failure incidents with all the relevant documents mentioned in the format. He requested all the utilities to also provide detailed colored photographs/videos for detail analysis of tower failure, as with limited strength in CEA, COVID restrictions & travel restrictions, some of the times it was not possible to depute officers for site inspection of all the transmission tower failures. He requested that all the utilities may coordinate with IMD for Wind speed data of the time and location of failure, as wind has been highlighted as the major cause of collapsing of the tower. In

such cases, it is important to have wind data from authentic observatory to collaborate that whether the speed of wind around the collapsed tower exceeded the wind speed for which the towers are designed. The availability of data indicating change in wind speed in a particular area may help to take necessary modifications in design parameters so that the failure of towers may be avoided. He further requested members from utilities to present their respective failure incidents before the Committee for deliberation.

3. Representative from POWERGRID gave a presentation summarizing the failures of towers, important highlights of which are summarized hereunder:

    i. In 2019, total number of towers affected are thirty-one in the total population of 2,56,000 towers of Powergrid. In 2020, total number of towers affected are twenty-one in the total population of 2, 69,000 towers. And in 2021, total number of towers affected are twenty-one in the total population of 2, 90,000 towers. Hence, there has been gradual decrease in the percentage of tower failure.

    ii. In the past three years a total of 73 towers had collapsed of which 59 towers are of suspension type and 14 towers are of tension type. It has been observed that the majority of the towers which got collapsed are of 400kV level Double Circuit configuration towers (44 towers) and the 765kV towers with delta configuration (18 towers)

    iii. Percentage of incidences of failure with respect to total population of towers of POWERGRID for the year 2019, 2020 & 2021 are 0.012%, 0.007% and 0.007% respectively.

    iv. Out of seventy-three number of tower failures, sixty towers had collapsed due to High velocity wind storms, cyclones and local phenomenon of whirlwind. Other towers were collapsed due to theft/ sabotage of the tower members, erosion of the tower foundation due to landslides and flash floods and large differential settlement of the footing.

4. Representatives from POWERGRID further informed that they had prepared the presentation based on the agenda circulated by CEA along with the meeting notice and the presentation does not cover in-detail case to case basis information of tower failure incidents. Chief Engineer (PSE&TD) stated that the details presented by POWERGRID in the table format is not clearly visible to participants and detailed case to case presentation having images of failed towers is required for detailed discussion and informed opinion of the Committee members. Director (PSE&TD) added that it is responsibility of the individual utilities to present their cases and such kind of ill preparedness from POWERGRID is disappointing. POWERGRID officials were directed by the committee that utmost care shall be taken by them to avoid such incidences in future. Further, representative from POWERGRID presented details of the individual cases of failures in their transmission lines from the presentation circulated with Agenda

of meeting and the causes of failure of towers were discussed in detail and important highlights are summarized hereunder:

i. It has been observed by the Committee that some of the 400kV lines of Powergrid having conductors in Quad configuration (400 kV Agra-Sikar transmission line, 400 kV Nellore-PS Gooty transmission line, 400 kV Dulhasti-Kishenpur II transmission line, 400 kV D/C Kaithal-Baghpat transmission line etc.)are commissioned after the notification of CEA regulations, 2010. However, these lines are designed as per Reliability level-1 instead of Reliability level-2 which is to be adopted for quad conductor configuration lines as per aforementioned regulations. Committee noted that CEA regulations have been drafted after detailed consultation with the stakeholders and shall be adhered to in any case and directed POWERGRID to ensure that Reliability level to be adopted for all the future transmission lines shall be in accordance to CEA regulations.

ii. In case of 400kV Narendra-Devanagari Transmission line, it was highlighted that two incidences of failure of this line had occurred within a time span of two months and in total seventeen (17) towers of the line had failed. Committee noted that deficiencies like, rusting in the stubs, miss-alignment of stubs & concrete pedestal, unplugged holes, improper coping of the chimney & covered in the grass, etc. were observed by the team which visited the tower failure sites. Further, the failed towers were located in the open field areas with very few trees/vegetation around the towers, however, these were designed considering Terrain Category-II. Committee suggested that since this transmission line has failed twice in a year, the patrolling frequency may be increased. Committee noted that small trade-off in the integrity of structure may lead to its collapse. Utilities shall improve their erection and operation & maintenance practices and ensure that structural strength is not compromised due to deficiencies like, unplugged holes, rusting of stubs, etc.

iii. In some of the failed tower location in lines of POWERGRID (like 400kV Narendra-Devanagari Transmission line&400kV Quad Nellore-Gooty Transmission line) deficiencies in the erection of transmission lines like the mis-alignment of stubs (i.e. tower legs not located in the center of the chimneys) was observed. The photographs of such observations were shared with the Committee. Committee deliberated on the impact of stubs being offset from the chimney, on the tower structure and noted that in case back to back dimensions are not in accordance to tower designs, the residual stresses may develop in the tower structure which may lead to its collapse. Committee directed utilities to ensure good erection practices and ensure that casting of chimneys and placement of stubs are done as per approved drawings. Further, in future during investigation of failed towers, wherever possible, stub setting dimensions, including back to back distance measurements, should be measured and submitted to the Committee along with the failure report.

iv. In case of 400kV D/C Quad Agra-Sikar transmission line which had failed in 2019& 2020, Committee noted that there was deficiency in the erection/O&M practices adopted by Powergrid as no. of bolts were found missing in the Leg members at some of the failed tower locations. Director (PSE&TD) also highlighted that at one location, distance of bolt hole from the edge of the members also appeared to be on lower side. Committee noted the above and directed POWERGRID to improve their operation & maintenance activities and as there are many failures in Agra region in past years, special measures like, higher frequency of patrolling of the lines may also be adopted by Powergrid.

v. Committee noted that in failure of 400kV D/C Kishanganj-Patna Transmission line, even though the highest water level measured during the flood was lower than the HFL level considered in designing of pile foundations, the Pile foundations had failed. POWERGRID informed that the failed tower has been shifted to another location for restoration and higher scouring depth has been considered for new pile foundation. The testing of the damaged pile foundation has been carried out and reports are still awaited. Committee requested POWERGRID to share the report of foundation testing. Further, Committee noted that one of the failed tower had been tested for +9 m body extension and has been erected with +25 m body extension with the tower structure. Committee requested Powergrid to review the design of Tower extension part adopted in the failed tower location to ensure the stability of bottom most panels as the K- bracing placed at this panel appears to be not bearing the loads because of very high base width to height ratio and share the analysis report with the Committee.

vi. In case of failure of 400kV D/C Vindhyachal-Jabalpur transmission line, in the material test report of the collapsed tower members, the Ultimate tensile strength (UTS) of some of the members of the tower were found to be lower than the specified values required as per IS codes. POWERGRID representative informed that the transmission line is quite old and was commissioned in 1989. The tower structure steel was imported from Russia and was designed as per Russian standards, however, the copies of codes used in design of these towers are not available with POWERGRID. Representative from CPRI highlighted that UTS of the transmission tower members may be degraded since the line is in operation for so many years, but the chemical composition shall remain same. Representative from SERC highlighted that in most of the failed transmission towers, the tower got bent from the panel above the diaphragm level indicating that the tower is not able to take the torsional load. Committee noted that the narrow front wind load on the tower body might not have been considered in the design of these towers. Further, as different design codes had been used for design of these towers, it is not correct to compare the material properties with respect to codes currently in practice.

vii. Committee noted that suspension type towers of many765 kV transmission lines of Powergrid having S/C delta configuration (like 765 kV S/C Varanasi-Fatehpur transmission line, 765 kV Sasan-Satna II transmission line, 765 kV Jhatikara-Bhiwani line,765 kV Meerut-Moga transmission line) had failed during the April 2019 to December 2021 period and enquired about the status of strengthening of such towers as directed in previous standing committee meetings. Powergrid officials informed the Committee that, the strengthening of existing 765 kV S/C delta configuration suspension type towers which are located in Wind zone 4 & Wind zone 2, is being executed by Powergrid in phased manned and at present, only fifty-six (56) numbers of S/C 765kV towers (Delta configuration) in the Western Region-1 are remaining to be strengthened. In 765 KV Jhatikara-Bhiwani Transmission Line, the tower was collapsed after the strengthening work of S/C 765kV towers (Delta configuration) has been done. In rest of the cases the failure of S/C 765kV towers (Delta configuration), the strengthening work is done after the incident of tower failure.

The strengthening of towers includes clamping of some of the members as well as replacement of few tower members. Strengthening of towers in same manner as suggested by the Standing Committee in the previous meetings, i.e. by replacement of all members, is not possible for already erected tower members as long shutdown of transmission lines will be required. However, failed towers are always replaced by completely strengthened tower in line with the recommendations of committee. Further, strengthening of few other tower members, as suggested byM/s. Minitoba Hydro is also being adopted by Powergrid. The tower with strengthening currently being adopted by Powergrid (i.e. clamping of few members and replacement of some members) had also been tested at the CPRI test bed.

viii. In case of 220kV RAPP C-Anta transmission line, Committee noted even though the transmission line was commissioned in year 2000, the line has been designed as per old IS 802:1977 instead of IS 802:1995.Similary in case of 400 kV Quad Kishenpur-Dulhasti transmission line, the line was commissioned in 2018, however, the towers used were designed as per old standard IS 802:1995 instead of IS 802:2015. Committee directed Powergrid to examine the background of adoption of old designs for these transmission lines and submit the reason for the same to the Committee. Further, Committee noted that in order to save the cost of designing & testing, transmission utilities might continue to use old designs of towers even after revision of IS codes. Committee recommended that such type of practices shall not be adopted by the utilities and it shall be ensured that the transmission lines are designed and erected as per latest IS codes, regulations and recommendations of the Standing Committee / Task Force, as applicable.

ix. In the failure of 400kV Quad Kishenpur-Dulhasti transmission line, Committee noted that single circuit was strung on the double circuit tower and enquired whether the towers were designed & tested considering the single side stringing. Powergrid representative informed that the strength of tower to withstand single side stringing was verified during testing of tower at the test bed and informed that a geo-technical investigation of the affected locations is also being carried out by the Powergrid. Committee requested Powergrid to take suitable safety measures considering the geotechnical investigation and suggested that anavalanche protection retaining wall may also be constructed around the tower to safeguard the tower from hitting of the boulders.

x. In case of 400 KV Purnea- Gokarna -400 kVPurnea-Farakka transmission line, Committee noted that due to continuous land cutting by river, the tower became vulnerable and the same was intentionally felled down by Powergrid after taking the shutdown. Committee decided that the incident may not be considered as tower failure as the remedial action was taken by Powergrid and may not be discussed in the meeting.

xi. In case of the 765kV Bina-Gwalior transmission line, Powergrid representative informed that severe theft of tower members was observed at the failure site. Representative from MPPTCL also confirmed that there are many incidences of thefts/sabotage in the Gwalior region and MPPTCL is also facing these types of problems in some of their transmission lines and had adopted painting of transmission towers with Tarcoal paint. POWERGRID informed that they had increased the patrolling frequency and had installed vibration sensitive cameras at some of the locations to avoid thefts/sabotage. Committee noted the above and requested utilities to proactively adopt such practices and to increase the frequency of patrolling at theft prone areas to avoid failure of towers.

xii. In the failure of the 400kV Korba-Raipur III & IV transmission line, it was observed that there was de-capping of the insulator, which resulted in damage of the cross arm of the tower. Representative from MPPTCL also confirmed that the transmission lines of MPPTCL is also facing similar problems in this region and a pilot project considering line surge arrestors is being implemented by MPPTCL to overcome the issue. Also, MPPTCL is planning to install anemometer at the EHV substations to measure the wind speed. Powergrid representative informed that Powergrid had also installed Anemometers on its substations and experience report of the same will be shared to MPPTCL for reference purpose.

xiii. In case of 400 KV Kishenpur-New Wangpoh 3&4 Transmission Line, Powergrid informed that due to land slide the tower located at lower height was shifted due to which the tension in the conductor had increased which had led to failure of adjacent tower located at higher location. Committee requested Powergrid to ensure that the geological investigation of the land mass is carried out and based on the report, take the necessary strengthening measures required for tower foundations &/or for the hill slope, so that such incidences does not repeat and lead to failure of other towers.

xiv. In case of 765 kV Meerut-Moga line, Powergrid representative highlighted that at the time of erection, the towers were designed considering wind zone 4 as per the wind map applicable at that time, however, the wind zone of the area has been updated to wind zone 5 in the latest wind map published in national building code. Committee noted the above and requested Powergrid to share the image screenshot of Google earth depicting the transmission line superimposed on the wind map of India and clearly indicating the failed transmission tower locations with the Committee.

xv. In case of failure of 765 kV Moga-Bhiwani line, Powergrid representative informed that the failed tower was of B type tower with +25 m body extension and was spotted with a lower span and with zero degree deviation angle. Committee noted that only the +25 m Body extension part was damaged and basic body structure of the failed tower was intact. Representative from Torrent Power highlighted that in case of +25 m body extension, normally the stub setting templates are not available and props are used for this purpose. Special precaution is required to be taken to ensure the correct slope of stubs in addition to the correct back to back distance between the stubs. Committee also noted that in this case the B type tower have been spotted with lower span values and hence, have inherent safe margin and in case failure was due to wind the nearby suspension type towers would have collapsed instead of this tower. Further, as only the extension part had collapsed and basic body structure is intact, it indicates that there must have been some erection deficiency in erection of extension part which had led to collapse of tower.

5. Powergrid representative highlighted that due to non-availability of observatory of IMD at the tower failure locations, it is not possible to collect the authentic information of wind speed prevailing at the tower failure location. Representative from IMD responded that that due to limited no. of observatories of IMD it will not be possible to find out the exact speed of the wind around the tower on the date of failure of transmission tower. Further, if observatory is not available at the location, the only way to conclude the wind speed at the failure site location is through indirect calculation or estimation by considering the damages observed in the area. However, utilities can approach National Data Centre of IMD, Pune for details of maximum wind speed recorded at observatories. Committee noted the above and directed that for all the transmission line failures in which High wind speed is claimed as the major cause of failure, utilities shall approach IMD with the details of failed towers of all the transmission lines (including coordinates and date & time of failure incident) to obtain the actual wind speed observed in the area. Committee also directed the utilities that the details of failure shall be submitted to CEA as soon as the failure incident occurs and wind speed details obtained from IMD shall also be submitted along with the duly filled tower failure intimation format available on CEA website.

6. Committee deliberated on the possibility of designing of towers which are erected in open fields, with considering Terrain category-I. Powergrid officials highlighted that out of a complete length of transmission line, there are few small sections which are located in the open areas & fall under Terrain Category-1, and it is not possible to design separate few towers specific to these locations considering Terrain Category-I factors. Powergrid had executed a study in the Kutch area of Gujarat regarding Terrain category and it was found that the towers designed with Terrain category-II and 400 m span have to be spotted with reduced span of 370 m in locations under Terrain category-I conditions. Committee noted the above and highlighted that Utilities shall pay utmost care in adopting the design parameters as per the terrain category faced along the route of transmission lines.

7. Committee deliberated on the prospect of adopting wind speed corresponding to Wind zone-II for designing of transmission towers located in area under Wind zone-I. Representative from the M/s. KEC International Ltd. suggested that the area covered under Wind Zone-1 is limited and lines passing through this area may be designed considering higher wind zone as there is huge gap in the basic wind speed specified for the Wind Zone-1 (i.e. 33 m/s) and that specified for Wind zone 2 (i.e. 39m/s). Representative from M/s. Sterlite Power also added that in some of the areas, there might have been change in the wind speed due to the continuous deforestation and higher wind zone may be considered for future designs. Committee deliberated on the issue and concluded that the decision of modification in wind zone cannot be taken on basis of single event of failure and holistic view based on analysis of frequency of failures of transmission lines in wind zone-I need to be taken. Thus, the decision to modify the wind zone can be taken at later stage in case multiple failures are observed in the Wind zone-I area.

8. Representative from CPRI highlighted that as seen from the past data, most of the failure of the transmission towers occur in the month from April to July and there is a possibility of certain seasonal effect due to which the higher wind speed is observed in this period. Representative from SERC stated that in the North Western region of India, many towers had failed in past years in the pre-monsoon period. In 2016, SERC published a research paper in which it was observed that dust storms occur in the north western region particularly in the Gangatic region, every year, which may lead to tower failures. He informed that increase of0.01% of dust in wind (by volume) will increase the load on the tower by ten (10) percent. Representative from IMD added that during the period April to July, there are many thunderstorms in the different regions of the country. Committee discussed the issue and requested SERC to share the research paper& studies with the Committee for further examination and evaluation.

9. Representative from MPPTCL highlighted that cyclonic circulation of wind is observed in some part of the MP which causes torsional wind load on the tower structures. Representative from M/s Sterlite also added that these torsional winds are more prominent in few months of summer seasons and lead to cascading failure of towers. Representative from Powergrid informed that Powergrid had proposed some

modifications to BIS in regard of inclusion of effect of cyclonic wind in the relevant IS in line with CIGRE guidelines.

10. Committee noted that wind map of India may also need further revision as latest wind map was published by SERC in year 2009. Committee requested SERC to carry out the exercise for revision of Wind Map of India.

11. Representatives from KPTCL presented details of the failures in their transmission lines (copy of presentation attached) and the causes of failure of towers were discussed in detail. Regarding the failure of 220kV Kapnoor-Shahbad-Shahpur D/C transmission line, representative of KPTCL informed the Committee that the line was commissioned in 2003, however, the towers used in the transmission line were designed as per old IS 802: 1977 in which only transverse load (wind at 0 degree) was considered as wind load on tower body. In this case, as highlighted in the investigation of failure done by technical committee of KPTCL, the wind span length between tower locations 390 (DB+15) and 391 was 340 m, which is on higher side considering the +15 m body extension and hence, the wind acting on the tower led to failure of towers. Committee noted that as the towers are spotted with a zero degree deviation angle, there is sufficient safety margin available for B type tower even with considered span of 390 m. However, as the towers are designed as per old IS codes, the narrow front wind factor and oblique wind load on tower structure would not have been considered in the design of towers. Committee requested KPTCL to share the colored photographs of the failed towers.

12. Representatives from MPPTCL presented details of the failures in their transmission lines (copy of presentation attached) and the causes of failure of towers were discussed in detail and important highlights are summarized hereunder:

    i. It was informed that in the period from April 2019 to December 2021,five transmission lines of 400kV voltage level (in which 37 suspension towers and 6 tension towers) and six transmission lines of 220kV voltage level (in which 21 suspension towers and 2 tension towers) were affected.

    ii. Regarding the failures of 400kVMalwa-TPH-Pithampur transmission line, it was noted that the transmission line had failed four times in the period from April 2019 to December 2021. MPPTCL representative informed that the line was commissioned in 2013, however, the transmission towers were designed as per old standard IS 802:1977considering medium Wind zone. Committee noted that as these towers were designed as per old IS 802:1997, diaphragm bracing members are not present in the towers near the X bracings and as such oblique wind loads and narrow front wind loads are not considered in design of these towers. MPPTCL representative further highlighted that whirlwind kind of pattern is observed in particular patch of area of MP which lead to failure of multiple transmission lines in recent years. Committee noted the above and directed that whenever failure of transmission towers occurs, the failed towers shall be replaced by towers designed as per latest IS codes.

iii. MPPTCL representative informed that repetitive failure incidents have been observed in two of the transmission lines (400 kV Katni-Damoh transmission line & 400 kVMalwa-Pithampur transmission line) and MPPTCL had created a plan to strengthen the suspension towers of these transmission lines in a phased manner. Committee noted the above and suggested MPPTCL that in case multiple tower failures are observed in the other transmission lines, towers of those lines can also be considered for strengthening. Committee also suggested that as there is huge capital investment involved in the strengthening procedure, MPPTCL may consider a third party vetting of proposed design modifications which are to be adopted for strengthening of the transmission lines.

iv. Committee noted that as per the material test reports submitted by MPPTCL, the elongation percentage and yield strength of some of the failed tower members of some of the transmission lines (like, 400kV Malwa-TPH-Pithampur transmission line&220 kV Malanpur-Auraiya transmission line) were not as per IS standards which might have also contributed to failure of towers. MPPTCL was directed to increase the scrutiny of material testing to ensure good quality raw material is used in erection of transmission lines.

v. In the failure of the 400kV Rajgarh SSP transmission line MPPTCL representative informed that the transmission line failed during the period of effect of Vayu Cyclone which affected Gujarat and western parts of M.P. Committee requested MPPTCL to share the photographs of failed tower structures with the committee and the supporting documents suggesting high wind speed observed at the location due to the Vayu cyclone.

vi. In the failure of the 220kV Omkareshwar Barwaha tap Nimrani transmission line, it was highlighted that the line was failed due to the collapse of the 765kV Khandwa-Dhule of the M/s Khargone Transmission Corporation Limited.

vii. In the failure of 220kV Jabalpur Narsinghpur transmission line it was highlighted that the tower was erected to increase the height of the line due to crossing of NHAI road expansion work, but the newly erected tower failed within a week of erection. Committee noted that as the basic tower structure of failed tower is intact and only the body extension part had failed; there might be some deficiency in the erection of tower which had led to failure of tower structure.

viii. In the failure of the 220 kV Malanpur-Auriyaline& 220 kV Mehgaon-Adani line, it was observed that non-galvanized black towers had been used by MPPTCL for erection of the line. Further, some of the bolts were also found to be missing in the structures. Committee noted the above and highlighted that the strength of tower structures get compromised due to missing bolts and utilities shall be highly cautious to ensure that erection deficiencies are avoided in the tower structures. Further, the Committee decided that balck (un-galvanized) towers shall not be used by the utilities in the erection of future transmission lines.

ix. In case of failure of 220 kV Amarkantak SGTPS Birsinghpur/Panagar, Committee enquired about the details of previous failure of transmission line. Committee noted that the transmission towers have been designed considering old IS 802:1977. Committee noted that most of the transmission towers of MPPTCL which had failed are designed as per old IS 802:1977, in which the oblique wind load and narrow front wind load was not considered. As a precautionary measure, MPPTCL may review the design of these towerswith respect to latest code of IS 802:2015, Regulations and recommendations of the Standing Committee / Task Force, as applicable.

13. Representatives from UPPTCL presented the details of the failure of 765kV Lalitpur – Fatehabad transmission line (copy of presentation attached). Committee noted that POWERGRID had installed an anemometer on the Agra substation and requested thatthe wind speed data of the date of failure of lines of UPPTCL and; the details of maximum wind speed observed in a period of six months basis may be shared with the Committee for reference and analysis purpose. UPPTCL representative informed that IIT Kanpur had been requested to examine the root cause of failure of towers of these lines and IIT Kanpur had found in their analysis that twenty two (22) members of A type tower and sixteen (16) members of D type tower have slenderness ratio greater than unity and had recommended strengthening of these towers. Committee requested UPPTCL to share the tower failure report, colored photographs, material test reports so that the same can be included in the report of the Committee. UPPTCL was also requested to share the report of IIT Kanpur with the Committee for reference.

14. RVPNL representative presented the details of the failure of 765kV Anta-Phagi transmission line to the Committee (copy of presentation attached). She informed that the765 kV Anta-Phagi transmission line has been erected with delta configuration towers designed by Powergrid and in year 2015, Standing Committee of Experts had recommended for strengthening of suspension type delta configuration towers of this line in similar way as suggested for 765 kV Gaya-Fatehpur transmission line of Powergrid. RVPNL had consulted Powergrid and had adopted the same procedure as currently adopted by Powergrid for strengthening of delta configuration towers and at present, the strengthening process is under bidding stage. Committee noted the above and highlighted that Powergrid is adopting the strengthening procedure which has been verified by Powergrid by testing at the CPRI test bed and suggested RVPNL to ensure that the similar strengthening procedure is adopted by RVPNL to strengthen their towers. Committee noted that at some locations deficiencies like, unplugged holes, loose nut&

bolts, etc. were observed in the failed towers and suggested RVPNL to plan and conduct a Structural quality Audit of towers of this line at random basis. Committee further requested RVPNL to share the colored photographs, material test reports, copy of presentation and any other relevant document for inclusion in the report of Committee.

15. Committee deliberated on the likelihood of increase in the wind loads on the structures due to tunneling effect in the valley regions and the influence of topography of the location on the wind loads acting on the transmission towers. Representative from CPRI highlighted that topographical factor [of upto 30%] is included in the IEC 60826 for transmission lines located in mountains/complex topographical areas, however, at present the same is not considered in the design of transmission towers as per IS codes and this issue will be taken up in the next meeting of BIS.

16. Director (PSETD) stated that at present only two grades of steel (E250 & E350) are specified for tower structure and enquired whether the higher grade steels (such as E410) may also be allowed for transmission lines. Representative from M/s. Sterlite highlighted that his experience for usage of super high tensile steel, which was adopted around 20 years ago in design of one of the transmission lines, was not satisfactory. As carbon content of the steel increases, the strength of steel increases but the steel becomes brittle and elongation properties reduces which led to multiple failure of towers. Over the time, the developers of higher strength steel have developed and the same are also being used in Monopole structures, however, a cautious approach based on the detailed studies & tests of material properties is required to be adopted. Torrent Power representative added that the issue of modification of properties of super high tensile steel during the Hot dip galvanization process was observed earlier. The practices & precedence of usage of such steels in the overseas countries may be studied before adoption of such steels in transmission lines. Representative from CPRI added that with usage of super high strength steel can be tested and the associated advantages can be explored on pilot basis. Committee deliberated on the issue and noted that the nature of loads acting on transmission towers is different than the other structures and usage of higher grade of steel require further studies before adoption in the transmission sector and a cautious approach is required to be taken in this field.

17. Representatives from M/s Sterlite Power presented details of the failures in their transmission lines (copy of presentation attached). Regarding the failure of 765 kV D/C Khandwa pool-Dhule transmission line, Committee noted that failure of towers of this line of M/s Sterlite powerled to cascading failure of 400 kV Khandwa-Indore transmission line of Powergrid and 400 kV Malwa(TPH)-Pithampur & 220 kV Omkareshwar - Barwaha tap to Nimrani transmission lines of MPPTCL, which were passing below the 765 kV D/C Khandwa pool-Dhule transmission line. Representative of M/s Sterlite briefed about the damages observed at various tower locations and highlighted that some of the failed towers of 765 kV D/C Khandwa Pool- Dhule transmission line had collapsed towards right side of the center line of transmission line and some had failed towards its left indicating that a circular rotation of the movement of

wind was observed in the area at the time of tower failure incident.Committee noted that the 765 kV voltage level D type towers of M/s Sterlite, which are generally considered inherently strong towers as are designed with reliability level 2 and are used as anti-cascading towers, had failed in the wind event observed in the area however, no damage has been observed in the lines of Powergrid & MPPTCL which were also in the vicinity of the 765 kV D/C Khandwa Pool- Dhule transmission line. Committee further requested M/s. Sterlite to share the details of all the failure incidents including the color images of failed towers, material test reports, reports of test conducted on nuts& bolts, duly filled CEA format& preliminary investigation reports covering the details of failure and the presentation with the committee.

18. Representatives from DMTCL presented details of the failure of 400kV D/C Motihari-Gorakhpur transmission line and 400kV D/C Barh- Motihari transmission line (copy of presentation attached). He highlighted that around 0.5 kilometers of land from the bank of the river got washed away due to change in the course of Gandaki River. Two towers each of 400kV D/C Motihari- Gorakhpur transmission line and 400kV D/C Barh-Motihari transmission line failed due to change of the river course. He further briefed about the preventive & restoration measures adopted by DMTCL to avoid the failure of transmission line and informed that in addition to the collapsed towers, to take extra precaution in respect of change of course of river in future, six more towers had been shifted to the pile foundations as per the recommendations of the Committee, constituted by CEA, to study the failure. Committee deliberated on the issue and appreciated the efforts taken by DMTCL to avoid the failure of line in future. Further, DMTCL was requested to share the old soil testing report considered at the time of erection & commissioning of the transmission line for which they expressed their inability due to non-availability of old data with them as the line was transferred to them by the original owner. Committee noted that new water course was created due to high floods and transmission line failed due to change of the river course. Committee highlighted that adoption of Pile type foundation should be envisaged by the transmission utilities on the basis of river flow data of previous years& previous changes in the course of river observed in the region and, additional precautions like, routing of transmission lines few kilometers away from the river bank/ anticipated future river course, Providing proper revetment & use of geo-synthetic material in foundation, concrete encasing & painting of stub in water logging areas, etc. shall be adopted by utilities, wherever required.

19. Representatives from RSTCL presented the details of the failure of 765kV S/C Raichur-Sholapur transmission line (copy of presentation attached). Committee discussed the failure pattern observed in the case and noted that the chemical composition of some of the failed tower members was not as per IS codes. Due to higher percentage of Carbon, and Phosphorous observed in the samples, the material might have become prone to brittle fracture. Committee observed that the failure tower images shown by RSTCL are taken from a distance and does not clearly show the condition of stubs, legs and other tower members and further requested RSTCL to submit the colored photographs and any other relevant information for further analysis and inclusion in the report.

20. Committee noted that all the utilities should intimate the failures of transmission line timely and should provide all the relevant details/documents including images, duly filled CEA proforma, wind speed data, coordinates of failed towers, material test reports, etc. so that a proper investigation of cause of failure may be carried out. IMD and other agencies involved in metrological field may be requested to assist the affected utilities for obtaining the wind speed data of the failed tower locations.

21. After detailed deliberations / discussions among all participants, the Committee observed the various causes which attributed to failure of EHV towers and various suggestions emerged which shall be adopted to avert failure of towers. These will be incorporated appropriately in the Report of the Committee which shall be circulated to all the Committee members and Stake holders.

Meeting ended with the Vote of Thanks to the Chair.

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Annexure – I

S. No.	Name of the Transmission Line	Name of Utility	Date of Failure	No. of Towers Failed
1.	400kV D/C Khandwa- Indore 1 and 2 line	POWERGRID	16.04.2019	1
2.	400kV D/C Narendra- Devangere transmission line	POWERGRID	28.04.2019	10
3.	400 kV D/C Pandiabili – Duburi – Baritada transmission line	POWERGRID	03.05.2019	1
4.	400kV D/C Quad Nellore PS – Gooty transmission line	POWERGRID	27.05.2019	7
5.	400kV D/C Narendra- Devangere (Guttur) transmission line	POWERGRID	06.06.2019	7
6.	400kV D/C Quad Agra – Sikar transmission line	POWERGRID	12.06.2019	3
7.	400kV D/C Silchar – Meliriat transmission line	POWERGRID	19.07.2019	1
8.	400 kV D/C Kishanganj – Patna transmission line	POWERGRID	06.08.2019	1
9.	765 kV D/C Khandwa Pool- Dhule transmission line	M/s Sterlite Power	16.04.2019	5
10.	765kV S/C Jabalpur – Bina transmission line	M/s Sterlite Power	07.06.2019	5
11.	220 KV Bagalkot-Vajjramatti line	KPTCL	09.08.2019	1
12.	400 kV Malwa TPH (TPH)- Pithampur one transmission line	MPPTCL	16.04.2019	2
13.	220KV OmkareshwarBarwaha tap to Nimrani line	MPPTCL	16.04.2019	1
14.	400 kV DCDS Malwa TPH (SSTPH)- Pithampur Circuit I & II transmission line	MPPTCL	02.06.2019	24
15.	400 KV Rajgarh- sardarsarovar DCDS line	MPPTCL	11.06.2019	5
16.	220 kV DCDS Jabalpur-Narsinghpur transmission line	MPPTCL	13.06.2019	1
17.	765 kV D/C Raicursholapur transmission line	M/s RSTCL	03.06.2019	6
18.	400kV D/C Motihari- Gorakhpur	DMTCL	15.08.2019	1
			25.09.2019	1
19.	400kV D/C Barh- Motihari transmission lines	DMTCL	04.09.2019	1
			07.10.2019	1
20.	765 KV New Ranchi-Dharamjaygarh LINE-I	POWERGRID	21.04.2020	3
21.	400KV D/c Vindhyachal-Jabalpur Ckt 1&2 Line	POWERGRID	30.04.2020	4

22.	765KV S/C VARANASI-FATEHPUR	POWERGRID	10.05.2020	4
23.	765KV Sasan- Satna - I	POWERGRID	28.05.2020	1
24.	765KV Sasan- Satna - II	POWERGRID	28.05.2020	1
25.	400kV Quad Agra Sikartransmsison line	POWERGRID	29.05.2020	4
26.	220KV S/C ANTA-RAPP transmission line	POWERGRID	03.07.2020	1
27.	400 KV Dulhasti- Kishenpur II & III	POWERGRID	10.09.2020	2
28.	400 KV PurneaGokarna&400 KV PurneaFarakka	POWERGRID	11.09.2020	1
29.	765KV Anta-PhagiCkt-II line	RRVPNL	04.05.2020	2
30.	765 kV Fatehabad–LalitpurCkt-I transmission line	UPPTCL	03.05.2020	2
31.	765 kV Fatehabad–LalitpurCkt-I transmission line	UPPTCL	03.05.2020& 28.05.2020	8
32.	220 KV Malanpur-Auriya line & 220 KV Mehgaon-Adanickt	MPPTCL	28.05.2020	11
33.	220KV Malanpur-MorenaCkt I&II	MPPTCL	29.05.2020	3
34.	220 KV Malanpur-POWERGRIDckt I&II	MPPTCL	29.05.2020	5
35.	400 kV S/C Malwa TPH Pithampur Transmission line of MPPTCL	MPPTCL	26.03.2020	7
36.	220KV Shahapur/Shahabad to Kapnoor transmission line	KPTCL	17.04.2020	2
37.	765 KV Bina-Gwalior-3 transmission line	POWERGRID	05.01.2021	1
38.	765 KV Jhatikara-Bhiwani Transmission Line	POWERGRID	06.05.2021	1
39.	±800 KV HVDC Agra-BNC Transmission Line	POWERGRID	10.05.2021	1
40.	400 KV Raipur-Korba Transmission line	POWERGRID	11.05.2021	1
41.	765 KV Wardha-Aurangabad Transmission line	POWERGRID	27.05.2021	5
42.	400 KV Korba-Bhilai-1 Transmission Line	POWERGRID	30.05.2021	1
43.	765 KV Meerut-Moga Transmission Line	POWERGRID	10.06.2021	3
44.	765 KV Moga-Bhiwani Transmission Line	POWERGRID	12.06.2021	3
45.	400 KV D/C (Quad)Kaithal-Baghpat transmission line	POWERGRID	08.07.2021	4
46.	400 KV Kishenpur-New Wangpoh 3&4 Transmission Line	POWERGRID	23.10.2021	1
47.	400 KV D/C Malwa TPH (SSTPH)-PithampurCkt I&II line	MPPTCL	29.05.2021	5
48.	220 KV Amarkantak-Panagar/SGTPS Birsinghpur	MPPTCL	21.09.2021	2

Annexure – II

List of Participants

Central Electricity Authority:

1. Shri Ashok Kumar Thakur, Chief Engineer, PSE&TD Division
2. Shri Y.K. Swarnkar, Director, PSE&TD Division
3. ShriBhanwar Singh Meena, Deputy Director, PSE&TD Division
4. ShriMohitMudgal, Deputy Director, PSE&TD Division
5. Shri Deepak Singh Raghuvanshi, Deputy Director, TCD Division
6. ShriAkshayDubey, Deputy Director, PSE&TD Division
7. Shri Karan Sareen. Assistant Director, PSE&TD Division
8. ShriApoorvGoyal, Assistant Director, PSE&TD Division

Southern Regional Power Committee:

1. Shri J. B. Len, Executive Engineer

CSIR- SERC:

2. Dr. Napa Prasad Rao

Central Power Research Institute (CPRI):

1. Dr. Selvaraj. Joint Director
2. Shri Vijay Kumar

Indian Meteorological Department (IMD)

1. Shri S. C. Bhan

POWERGRID:

1. ShriSurendra Kumar, Senior General Manger (Engg-TL)
2. Shri G.K. Gupta, Senior Deputy General Manager
3. ShriNitesh Kumar Sinha, Deputy General Manager (Engg-TL)
4. ShriManoj Kumar Singh, General Manager (Asset Management)

Madhya Pradesh Power Transmission Corporation Limited:

1. ShriAvinash Vajpayee, Director (Technical)

2. Shri N.P. Gupta, Chief Engineer

Uttar Pradesh Power Transmission Corporation Limited:

1. ShriPankajBalia, Director (Operations)
2. ShriR.N. Yadav, Chief Engineer, TSW
3. ShriBinod Kumar Bhasker, Executive Engineer

Karnataka Power Transmission Corporation Limited:

1. ShriRamesh Pavey, Executive Engineer
2. ShriSrinivasan Murthy, Assistant Executive Engineer

Rajasthan VidhyutPrasaran Nigam Limited:

1. Shri K. K. Meena, Chief Engineer
2. Smt. Mamta Mehta

Darbhanga-Motihari Transmission Corporation Limited

1. ShriNeeraj Kumar Verma
2. ShriVijayanandSemletty

Raichur-Sholapur Transmission Corporation Limited

1. ShriBirendra Kumar Singh

M/s. Sterlite Power:

1. ShriDeepak Lakhpati,

M/s. Torrent Power:

1. ShriBipin B Shah, Vice President

M/s.Sekura Energy Limited:

1. ShriNimish Seth, Chief Operating Officer

KEC International Limited:

1. Shri E.V. Rao
2. Shri Ravi Ratna Patel, General Manager

STANDING COMMITTEE OF EXPERTS ON FAILURE OF EHV TRANSMISSION LINE TOWERS

Standing Committee of experts in the field of design & operation of EHV Transmission line (from CEA, POWERGRID & research/academic institutes) constituted by Central Electricity Authority in 1999 as per old Electricity (Supply) Act No. 54 of 1948, continues to carry out investigation of failure of transmission line towers of Power utilities as per the Section 73(1) of Electricity Act 2003.

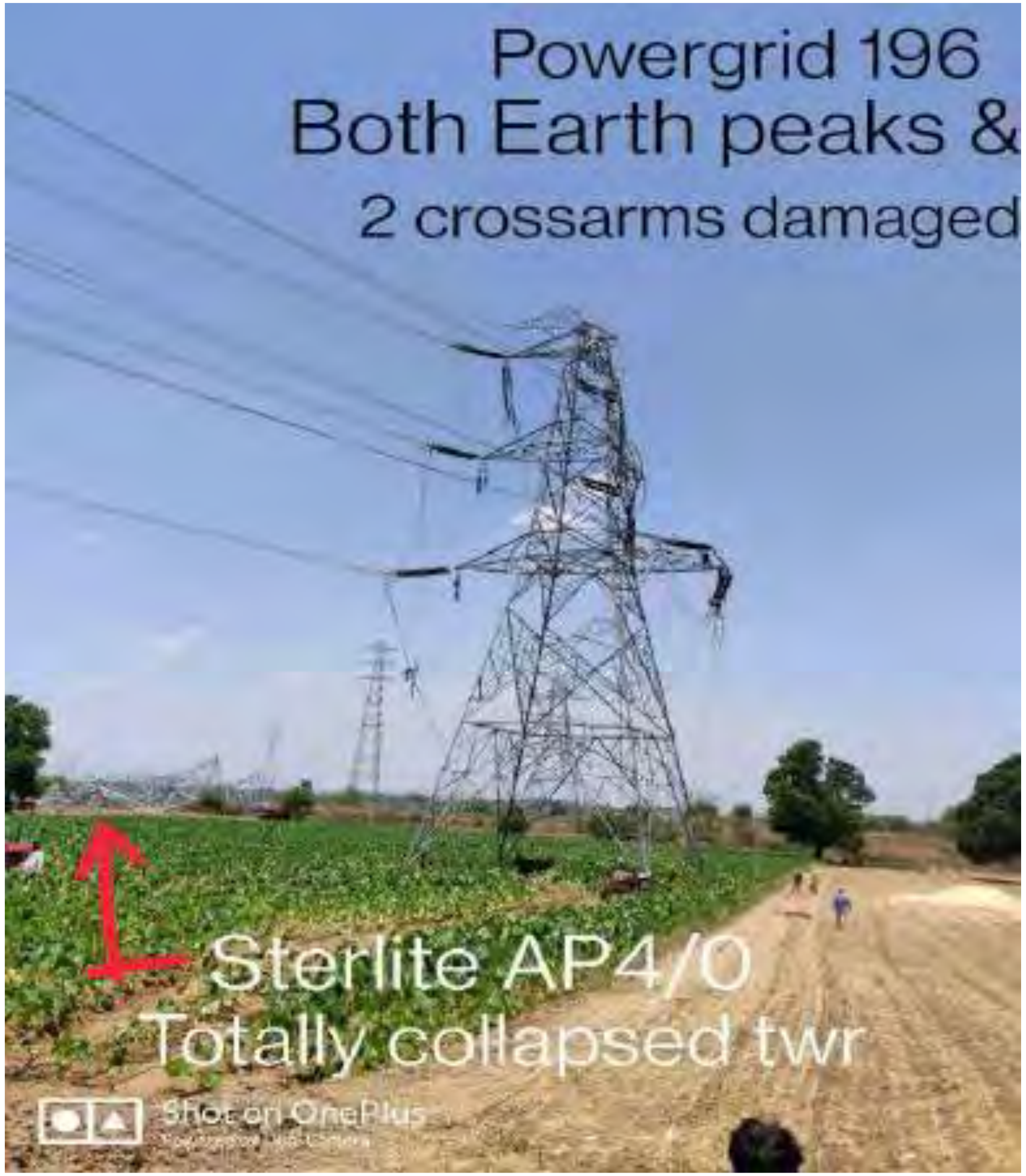
Details of Transmission line towers failed / damaged during the period from April, 2019 to March, 2021 (Reported to CEA)

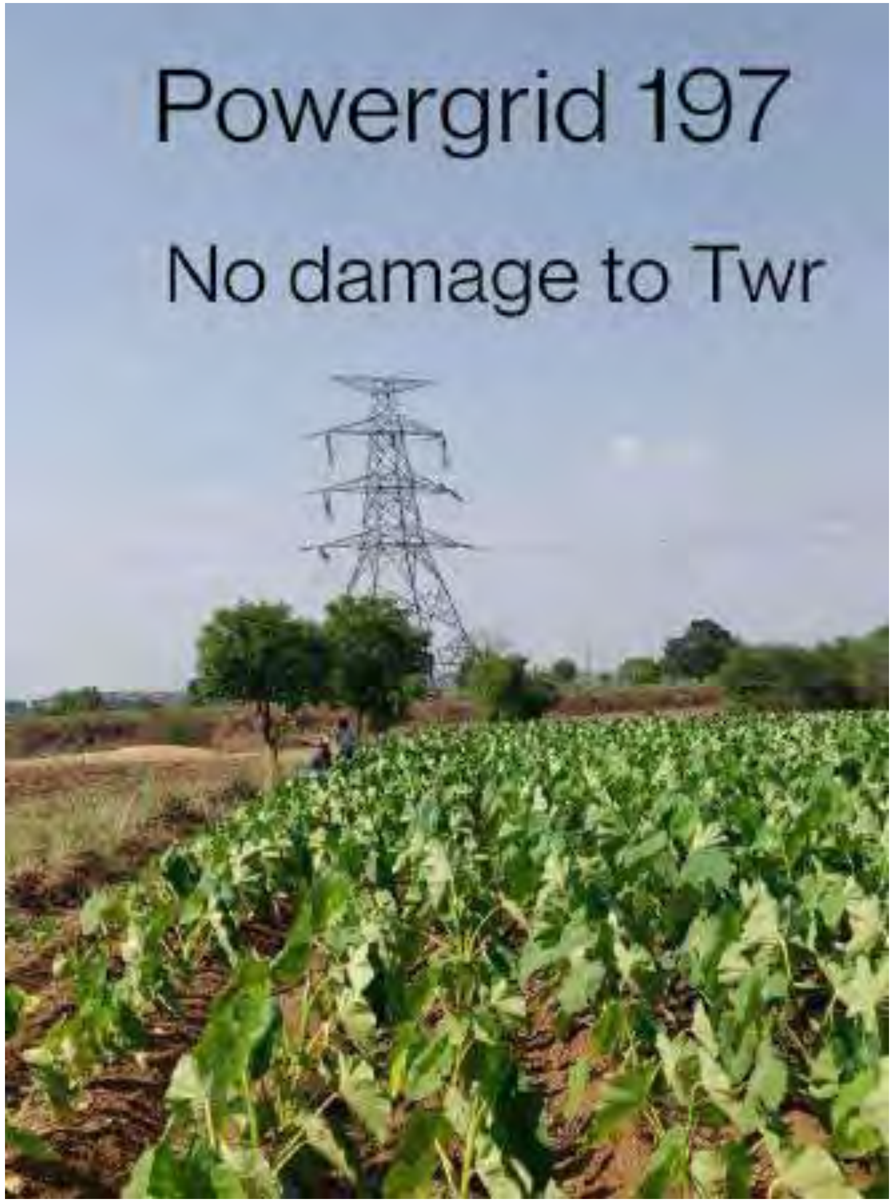
Voltage Level	Utility	No. of Affected Lines	Suspension Towers	Tension Towers	No. of Towers Affected
800 kV (HVDC)	POWERGRID	1	1	0	1
765 kV	POWERGRID	9	17	5	22
	UPPTCL	2	-	-	10
	RRVPNL	1	1	1	2
	RSTCL	1	5	1	6
	Sterllite	2	10	0	10
400 kV	POWERGRID	16	40	9	49
	MPPTCL	5*	37	6	43
	DMTCL	2	2	2	4
220 kV	POWERGRID	1	1	0	1
	MPPTCL	6	21	2	23
	KPTCL	2	0	3	3
Total		**48**	**135**	**29**	**174**

*400 kV Malwa TPH (SSTPH)- Pithampur Circuit I & II transmission line of MPPTCL failed four times.

400kV D/C Khandwa-Indore Transmission Line of POWERGRID

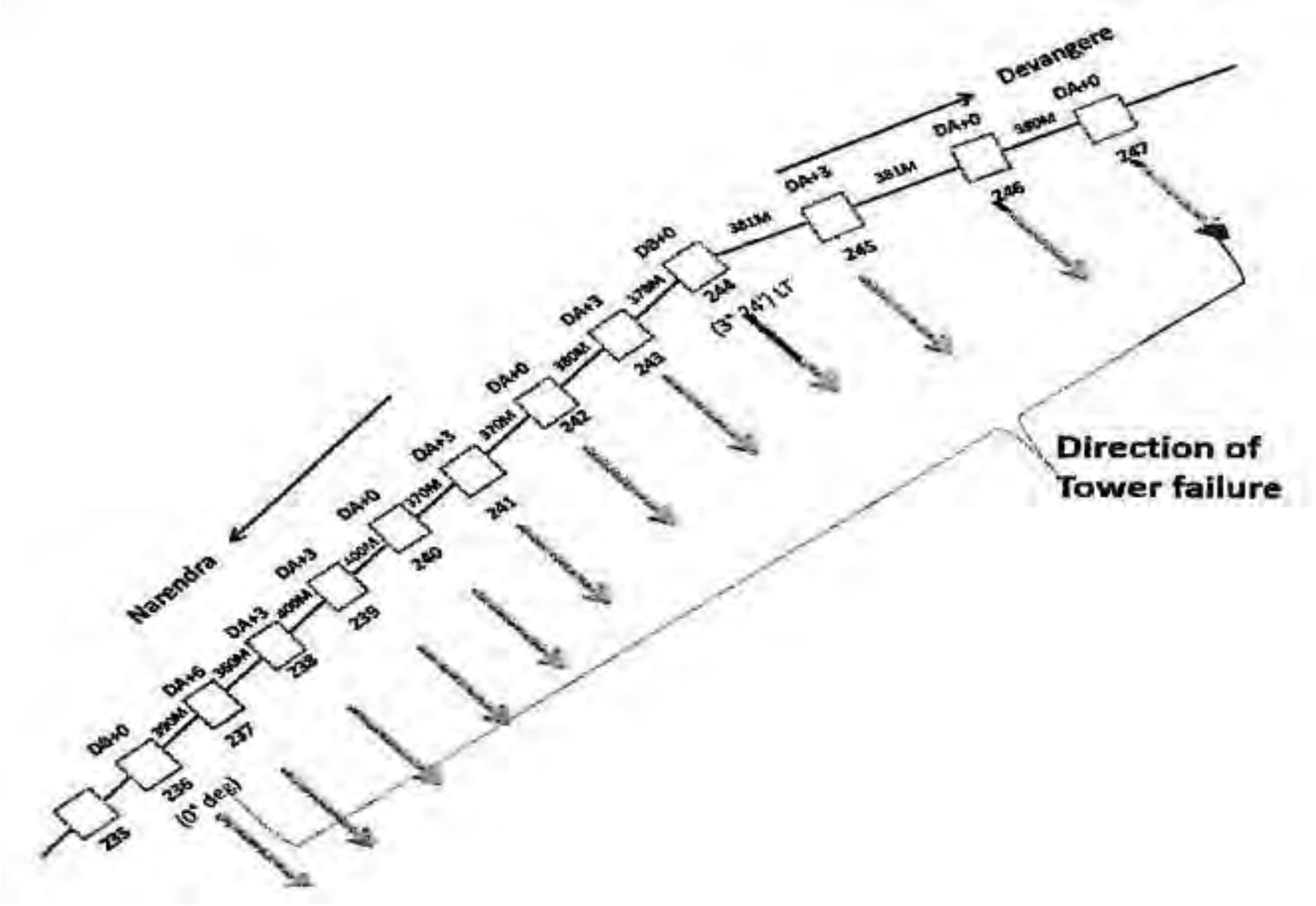
Date of Failure/ Commissioning		16.04.2019/July 2016
No. of Towers failed	**Tension tower**	1
	Suspension tower	0
	Total	1
Observations		• Tower Configuration :- Vertical • Conductor Type :-Twin ACSR Moose • Insulator type :-“I” Suspension insulator string
		• **Reason Given by Utility :-** The crossing Towers AP4/0 and AP5/0 of **765 KV D/C Hexa Khandwa-Dhule line of M/s Sterlite had collapsed** and conductor of that Hexa D/C line had fallen over POWERGRID’s existing 400KV D/C Khandwa-Indore Line over the conductor span between tower 196-197 . This has resulted into damage of Tower 196(DD+0), insulators and conductor in the span (196-197).


Powergrid 196
Both Earth peaks &
2 crossarms damaged
Sterlite AP4/0
Totally collapsed twr
Shot on OnePlus

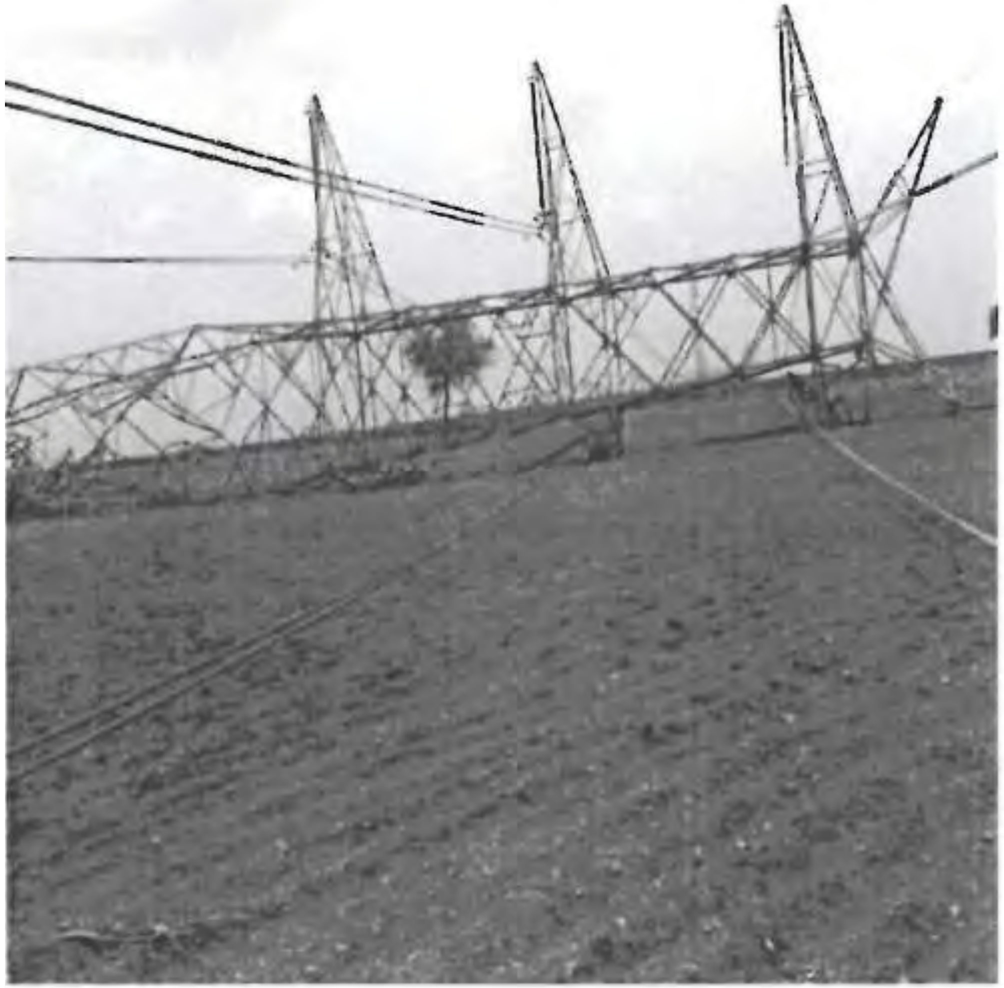

Powergrid 197
No damage to Twr

400 kV D/C NARENDRA- DAWANGERE TRANSMISSION LINE OF POWERGRID

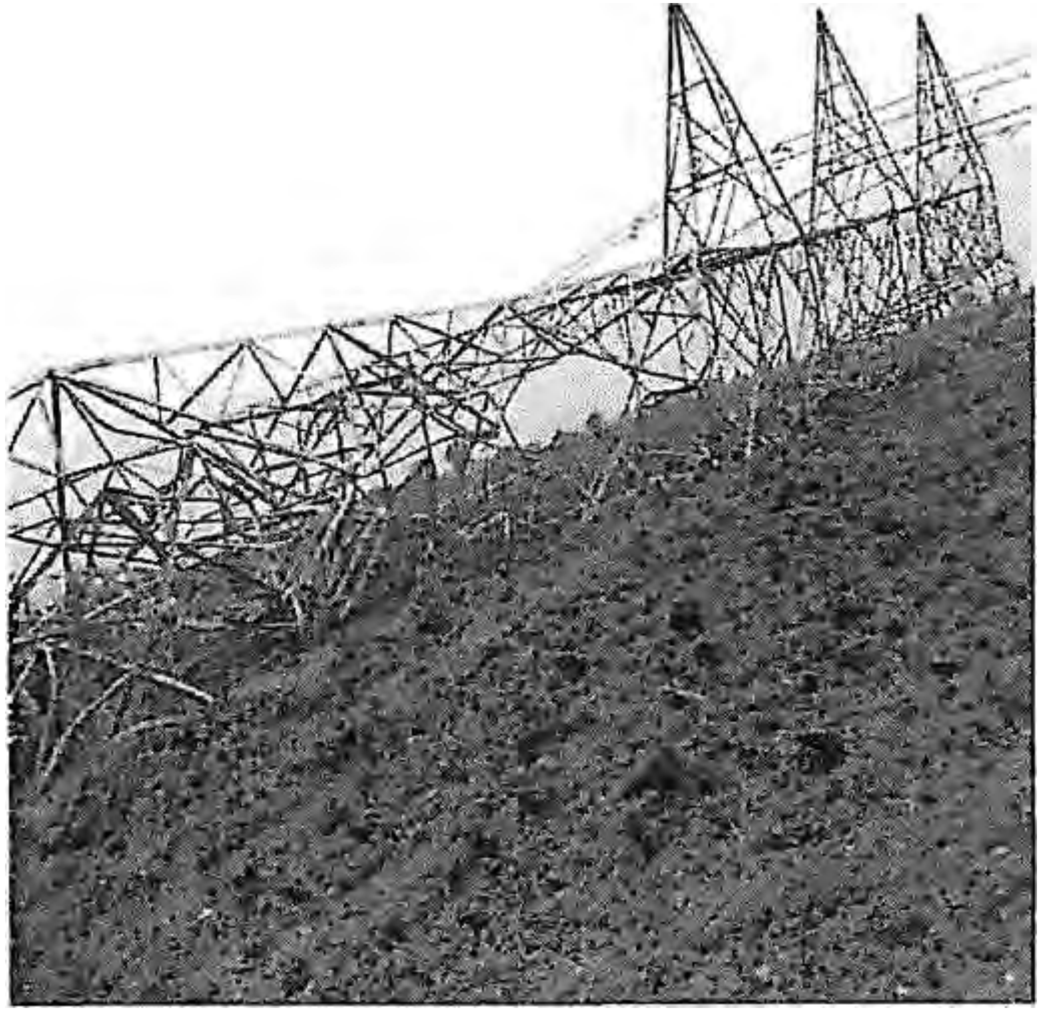
Date of Failure/ Commissioning		28.04.2019 /Feb 2008
No. of Towers failed	Tension tower	1
	Suspension tower	9
	Total	10
Observations		• Vertical configuration, Conductor Type :- Twin Moose ACSR • Line designed as per IS:802 1995, Wind Zone-1 • All the ten towers have fallen in the perpendicular direction to the transmission line. • **The suspension towers are designed for wind zone-1 and tension towers are designed for wind zone-2** • The towers from tower locations 237 to 246 have collapsed completely to the ground. There is no failure of foundation. • Material test Results are within limit.
		Reason Given by Utility :- All the ten towers are collapsed due to high speed localized thunderstorm/ windstorm in this area which has resulted in the large wind load on phase conductors and earth wire as well as on the tower body itself beyond the design values.


Devangere
Narendra
Direction of
Tower failure
235
236
237
238
239
240
241
242
243
244
245
246
247

Loc. No. **237**



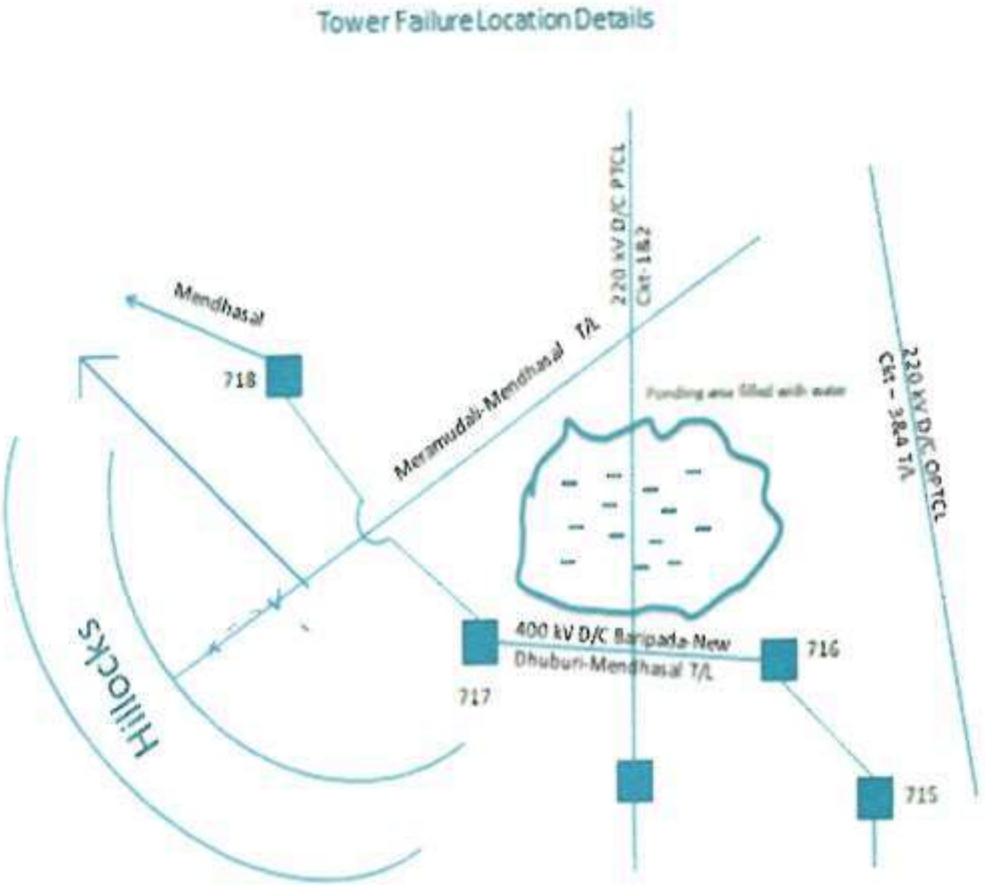
Loc. No. **239 DA+3’**



Loc. No. **240’DA+0’**

400 kV D/C BARIPADA-DUBURI-PANDIABILI Transmission line of POWERGRID

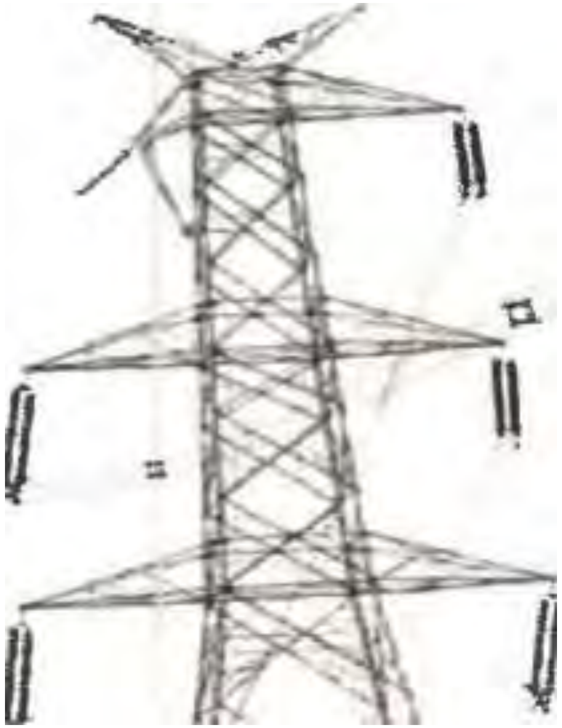
Date of Failure/ Commissioning		03.05.2019/01.09.2011
No. of Towers failed	**Tension tower**	1
	Suspension tower	0
	Total	1
Observations		• Tower at location no. 717 **(DD+25+4m RC)** failed completely to ground in transverse direction.. • Conductor Type :- ACSR Twin Moose • The tower at location no. 717 collapsed completely on the ground in the transverse direction. • Tower designed for wind zone -V (50 m/s), IS 802-1995
		Reason Given by Utility :- Due to the cyclone 'FANI', speed of the winds were more than 200 Km/hr which initiated the tower failure.



Loc. No. **717 (DD+25+4m RC)**

400 kV D/C QUAD GOOTY-NELLORE PS TRANSMISSION LINE OF POWERGRID

Date of Failure/ Commissioning		27.05.2019/Apr. 2013
No. of Towers failed	**Tension tower**	0
	Suspension tower	7
	Total	7
Observations		• Tower Configuration :- Vertical • Conductor Type :- Quad Moose ACSR • All six towers collapsed in the direction perpendicular to the transmission line. • Line designed as per IS:802 1995, Wind Zone-2 • Towers at location no. 547 to 552 were collapsed, • At location no. 546 --top cross arm got damaged.
		Reason Given by Utility :- All towers were collapsed due to the high speed localized thunderstorm in this area.



Location no. 546

Location no. 547

Location no. 548 (DA+0)

Location no. 549 (DA+0)

Location no. 550

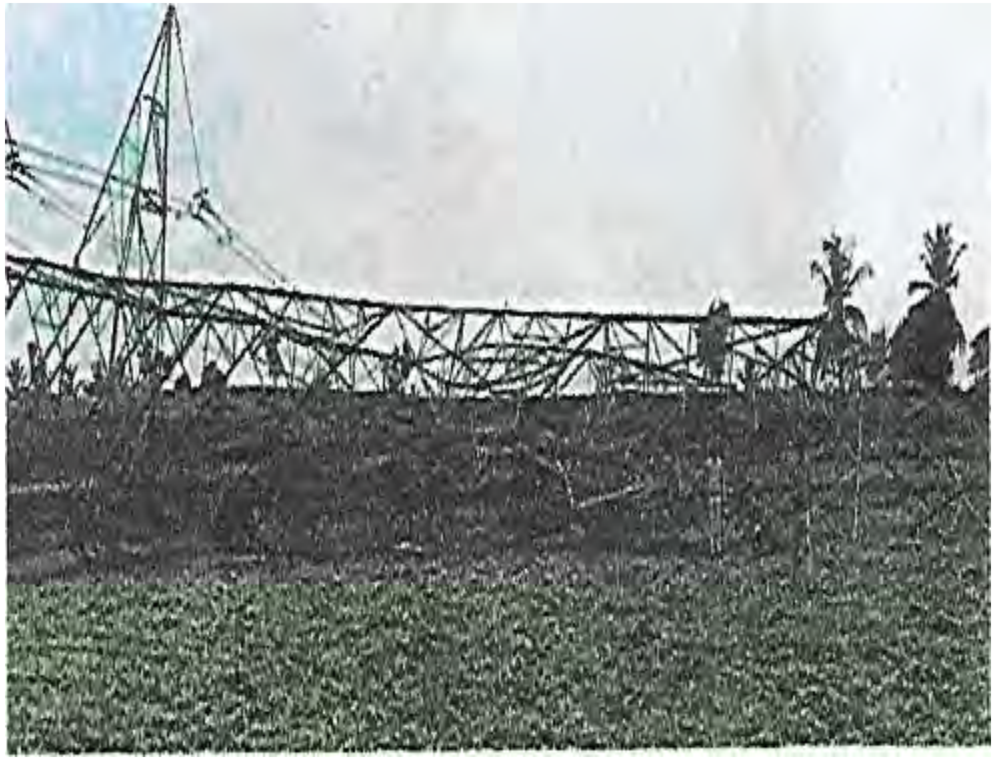
Location no. 552

400 kV D/C NARENDRA-DAVANGERE(GUTTUR) Transmission line of POWERGRID

Date of Failure/ Commissioning		06.06.2019/Feb 2008
No. of Towers failed	Tension tower	1
	Suspension tower	6
	Total	7
Observations		• Ten towers of the same transmission line had collapsed on 28.04.2019. • Tower Configuration :-vertical • Conductor Type :- Twin Moose ACSR Conductor • 5 numbers of towers (4 no. A type & 1 no. B type) starting from Loc — 361 to loc - 365 had collapsed during localized windstorm • EW peak of 360 & 366 damaged • there is no failure of foundation • minor damage to some foundation chimneys observed due to falling impact loading. In some of the locations, stub was also found to be damaged • Tower designed for wind zone -1(33 m/s) ; IS 802-1995
		Reason Given by Utility :- High speed localized windstorm/ thunderstorm

Location 361

Location 364

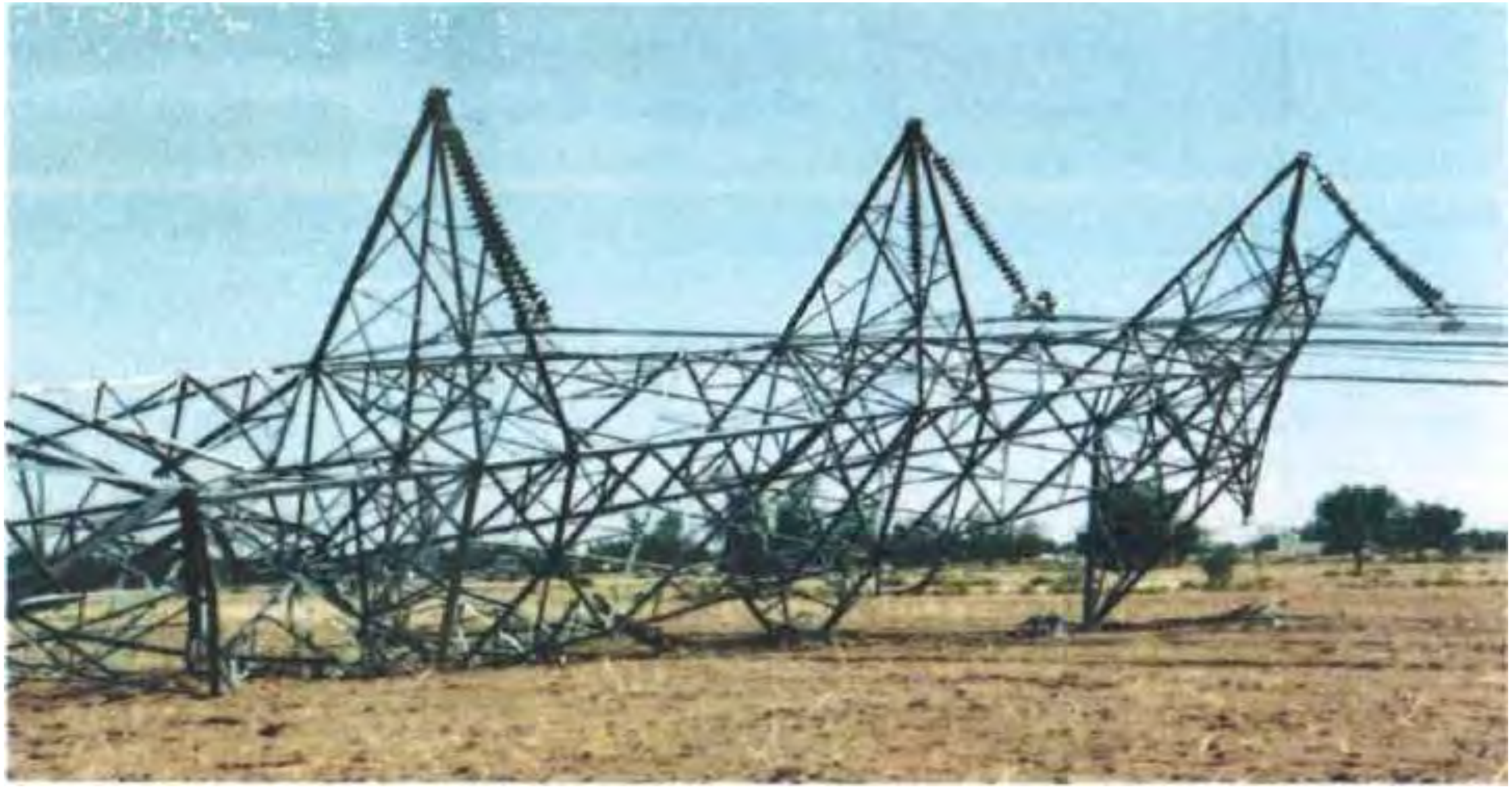


400 kV D/C Quad AGRA-SIKAR Ckt I & II Transmission line of POWERGRID

<table>
<tr><th colspan="2">Date of Failure/ Commissioning</th><th>12.06.2019/17.10.2013</th></tr>
<tr><td rowspan="3">No. of Towers failed</td><td>Tension tower</td><td>1</td></tr>
<tr><td>Suspension tower</td><td>2</td></tr>
<tr><td>Total</td><td>3</td></tr>
<tr><td colspan="2">Observations</td><td>• Tower Configuration :-Vertical configuration
• Conductor Type :-Quad Moose ACSR Conductor.
• The towers at locations no. 339 to 341 have collapsed completely to the ground.
• Wind Zone 4(47 m/s);
• Line is designed as per IS 802-1995</td></tr>
<tr><td colspan="2"></td><td>Reason Given by Utility :- All towers were collapsed due to the high intensity localised windstorm in this area.</td></tr>
</table>

Location no-339

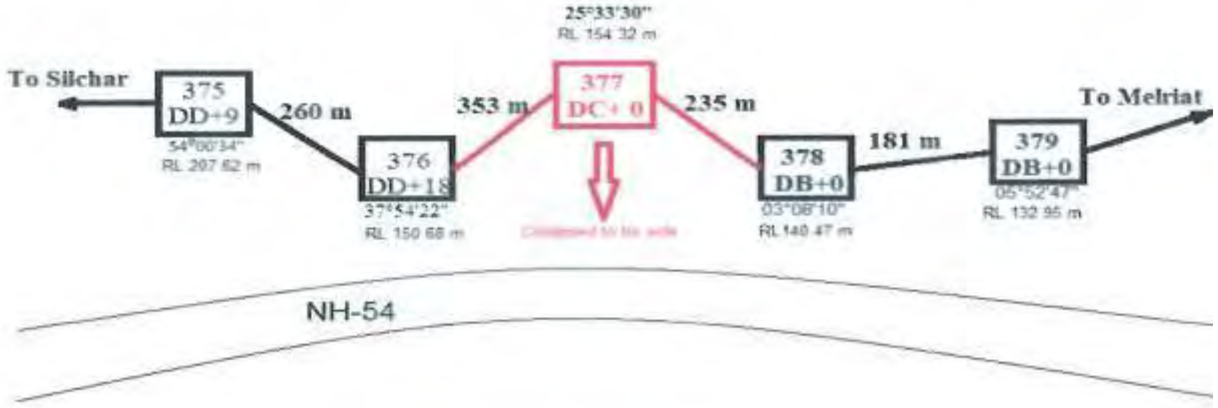
Location no. 340



Location no. 341

400kV D/C SILCHAR - MELRIAT TRANSMISSION LINE OF POWERGRID

Date of Failure/ Commissioning		19.07.2019/Dec 2018
No. of Towers failed	**Tension tower**	1
	Suspension tower	0
	Total	1
Observations		• Tower Configuration :- Vertical • Conductor Type :-Twin ACSR Moose • The Tower Location No. 377 fully collapsed laterally due to displacement of landmass suddenly during landslide. • The foundation of the Leg-A fell on the fault line of the separation and completely collapsed. • The tower had a deviation of $25^{0}33'30''$ towards right. • Wind Zone 6
		Reason Given by Utility :- The tower at this location collapsed due to the displacement of landmass during landslide.



Collapsed tower no. 377 due to landslide

Destroyed NH-54 due to landslide (below tower location 377

400 kV D/C Kishanganj – Patna Transmission Line Of POWERGRID

Date of Failure/ Commissioning		06.08.2019/29.03.2016
No. of Towers failed	**Tension tower**	1
	Suspension tower	0
	Total	1
Observations		• Tower Configuration :- Vertical • One of the main leg (Leg-D) was in the main river course and some members of the tower were deformed due to the differential settlement of pile foundation under Leg-A and Leg-D. • Wind Zone-4 • Tower with Pile foundation no. 409/0 (DD+25) • HFL had not crossed the design value, still the pile had failed. • Reports of pile foundation testing is awaited.
		Reason Given by Utility :- At the time of construction, tower at location no. 409 was on the right bank of the Koshi river. The pile foundation of the tower got failed due to change in river course towards right bank during recent heavy flood in the river Koshi resulting in bank erosion upto tower location.

Tilt in tower legs causing bending of members


765kV D/C Khandwa Pool-Dhule Transmission Line of M/s. Sterlite Power

<table>
<tr><th colspan="2">Date of Failure/ Commissioning</th><th>16.04.2019/ under construction</th></tr>
<tr><td rowspan="3">No. of Towers failed</td><td>Tension tower</td><td>0</td></tr>
<tr><td>Suspension tower</td><td>5</td></tr>
<tr><td>Total</td><td>5</td></tr>
<tr><td colspan="2">Observations</td><td>• Details were requested from Sterlite Power vide letter dated 23.04.2019.
• M/s Sterlite vide letter dated 27.04.2019 submitted the following
    • As the transmission line is under construction, the Investigation of failure is being done at their end.</td></tr>
<tr><td colspan="2"></td><td>Reason Given by Utility :- due to strong wind and heavy rainfall.</td></tr>
</table>


Sterlite AP4/0
totally collapsed tower


Sterlite collepsed towers
AP5/0
AP4/0

765kV S/C Jabalpur – Bina Transmission Line Of M/s. Sterlite Power

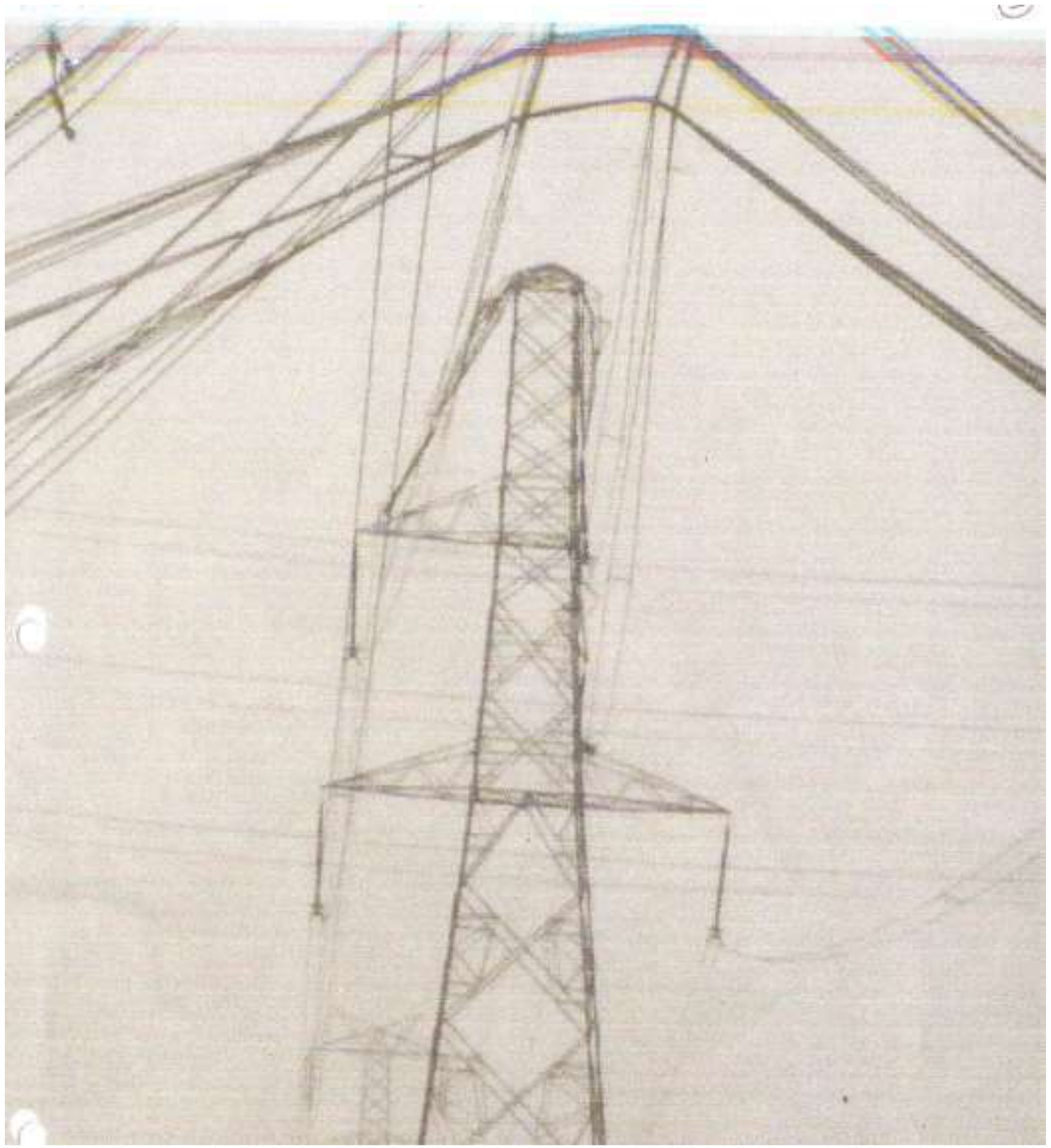
Date of Failure/ Commissioning		27.05.2019/June 2015
No. of Towers failed	**Tension tower**	0
	Suspension tower	5
	Total	5
Observations		• Tower Configuration :- Vertical • Conductor Type :- ACSR Bersimis conductor • Towers at Location no. 17/9(SA+3), 17/10(SA+3), 17/11(SA+0), 17/12(SA+9) collapsed & 17/8(SA+0) partially damaged • Wind zone-2 • Line designed as per IS 802: 1995 • Tower Coordinates provided with Failure intimation report were forwarded to IMD for inputs on wind speed. No inputs received from IMD.
		Reason Given by Utility :- High wind conditions

220 kV Bagalkot Vajjramatti Transmission Line Of KPTCL

Date of Failure/ Commissioning		09.08.2019/01.05.2001
No. of Towers failed	Tension tower	1
	Suspension tower	0
	Total	1
Observations		• Conductor Type :- Drake ACSR • Insulator type :- Tension insulator string • One river crossing tower collapsed at location 319 (DB+6) • Foundation was alright but stubs were bend at the bottom portion of the tower due to which tower collapsed.
		Reason Given by Utility :- Due to flash floods in Gathaprabha river on 8th and 9th August 2019, the tower locations from 318 to 326 of 220kV Bagalkot-Vajjarmatti line were submerged. Consequently, tower at location 319 (DB+6) collapsed.

400kV Malwa TPH-Pithampur DCDS Transmission Line of MPPTCL

Date of Failure/ Commissioning		16.04.2019/17.10.2013
No. of Towers failed	**Tension tower**	0
	Suspension tower	2
	Total	2
Observations		• Conductor Type :- Twin Moose ACSR • Insulator type :- “I” Suspension insulator string • 2 no. of tower partially damaged at the location No. 216 (FD0) and 217 (FD0) • Tower located in Wind Zone 2 • Line designed as per old IS 802 :1977
		Reason Given by Utility :- On 16.04.2019, five towers of **765kV Khandwa-Dhule line of M/s Khrgone transmission Corporation Ltd.** collapsed, due to which conductor of this line fall on the crossing position of 400kV TPH-Pithampur DCDS line of MPPTCL which partially damaged the crossing location towers (216(FD0) & 217(FD0)).



Tower at location 217

220 kV Omkareshwar Barwaha tap to Nirmani DCDS TRANSMISSION LINE OF MPPTCL

<table>
<tr><th colspan="2">Date of Failure/ Commissioning</th><th>16.04.2019/19.02.1982</th></tr>
<tr><td rowspan="3">No. of Towers failed</td><td>Tension tower</td><td>0</td></tr>
<tr><td>Suspension tower</td><td>1</td></tr>
<tr><td>Total</td><td>1</td></tr>
<tr><td colspan="2">Observations</td><td>• Conductor Type :- Zebra ACSR
• Insulator type :- “I” Suspension insulator string.
• Designed as per old IS 802 : 1977
• One tower partially damaged at location no. 22(A0)
• Located in Wind Zone 2.</td></tr>
<tr><td colspan="2"></td><td>Reason Given by Utility :- On 16.04.2019, five towers of 765kV Khandwa-Dhule line of M/s Khrgone transmission Corporation Ltd. collapsed, due to which conductor of this line fall on the crossing position of 220kV Omkareshwar Barwaha tap to Nirmani DCDS line of MPPTCL which partially damaged the crossing location towers (22(A0)).</td></tr>
</table>

220 kV OMK-Barwaha
220 kV OMK-Barwaha Tap Nimrani LOC-NO. 22 (A0)

Tower at location 22

400 kV DCDS Malwa TPH (SSTPH)- Pithampur Circuit I & II TRANSMISSION LINE OF MPPTCL

Date of Failure/ Commissioning		02.06.2019/17.10.2013
No. of Towers failed	**Tension tower**	4
	Suspension tower	20
	Total	24
Observations		• Tower Configuration :- Vertical • Conductor Type :- Twin Moose ACSR Conductor. • 24 numbers of towers of 400 kV DCDS Malwa TPH (SSTPH)- Pithampur Circuit I & II were collapsed. • 20 nos. suspension tower at location no. 126 to 131, 133 to 137, 139, 160 to 167, and 4 nos. tension tower 132, 138, 159 and 168 are partially damaged. • Wind Zone 2- medium • Coordinates of failed tower locations sent to IMD for wind data. No inputs received. • Line is designed as per **IS 802-1977 (commissioned in 2013)** • As per the test report attached, some of the failed **tower members failed to conform** to desired specifications/values of the Tensile strength, yield stress and elongation parameters. • Wind data provided by Tehsildar– after two hours of tripping– **3km/min.**
		Reason Given by Utility :- All towers were collapsed due to the high windstorm in this area.

Tower at Location 126

Tower at Location 127

Tower at Location 128

Tower at Location 129

Tower at Location 130

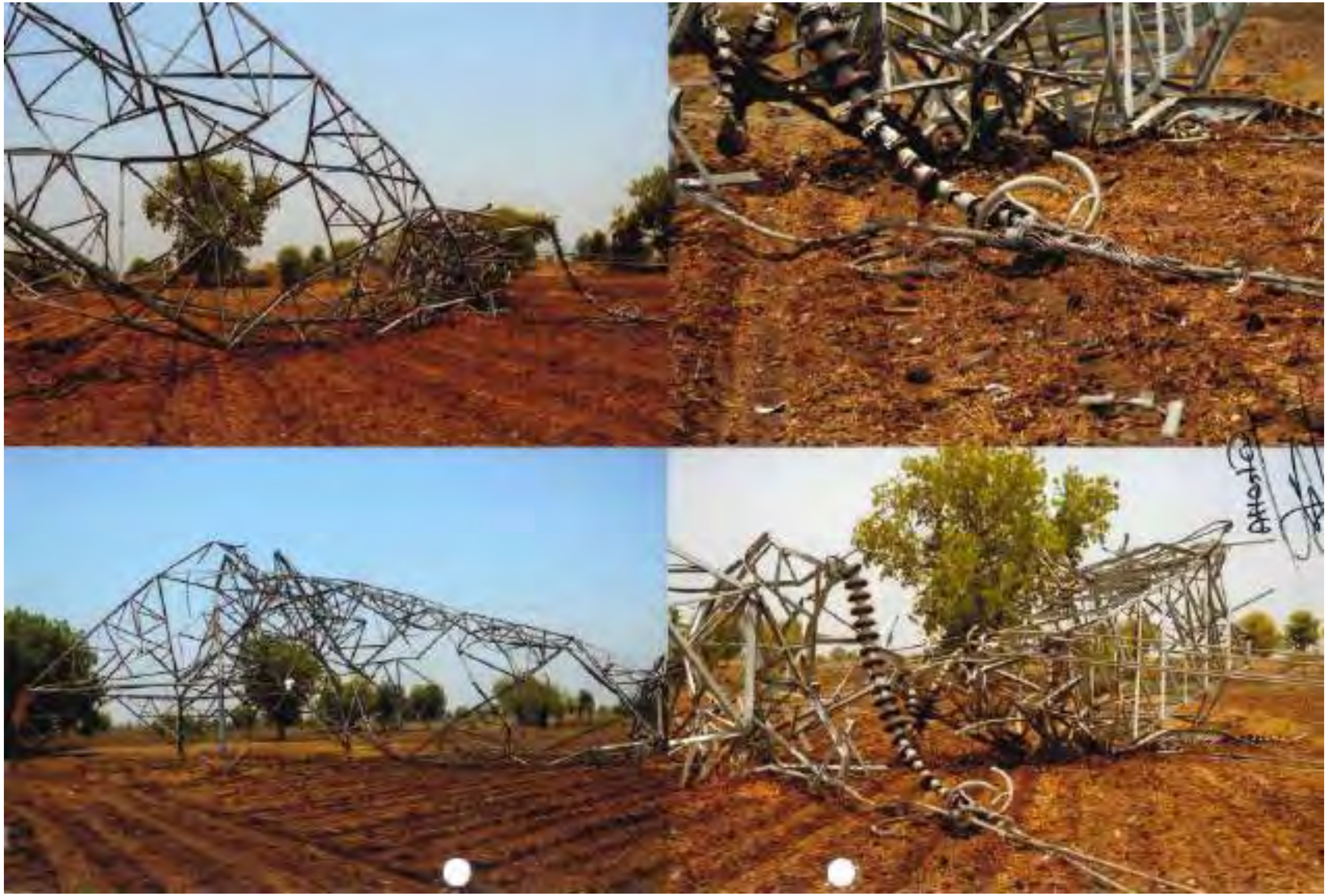
Tower at Location 131

Tower at Location 132

Tower at Location 133

Tower at Location 134

Tower at Location 135



Tower at Location 136

Tower at Location 137

Tower at Location 138

Tower at Location 139

Tower at Location 159

Tower at Location 160

Tower at Location 161

Tower at Location 162

Tower at Location 163

Tower at Location 164

Tower at Location 165

Tower at Location 166

Tower at Location 167

Tower at Location 168

400 kV DCDS Rajgarh-SSP TRANSMISSION LINE OF MPPTCL

Date of Failure/ Commissioning		11.06.2019/2002
No. of Towers failed	**Tension tower**	1
	Suspension tower	4
	Total	5
Observations		• Conductor Type :- Twin Moose ACSR • Insulator type :- I insulator string • Two suspension towers at location no. 565(FDO+6) & 564(FDO) are collapsed and three towers at location no. 566(FD30+10), 563(FDO+6) & 562(FDO+O) are partially damaged. • Wind Zone- medium • As per the test report attached, **one of the failed tower members failed to conform** to desired specifications/values of the Tensile strength, yield stress and elongation parameters. • **Line designed as per IS:802 1977 though commissioned in 2002**
		Reason Given by Utility :- Heavy Wind Storm

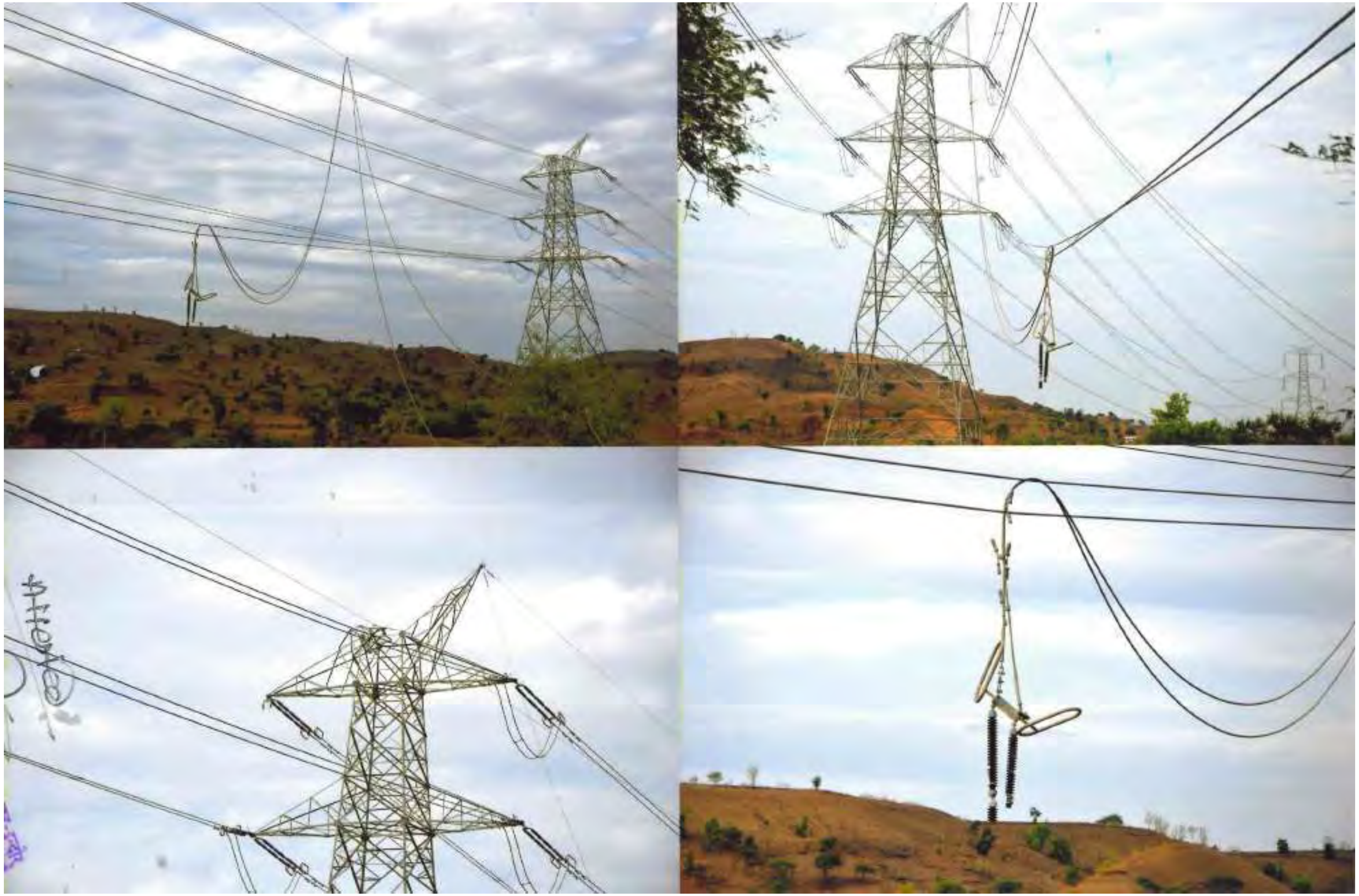
Tower at location 562

Tower at location 563

Tower at location 564

Tower at location 565

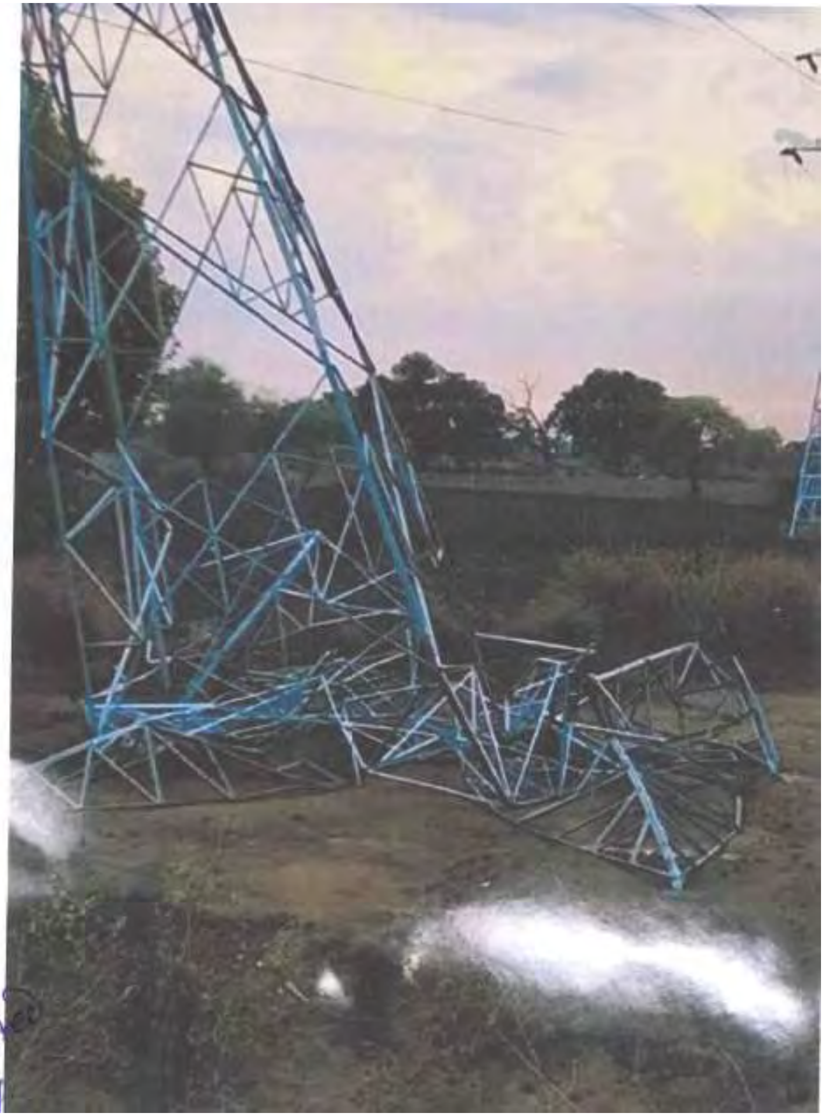
Tower at location 566



220kv Jabalpur-Narsinghpur DCDS Transmission line of MPPTCL

Date of Failure/ Commissioning		13.06.2019/07.06.2019 (line was commissioned in year 1962)
No. of Towers failed	**Tension tower**	0
	Suspension tower	1
	Total	1
Observations		• Conductor Type :- Zebra ACSR Conductor • 1 no. tower between location no. 11 and 12 (B0+10 m) is collapsed. • **Collapsed Tower was erected in 2019 for crossing of NHA1 between location no. 11 & 12.** • Tower collapsed by bending all 4 stubs with +10 m extension portion completely & 5 mtr lower portion of the tower super structure collapsed. • Line was designed for medium wind zone; IS: 802-1977. • Design details of new tower are awaited.
		Reason Given by Utility :- Heavy wind and thunderstorm

Tower at location 11A



attested

765kV S/C Raichur-Solapur Transmission Line Of RSTCL

Date of Failure/ Commissioning		03.06.2019/July 2014
No. of Towers failed	Tension tower	1
	Suspension tower	5
	Total	6
Observations		• Conductor Type :- Quad ACSR Bersimis • Insulator type :- "I" Suspension insulator string (Polymer type) • 5 suspension & one B type tower failed. • Cracks in chimney top of foundation observed after failure. • Wind Zone 2
		Reason Given by Utility :- due to thunder storm and whirlwind

400kV D/C Motihari-Gorakhpur TRANSMISSION LINE OF DMTCL

Date of Failure/ Commissioning		15.08.2019 & 25.09.2019 /2017
No. of Towers failed	**Tension tower**	1
	Suspension tower	1
	Total	2
Observations		• Conductor Type :- Quad AAAC Moose • Insulator type :- Tension type string at location no. 27/0 and I type string at location no. 26/5 • Line designed as per IS:802 1995, Wind Zone-4 • One tower at location no. 27/0 (DD+0) (Pile type foundation) collapsed on 15.08.2019 and other tower at location no. 26/5 (Suspension type) collapsed on 25.09.2019
		Reason Given by Utility :- Due to subsequent change in course of Gandak river which results in erosion of river banks in short span by strong river current. This caused collapse of tower at location no. 27/0. Subsequently, there was heavy rains in the region and the washing of the river bank still continued which results in washing away of tower foundation of tower at location no. 26/5 and resulting in collapse of tower.

Tower Loc. 27/0(DD+0)
submerged in river water

Tower Loc. 26/5(DA+0)
submerged in river water

400kV D/C Barh-Motihari TRANSMISSION LINE OF DMTCL

Date of Failure/ Commissioning		04.09.2019 & 07.10.2019/ 2017
No. of Towers failed	**Tension tower**	1
	Suspension tower	1
	Total	2
Observations		• One tower at location no. 26/0 (Tension type) collapsed on 04.09.2019 and other tower at location no. 25/5 (Suspension type) collapsed on 07.10.2019 • Conductor Type :- Quad AAAC Moose • Insulator type :- Tension type string at location no. 26/0 and I type string at location no. 25/5 • The tower at location 26/0 and 25/5 was initially located on land and nearest water stream was around 600m and 1000m away respectively. • Short piles of 2 meters depth were provided to develop additional uplift resistance force and to improve the factor of safety. • Line designed as per IS:802 1995, Wind Zone-4
		Reason Given by Utility :- Due to sudden change in course of river, the tower at location no. 26/0 and 25/5 experienced very high current and continuous change in discharge rate of water from Valmiki dam causing drastic change in water levels causes rapid cutting of one river bank and washing away of tower foundation which results in collapse of tower. Conductor along with other line material on both side of tower also got damaged.

Tower Loc. 27/0(DD+0) submerged in river water

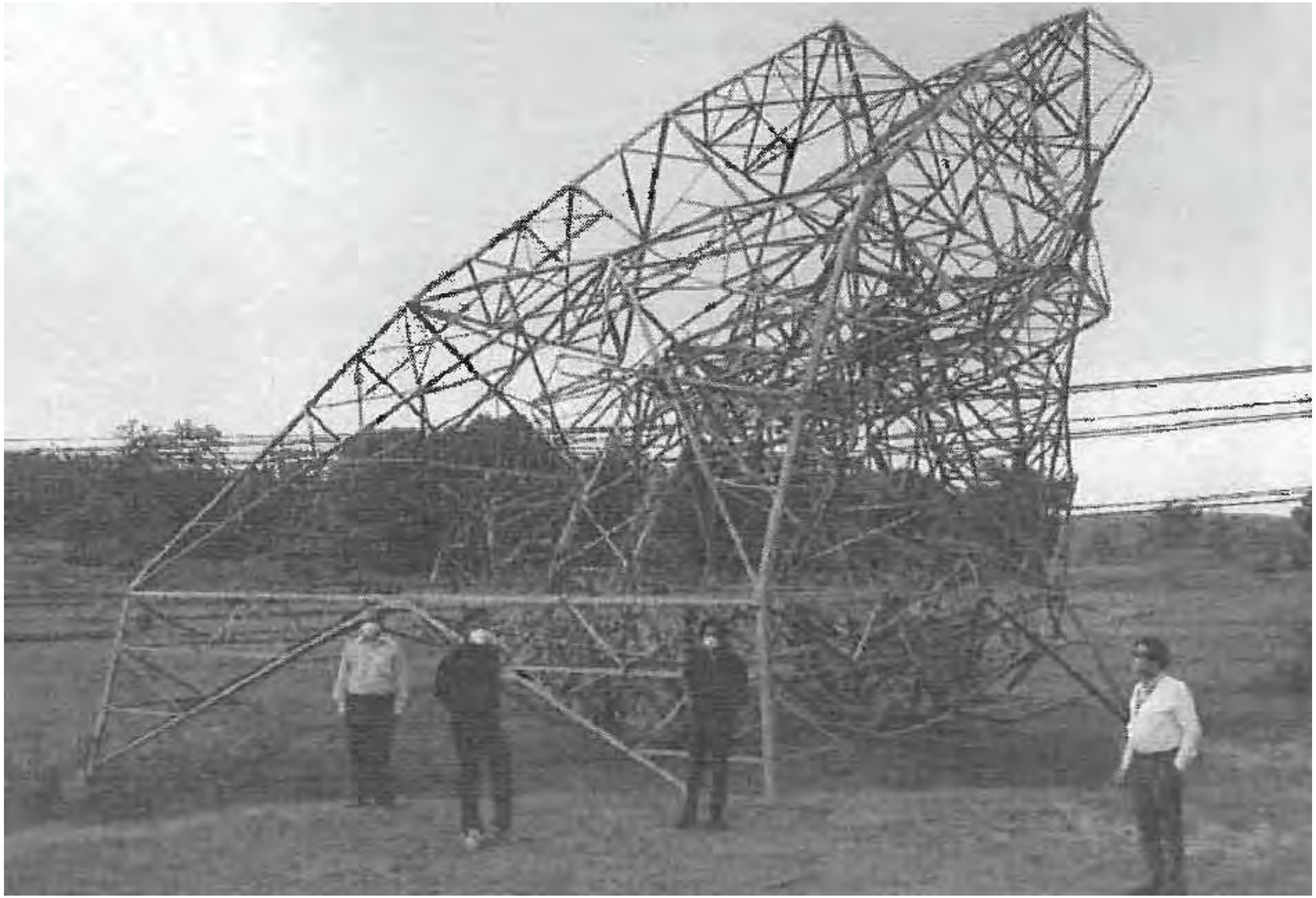
Tower 26/0 before failure

Tower 26/0 after failure

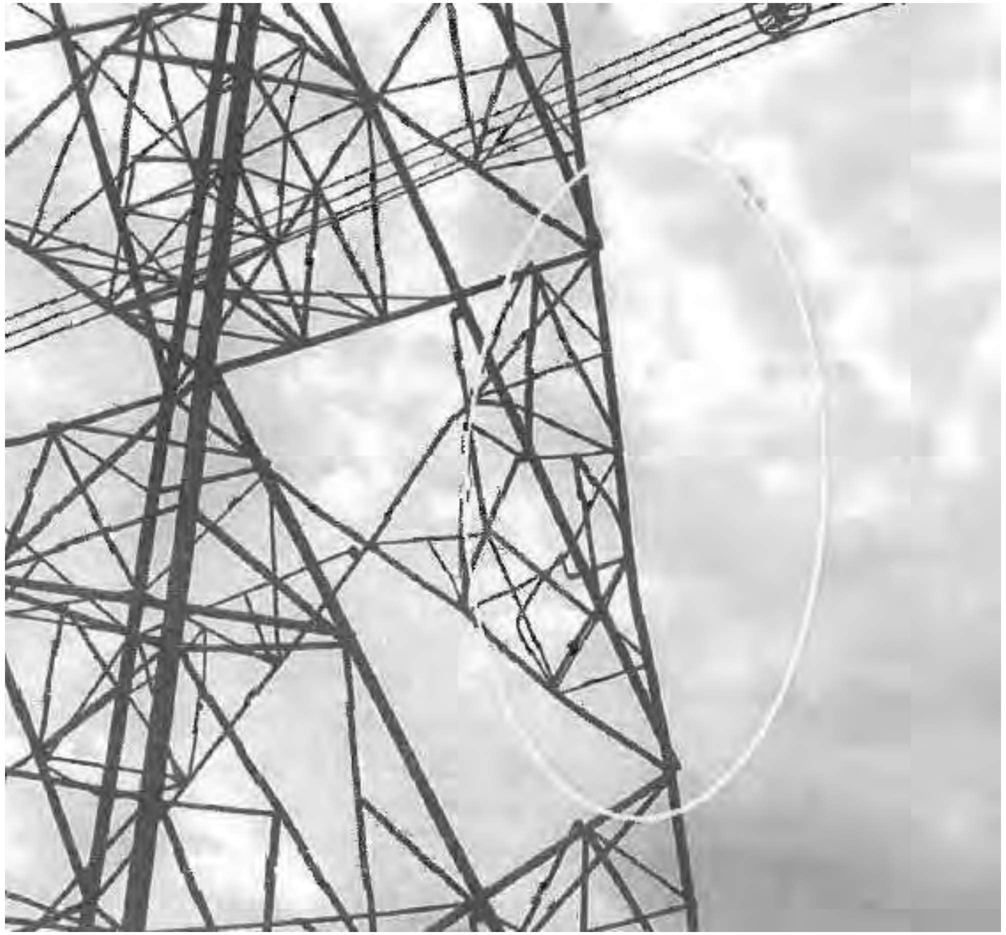
765 KV S/C RANCHI- DHARAMJAYGARH -I TRANSMISSION LINE OF POWERGRID

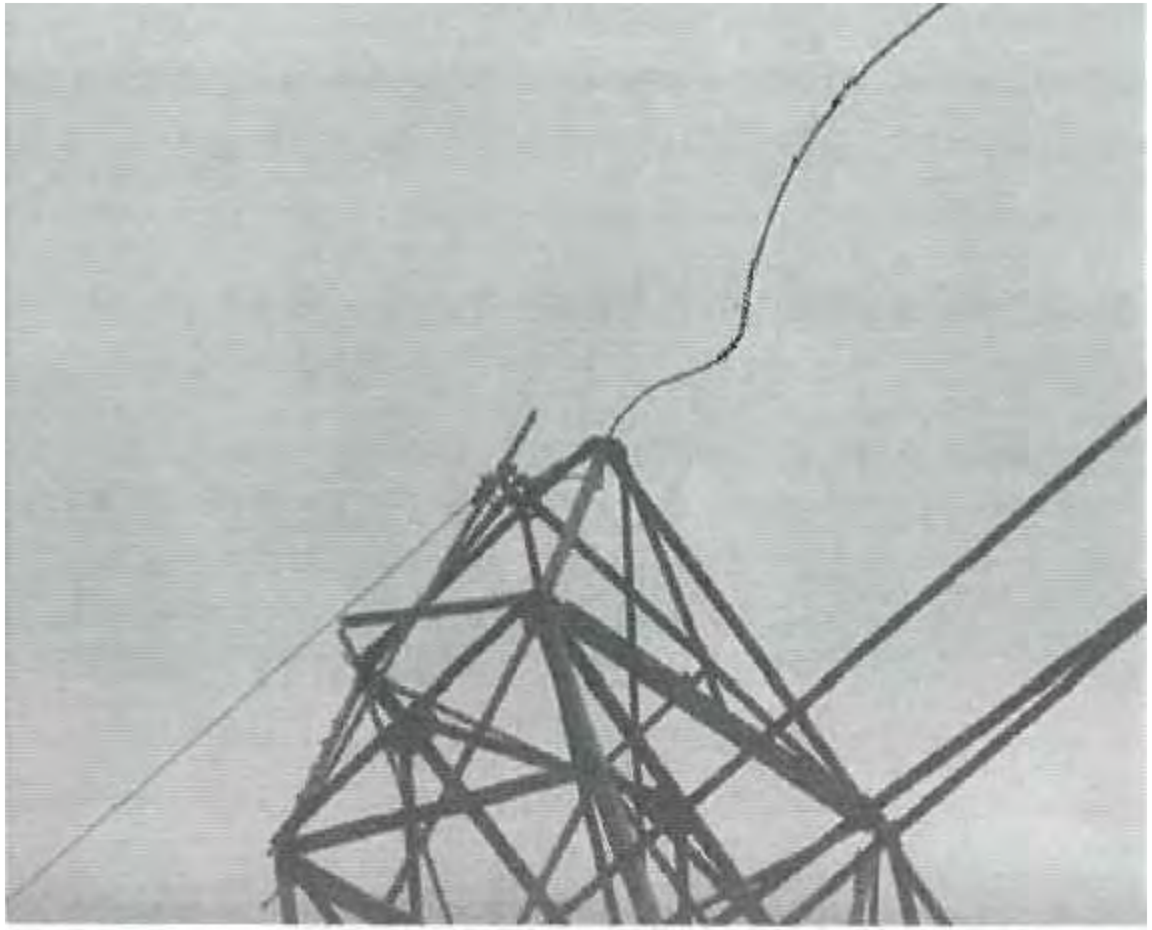
Date of Failure/ Commissioning		21.04.2020/31.03.2014
No. of Towers failed	**Tension tower**	0
	Suspension tower	3
	Total	3
Observations		• Line is designed as per IS 802:1995 • Wind Zone-2 • Horizontal Configuration • Quad ACSR Bermisis Conductor • One tower at Loc. no. 92 (A+3) has collapsed completely • Partial damage to peak / cross arms of towers at loc. nos. 91 (A+0) and 90 (A+3). • Material test reports found to be in order.
		Reason Given by Utility :- High intensity whirlwind

Tower at location 92 (A+3)



Tower at location 90 and 91





Bent Main leg of Loc. 91 (A+0)

400 KV Vindhyachal-Jabalpur-I&II TRANSMISSION LINE OF POWERGRID

Date of Failure/ Commissioning		30.04.2020/07.11.1989
No. of Towers failed	Tension tower	0
	Suspension tower	4
	Total	4

Observations		• The tower used in this line is were designed and supplied by Russia (Erstwhile USSR)
		• Vertical Configuration
		• Twin ACKC Conductor
		• Four suspension towers at location no. 948,949,950 (all DA+0) and 951 (DA+6) collapsed
		• The line is having glass insulators in single suspension I string configuration.
		• Wind speed submitted by utility– approx. 120 kmph.
		• Last patrolling reported to be done on 17.01.2020
		• Previous failure of line was in 2009. Three suspension towers collapsed.
		• **Material Test report-**
		  • **Three members (Member 4, 8 & 9) failed in ultimate stress test.**
		  • **Two members (member 3 & 6) had silica content more than prescribed limit.**

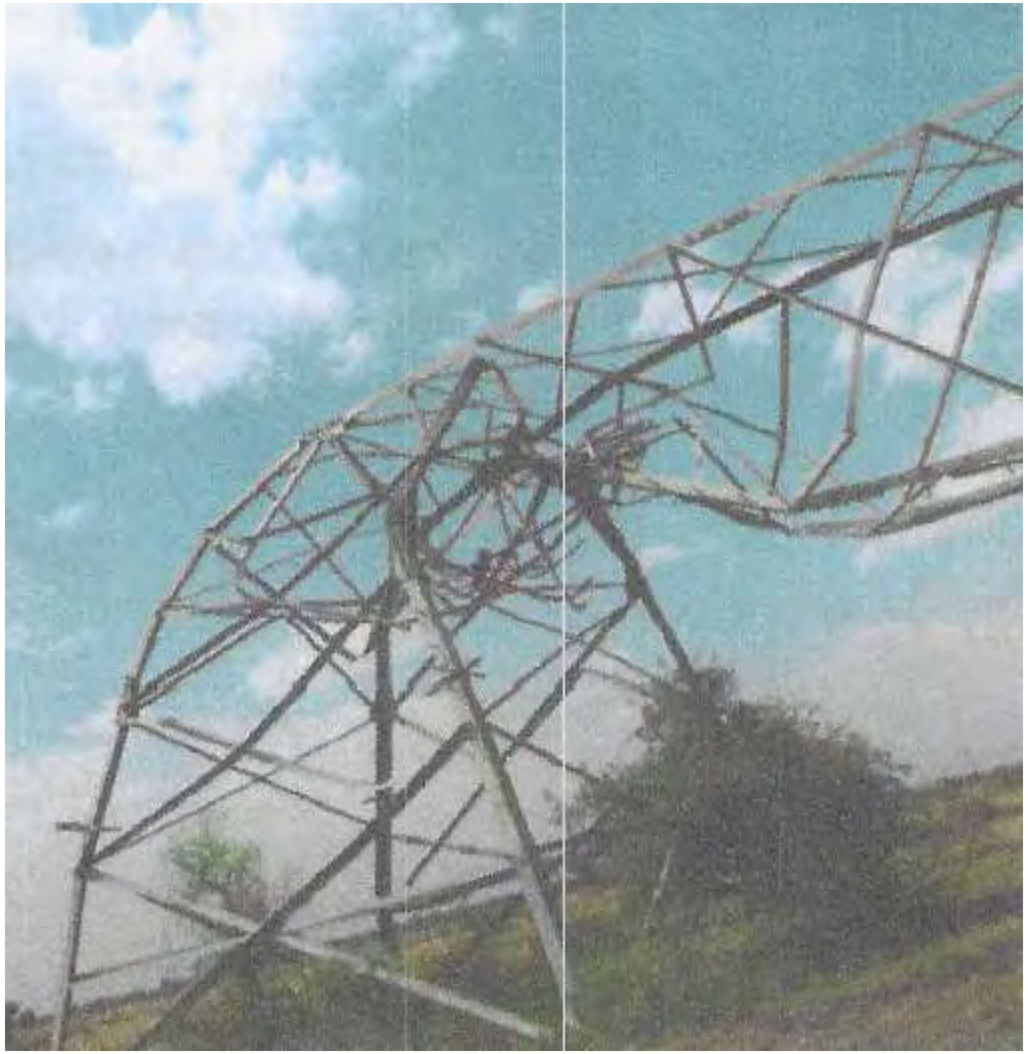
		Reason Given by Utility :- High speed windstorm

Sl. No.	Sample Code	Tower Location No.	Member No.	Angle Section Size (mm)	Size of Specimen Avg., Width (mm)	Avg., Thick (mm)	Area (sqmm)	Org., G.L (mm)	Yield Load (kN)	Ult. Load (kN)	Yield Stress (MPa)	Ult. Stress (MPa)	Final GL (mm)	Elongation (%)
1	S0087 (1)	948	363	100x100x7	26.24	6.99	183.52	75.86	63.16	85.93	344	468	102.68	35.35
2	S0087 (2)	948	352	70x70x6	26.00	6.30	163.80	72.04	47.36	68.47	289	418	97.52	35.37
3	S0087 (3)	949	314	180x180x11	28.14	11.10	312.35	99.56	114.80	149.84	368	480	132.26	32.84
4	S0087 (4)	949	326	70x70x6	25.96	6.18	160.43	71.12	47.10	63.49	294	396	98.02	37.82
5	S0087 (5)	949	157	70x70x6	26.08	6.26	163.26	71.78	46.35	67.22	284	412	91.10	26.92
6	S0087 (6)	950	314	180x180x11	28.12	11.82	332.38	103.08	117.19	155.47	353	468	138.62	34.48
7	S0087 (7)	950	363	100x100x7	26.12	7.06	184.41	76.82	63.19	81.46	343	442	104.32	35.80
8	S0087 (8)	950	326	70x70x6	26.04	6.22	161.97	72.26	46.65	64.86	288	400	96.96	34.18
9	S0087 (9)	951	367	56x56x5	25.88	5.82	150.62	69.82	43.74	57.69	290	383	90.22	29.22
10	S0087 (10)	951	157	70x70x6	25.98	6.36	165.23	72.02	54.42	77.32	329	468	94.46	31.16

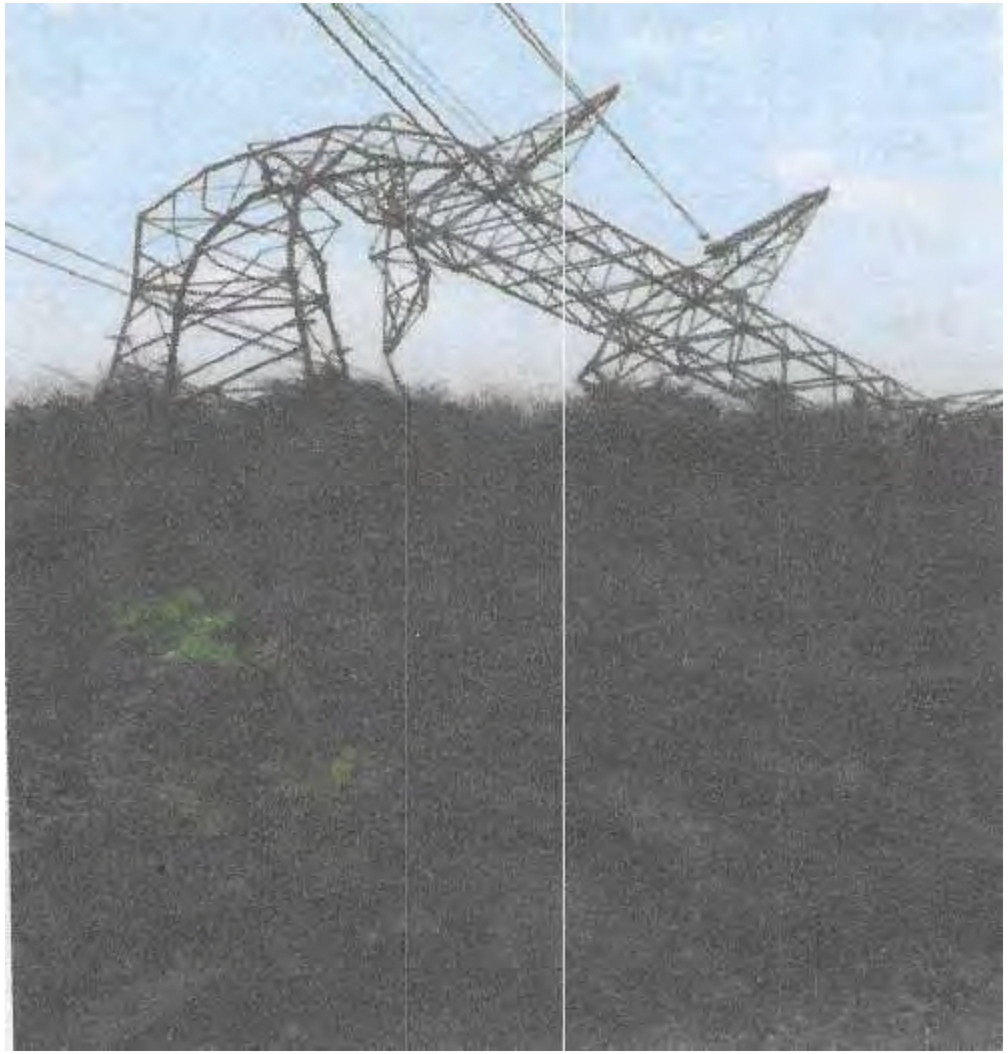
No.	Sample ID	Chemical composition (% by weight)				
		C	Si	Mn	P	S
1	MTDMWTL20/S-015 MEDTTL20S0088 (1) Sec Size: 100x100x7mm LOC/Member: 948/363	0.12	0.31	1.45	0.019	0.023
2	MTDMWTL20/S-016 MEDTTL20S0088 (2) Sec Size: 70x70x6mm LOC/Member: 948/352	0.15	0.08	0.56	0.032	0.034
3	MTDMWTL20/S-017 MEDTTL20S0088 (3) Sec Size: 180x180x11mm LOC/Member: 949/314	0.10	0.72	1.40	0.017	0.021
4	MTDMWTL20/S-018 MEDTTL20S0088 (4) Sec Size: 70x70x6mm LOC/Member: 949/326	0.15	0.06	0.43	0.029	0.032
5	MTDMWTL20/S-019 MEDTTL20S0088 (5) Sec Size: 70x70x6mm LOC/Member: 949/157	0.14	0.09	0.57	0.023	0.030
6	MTDMWTL20/S-020 MEDTTL20S0088 (6) Sec Size: 180x180x11mm LOC/Member: 950/314	0.09	0.74	1.48	0.026	0.023
7	MTDMWTL20/S-021 MEDTTL20S0088 (7) Sec Size: 100x100x7mm LOC/Member: 950/363	0.15	0.15	0.61	0.027	0.026
8	MTDMWTL20/S-022 MEDTTL20S0088 (8) Sec Size: 70x70x6mm LOC/Member: 950/326	0.15	0.06	0.43	0.032	0.032

Tower at location 948 and 949

Tower at location 950 and 951



Tower no. 950 (DA+0)

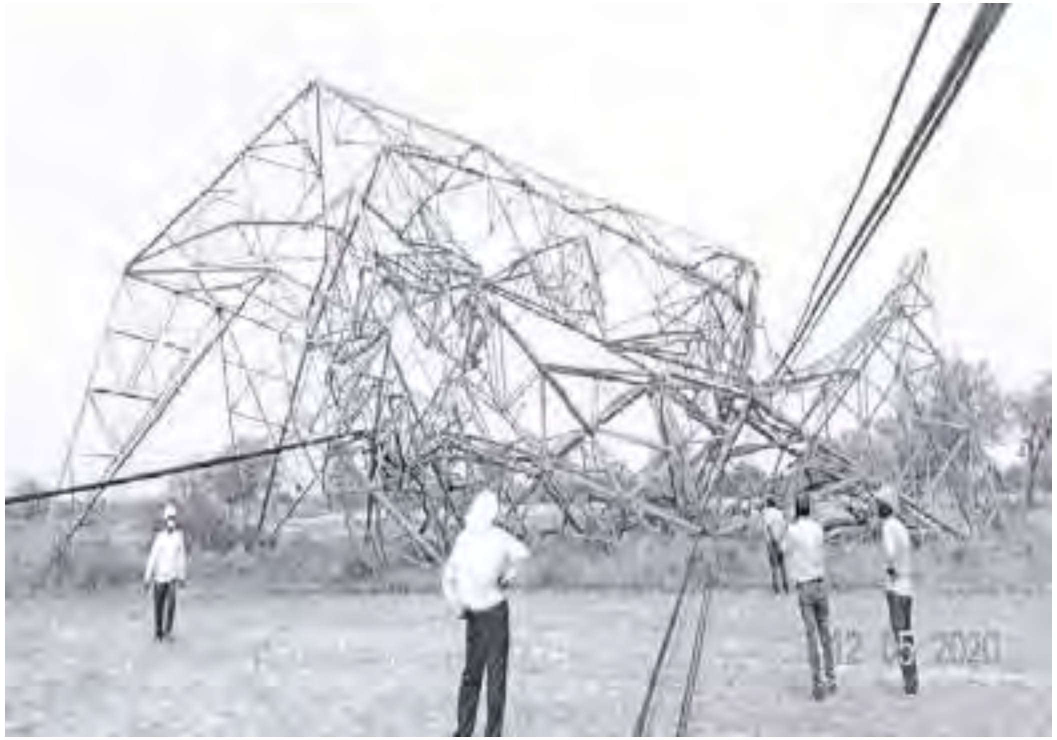


Tower no. 951 (DA+6)

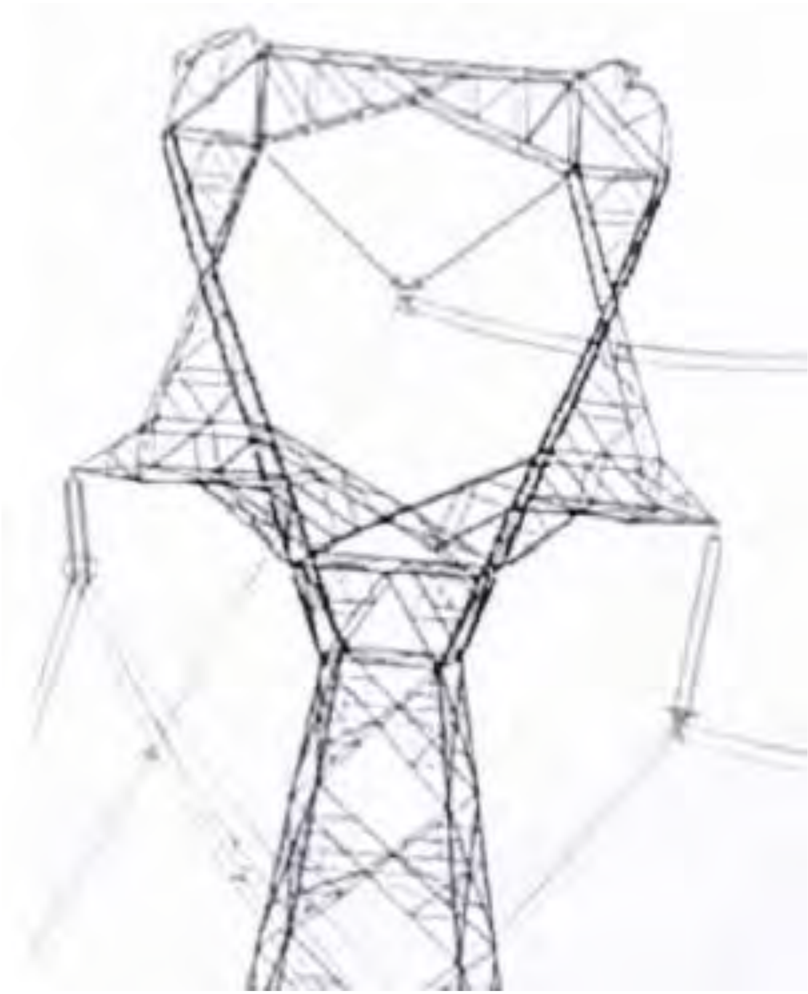
765 KV S/C Varanasi-Fatehpur Transmission Line Of POWERGRID

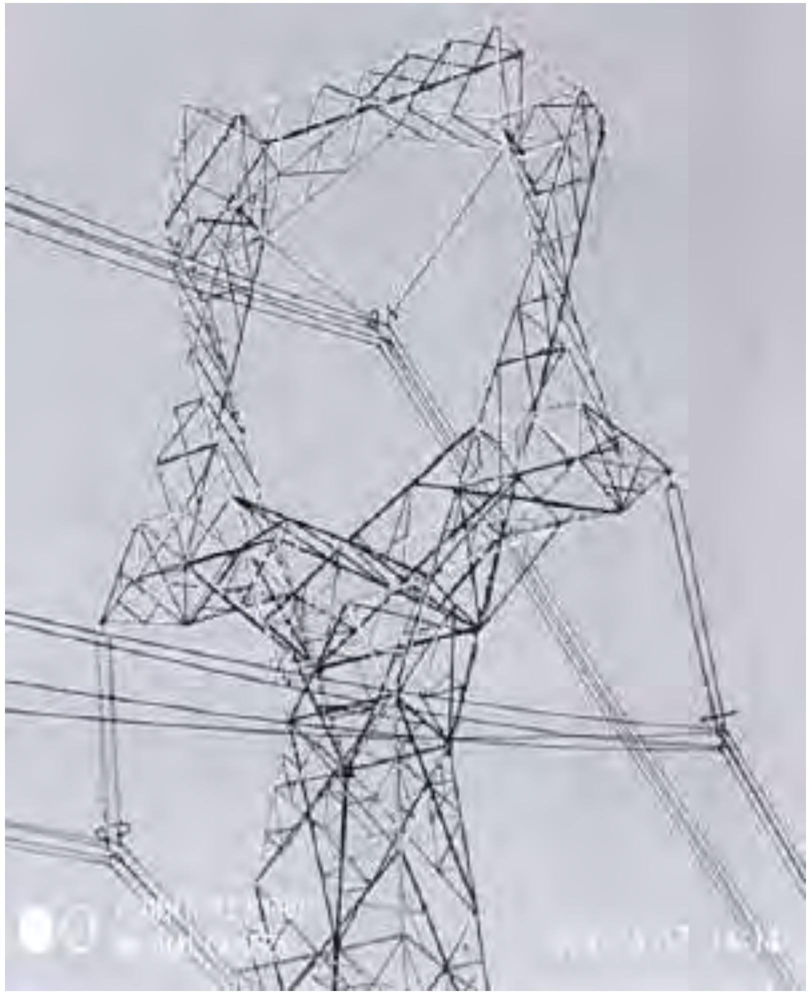
Date of Failure/ Commissioning		10.05.2020/June 2013
No. of Towers failed	Tension tower	0
	Suspension tower	4
	Total	4
Observations		• Line is designed as per IS 802:1995 • Wind Zone-4 • Delta Configuration • Two towers at location no. 641 (A+0) and 642 (A+0) are completely collapsed and towers at location no. 640 (A+3) and 643(A+0) was partially damaged. • The line is having porcelain insulators in I-V-I configuration. • ACSR Bersimis conductor • As per POWERGRID, the strengthening of the failed towers was completed. • Material testing report found generally to be within limits except the elongation percentage of two MS members which is marginally lower (21.84% & 22.10%)– required 23%
		Reason Given by Utility :- High speed windstorm

Tower at location 641 and 642



Tower at location 640 and 643





765 KV S/C SASAN-SATNA-I TRANSMISSION LINE OF POWERGRID

Date of Failure/ Commissioning		28.05.2020/December 2012
No. of Towers failed	Tension tower	1
	Suspension tower	0
	Total	1
Observations		• Line is designed as per IS 802:1995 • Wind Zone-4 & in Delta Configuration • One tower at Location No. 430 (B+0) damaged. • The line is having porcelain insulators in double V-V-V (DSV string) configuration. • Patrolling of the failed location- 29th February 2020 -15 no of redundant missing members were reported in bottom sections of the tower. The same were fixed in the month of March' 2020. • As reported by utility, some towers of 220kV Satna -Chhatarpur (MPPTCL) transmission line, 132 KV Satna- Satna (Prism Cement), 132 KV Satna -Majhgawan transmission line, 132 kV Satna -Satna Cement transmission line were also collapsed • Material Testing- chemical composition of two members found marginally higher than limit: • Member 6→ Pottasium (0.062 > 0.05) • Member 7 → Carbon (0.231 > 0.23)
		Reason Given by Utility :- High speed windstorm

Tower at location 430

765 KV S/C SASAN-SATNA-II TRANSMISSION LINE OF POWERGRID

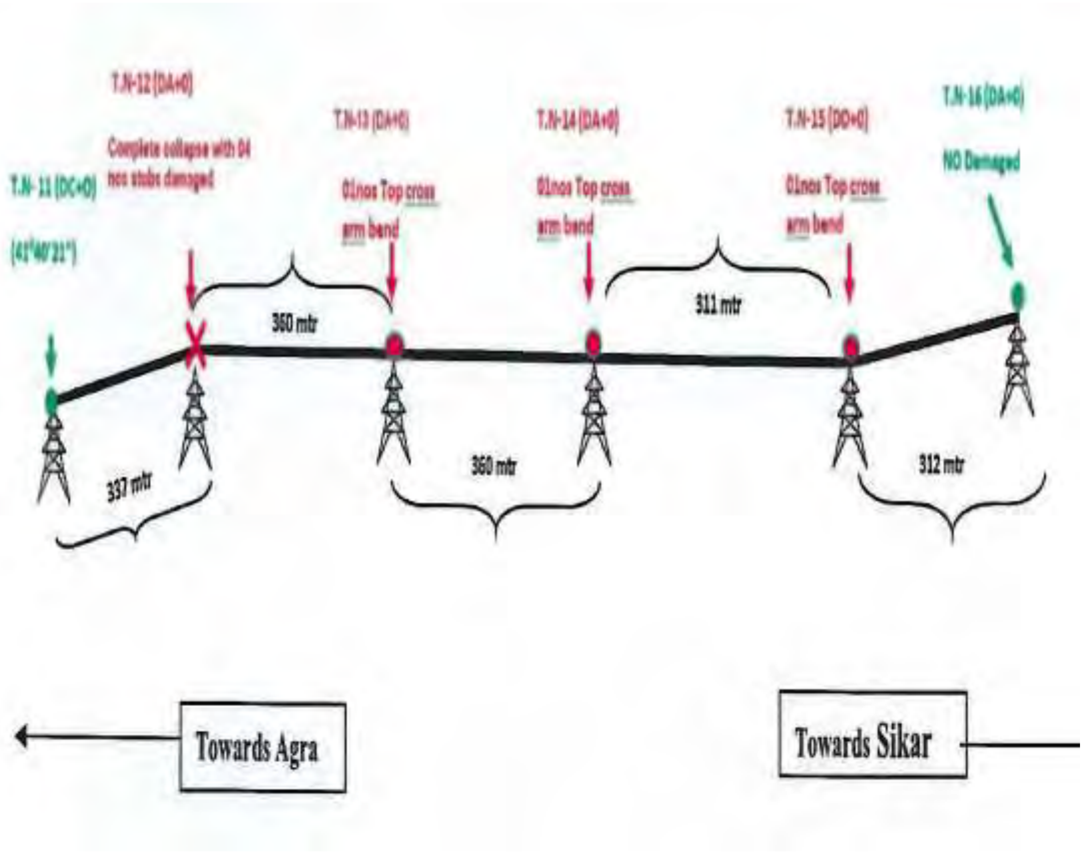
Date of Failure/ Commissioning		28.05.2020/ 30.04.2013
No. of Towers failed	Tension tower	0
	Suspension tower	1
	Total	1
Observations		• Line is designed as per IS 802:1995 • Wind Zone-4 • Delta Configuration 765 kV S/C suspension tower failed. • One tower at Location Nos. 673 (A+0) bent from above waist level • The line is having porcelain insulators in I-V-I (DI -DV-DI String) configuration. • Failed tower location was not taken up for strengthening. • As reported by utility, some towers of 220kV Satna -Chhatarpur (MPPTCL) transmission line, 132 KV Satna- Satna (Prism Cement), 132 KV Satna -Majhgawan transmission line, 132 kV Satna -Satna Cement transmission line were also collapsed • Material Testing report found to be within limit.
		Reason Given by Utility :- High speed windstorm

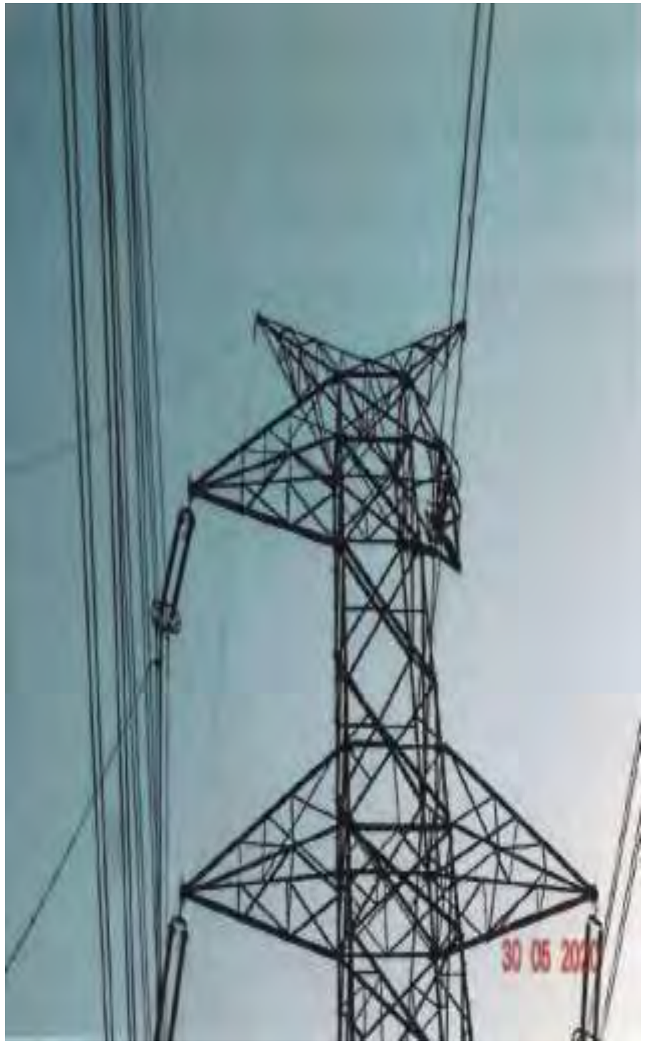
Tower at location 673

400kV D/C Agra-Sikar I&II TRANSMISSION LINE OF POWERGRID

<table>
<tr><th colspan="2">Date of Failure/ Commissioning</th><th>29.05.2020/January 2014</th></tr>
<tr><td rowspan="3">No. of Towers failed</td><td>Tension tower</td><td>1</td></tr>
<tr><td>Suspension tower</td><td>3</td></tr>
<tr><td>Total</td><td>4</td></tr>
<tr><td colspan="2">Observations</td><td>Line is designed as per IS 802:1995.
Previous failure in June 2019- locations no. 339 to 341 (2 suspension one tension) have collapsed completely
Wind Zone-4
Vertical Configuration
Tower at location no. 12(DA+0) has collapsed and all four stubs damaged.
Cross arms of towers at location no. 13(DA+0), 14(DA+0) and 15 (DD+0) has been damaged.
Material testing report found to be within limit.</td></tr>
<tr><td colspan="2"></td><td>Reason Given by Utility :- High speed localized thunderstorm</td></tr>
</table>

Tower at location 12





Tower at location 13 (DA+0)

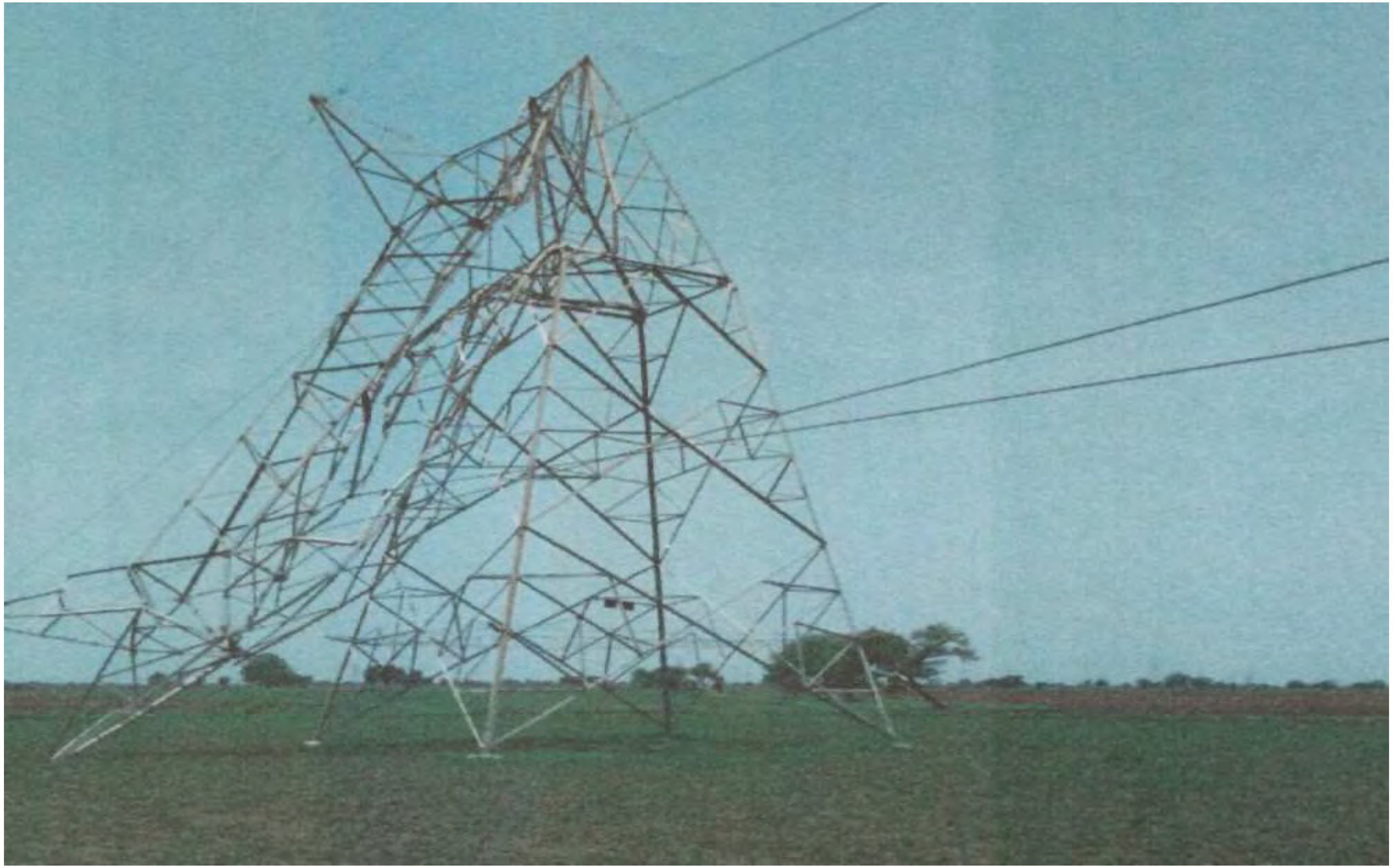
Tower at location 13 (DA+0)

Tower at location 15 (DD+0)

220kV S/C RAPP C-ANTA TRANSMISSION LINE OF POWERGRID

Date of Failure/ Commissioning		03.07.2020/10.01.2000
No. of Towers failed	Tension tower	0
	Suspension tower	1
	Total	1
Observations		• Line is designed as per IS 802:1977 • Medium Wind Zone • Horizontal Configuration • Reported as First incident of failure in transmission line by utility. • Tower used for transmission line is of 400 kV S/C (Horizontal Configuration) • One tower at location no. 213 (A+0) has damaged from the waist level. • Material testing report found to be within limits.
		Reason Given by Utility :- High speed localized thunderstorm

Tower at location 213 (A+0)



400kV Quad Dulhasti-Kishenpur II TRANSMISSION LINE OF POWERGRID

Date of Failure/ Commissioning		10.09.2020/19.01.2018
No. of Towers failed	Tension tower	2
	Suspension tower	0
	Total	2
Observations		• Line is designed as per IS 802:1995 • Wind Zone-4 • Vertical Configuration • Tower at location no. 261 (DB+6) has collapsed • Damage in top cross arm of the tower at location no. 262 (DC+4.5)had occurred. • No landslide & uphill landslip noticed at location & soil seems to be stable. • Material test report found to be in order.
		Reason Given by Utility :- • Gradual differential settlement of Pits A and B and jerk from hitting by boulders from upside hill. • Single circuit stringing may have caused unequal load distribution & torsional stress in tower which may have aggravated the tower collapse.

- Leg A - 0.667 Meter down
- Leg B – 0.597 Meter down
- Leg C – 0.00 Meter (Reference)
- Leg D – 0.014 Meter Up

Back to Back of Stub

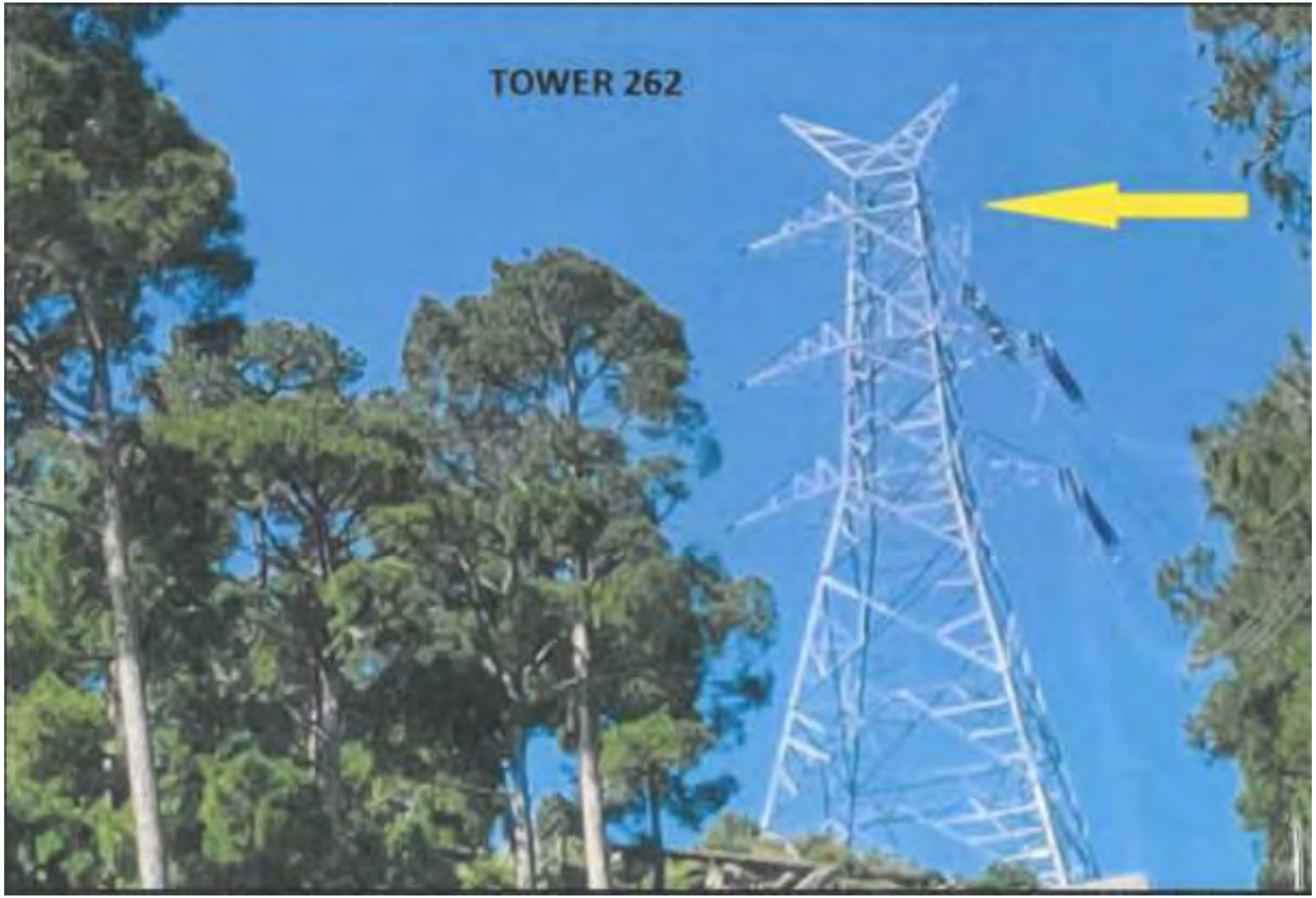
Leg to Leg	As per Drawing (In Mtrs)	As per Actual (In Mtrs.)
A to B	17.011	16.7568 Mtr.
B to C	16.432	16.6224 Mtr.
C to D	16.432	16.0669 Mtr.
D to A	17.011	17.2671 Mtr.

Diagonals (Stub 200 X 20, Length 4023 mm)

Diagonal	As per Drawing (in Mtrs.)	As per Actual (in Mtrs)
A to CP (Half Diagonal)	13.018+0.02-0.62235=12.416	12.7830 Mtrs. (12.7430+0.04) Mtrs.
C to CP (Half Diagonal)	12.199+0.02-0.62235=11.597	11.8773 Mtrs. (11.8373+0.04) Mtrs.
A to C (Full Diagonal)	24.013	24.6603 Mtrs.
B to CP (Half Diagonal)	12.199+0.02-0.62235=11.597	11.3371 Mtrs.

Photograph of uphill side boulders

Tower at location 261


TOWER 262

400 kV Purnea-Farakka and Purnea-Gokarna TRANSMISSION LINE OF POWERGRID

Date of Failure/ Commissioning		11.09.2020/
No. of Towers failed	**Tension tower**	1
	Suspension tower	0
	Total	1
Observations		• Tower at location no. 1103 (DD+0), sitauated on right bank of Ganga river became critical due to continuous erosion of river bank. • The shut down of line was taken by Powergrid citing continuous erosion on 04.09.2020. • Conductors & EW in the span 1102 to 1103 were lowered to reduce stress on tower. • The tower failed on 11.09.2020
		Reason Given by Utility :- Continuous cutting of river bank of Ganga

765 kV Anta-Phagi Transmission line of RRVPNL

Date of Failure/ Commissioning		04.06.2020/08.01.2015
No. of Towers failed	Tension tower	1
	Suspension tower	1
	Total	**2 [Location Nos.: 72/1(A+3) & 61/0(C+3)]**
Observations		• Conductor Type :- ACSR Bersimis Conductor • Tower at Location Nos.: 72/1(A+3) collapsed and at location no. 61/0(C+3) got partially damaged from top. • Tower designed for wind zone 4 • Horizontal configuration tower designed by POWERGRID. • Further Inputs requested on 15.07.20- not received.
		Reason Given by Utility :- Heavy Thunderstorm

766 kV Fatehabad - Lalitpur Ckt-I Transmission Line Of UPPTCL

Date of Failure/ Commissioning		03.05.2020 /1.10.2016 (CKT-I)
No. of Towers failed	Tension tower	
	Suspension tower	
	Total	2
Observations		• Tower erection work in consultancy with POWERGRID. • Transmission line restored on 21.05.2020 • Failure intimated vide letter dated 29.05.2020. • Letter requesting detailed information sent on 15.07.2020. no inputs received.
		Reason Given by Utility :-high wind storm

766 kV Fatehabad - Lalitpur Ckt-II Transmission Line Of UPPTCL

Date of Failure/ Commissioning		03.05.2020 & 28.05.2020 /11.04.2017(CKT-II)
No. of Towers failed	**Tension tower**	
	Suspension tower	
	Total	8
Observations		• 4 towers failed on 03.05.2020 & 4 towers failed on 28.05.2020. • Tower erection work in consultancy with POWERGRID. • Failure intimated vide letter dated 29.05.2020. • Letter requesting detailed information sent on 15.07.2020. no inputs received.
		Reason Given by Utility :- high wind storm

220 kv Malanpur-Morena (Ckt-I & II) Transmission line of MPPTCL

Date of Failure/ Commissioning		29.05.2020/16.02.2017
No. of Towers failed	**Tension tower**	0
	Suspension tower	3
	Total	3 **[Location Nos.: 31(B0), 32(B0+3) & 33(B0+3)]**
Observations		• Conductor Type :- ACSR Zebra • Tower at location 31(B0) collapsed, tower twisted from bottom phase cross arm at location 32(B0+3) and only bottom phase cross arm of CKT-II damaged at location 33(B0+3). • Tower designed for wind zone 4 (wind speed 47m/s = 169.2kmph) • Tower designed as per IS: 802-1995 • Wind speed informed by IMD to MPPTCL on 29.05.2020 – 7 kmph • Continuous record of wind is not available with IMD. • Material Test reports are found within limits.
		Reason Given by Utility :- Heavy Thunderstorm/Cyclone

Tower at location 31

Tower at location 32

Tower at location 33

220 KV Malanpur-Auraiya & 220 KV Mehgaon-Adani Transmission line of MPPTCL

Date of Failure/ Commissioning		28.05.2020/17.11.1993
No. of Towers failed	Tension tower	0
	Suspension tower	11
	Total	11 **[Location Nos.: 14 to 24]**
Observations		• Conductor Type :- AAAC Zebra • 11 nos (Suspension) towers collapsed from ground level. • No damage to Foundation is reported • Tower designed as per IS: 802-1977 • Wind speed informed by IMD to MPPTCL on 28.05.2020 – 5 kmph • Continuous record of wind is not available with IMD. • Material Test reports- **One of the sample failed in tensile strength test.** • **Members Rusted & Bolts are missing (As observed from images).**
		Reason Given by Utility :- heavy Thunderstorm/cyclone

Tower at location 14

Tower at location 15

Tower at location 17

Tower at location 18

Tower at location 19

Tower at location 20

Tower at location 21

Tower at location 22

Tower at location 23

Tower at location 24

400 kV S/C Malwa TPH Pithampur Transmission line of MPPTCL

Date of Failure/ Commissioning		**26.03.2020/2013**
No. of Towers failed	**Tension tower**	1
	Suspension tower	6
	Total	7 **[Location Nos.: 14 to 19]**
Observations		• Conductor Type :- Twin ACSR Moose Conductor • Desiged as per old IS 802 1977 • Tower located in Wind Zone 3 • 6 nos towers(Loc no 14 to 19) completely collapsed and 1 no (loc no 13) partially damaged due to cyclone • Utility suggested that strengthening of towers is required. •Material test report found to be within Limits.

220 KV Malanpur-PGCIL (Ckt-I & II) Transmission line of MPPTCL

Date of Failure/ Commissioning		29.05.2020/ 2010
No. of Towers failed	Tension tower	2
	Suspension tower	3
	Total	5 **[Location Nos.: 90 to 94]**
Observations		• Conductor Type :- ACSR Zebra • 05 nos (03 nos suspension & 02 no Tension) towers are collapsed • Tower designed for wind zone 4 • Tower designed as per IS: 802-1995 • Wind speed informed by IMD to MPPTCL on 29.05.2020 – 7 kmph • Continuous record of wind is not available with IMD. • Material Test reports-.found to be within limits.
		Reason Given by Utility :- Heavy storm/cyclone

Tower at location 90

Tower at location 91

Tower at location 92

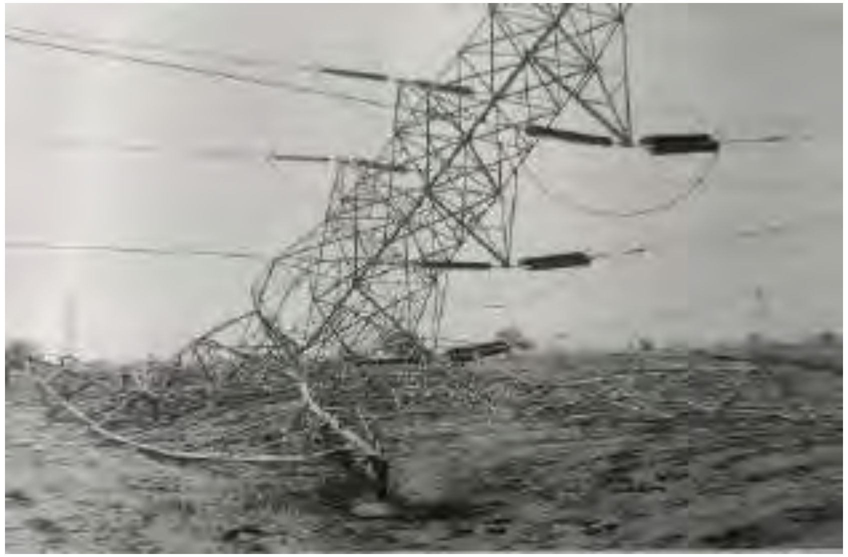
Tower at location 93

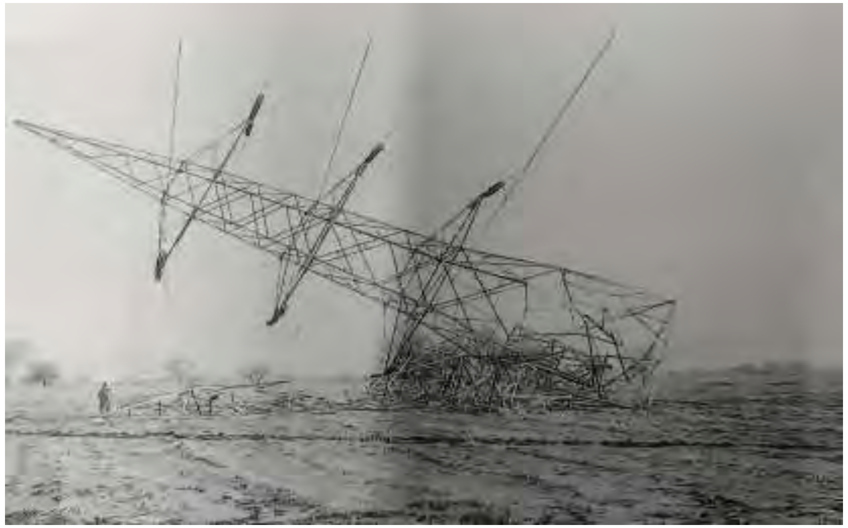
Tower at location 94

Shahapur/Shahabad to Kapnoor D/C Transmission line of KPTCL

Date of Failure/ Commissioning		17.04.2020/2003
No. of Towers failed	**Tension tower**	2
	Suspension tower	0
	Total	2**[Location Nos.: 389 & 390]**
Observations		• Conductor Type :- Drake • 02 nos (Tension) towers (B type) are collapsed. • There is no damage to Foundation • Tower designed for wind zone 2
		Reason Given by Utility :- Heavy rain and swirl wind

Photographs of Collapsed Towers



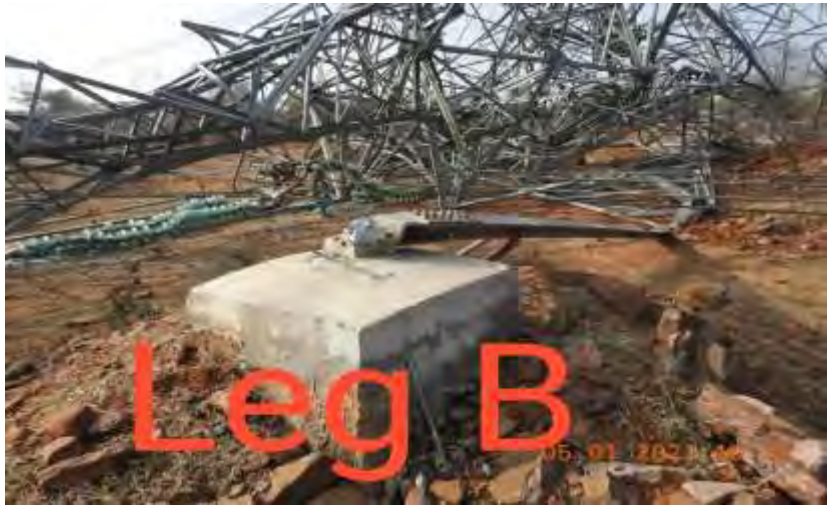


765 KV Bina-Gwalior-3 transmission line of POWERGRID

<table>
<tr><th colspan="2">Date of Failure/ Commissioning</th><th>05.01.2021/ May 2014</th></tr>
<tr><td rowspan="3">No. of Towers failed</td><td>Tension tower</td><td>1</td></tr>
<tr><td>Suspension tower</td><td>0</td></tr>
<tr><td>Total</td><td>1</td></tr>
<tr><td colspan="2">Observations</td><td>• Delta Configuration
• The Tower is designed as per IS 802: 1995 and Wind Zone-4
• The tower at location no. 611 has collapsed from top of concrete, just above stub level on the ground in the transverse direction.
• Removed tower member pieces, bolts and nuts were found scattered at the tower collapse site.
• Cutting of main bracing observed.
• All the redundant members of bottom section and three main bracing of the adjacent suspension tower at location no. 612 (A type) has also been removed, but the tower is standing.
• Last patrolling was done on 12.10.2020- No theft observed by utility representatives.</td></tr>
<tr><td colspan="2"></td><td>Reason Given by Utility :- Theft/ Sabotage of Tower members</td></tr>
</table>

Tower at location 611

Legs of tower at location 611



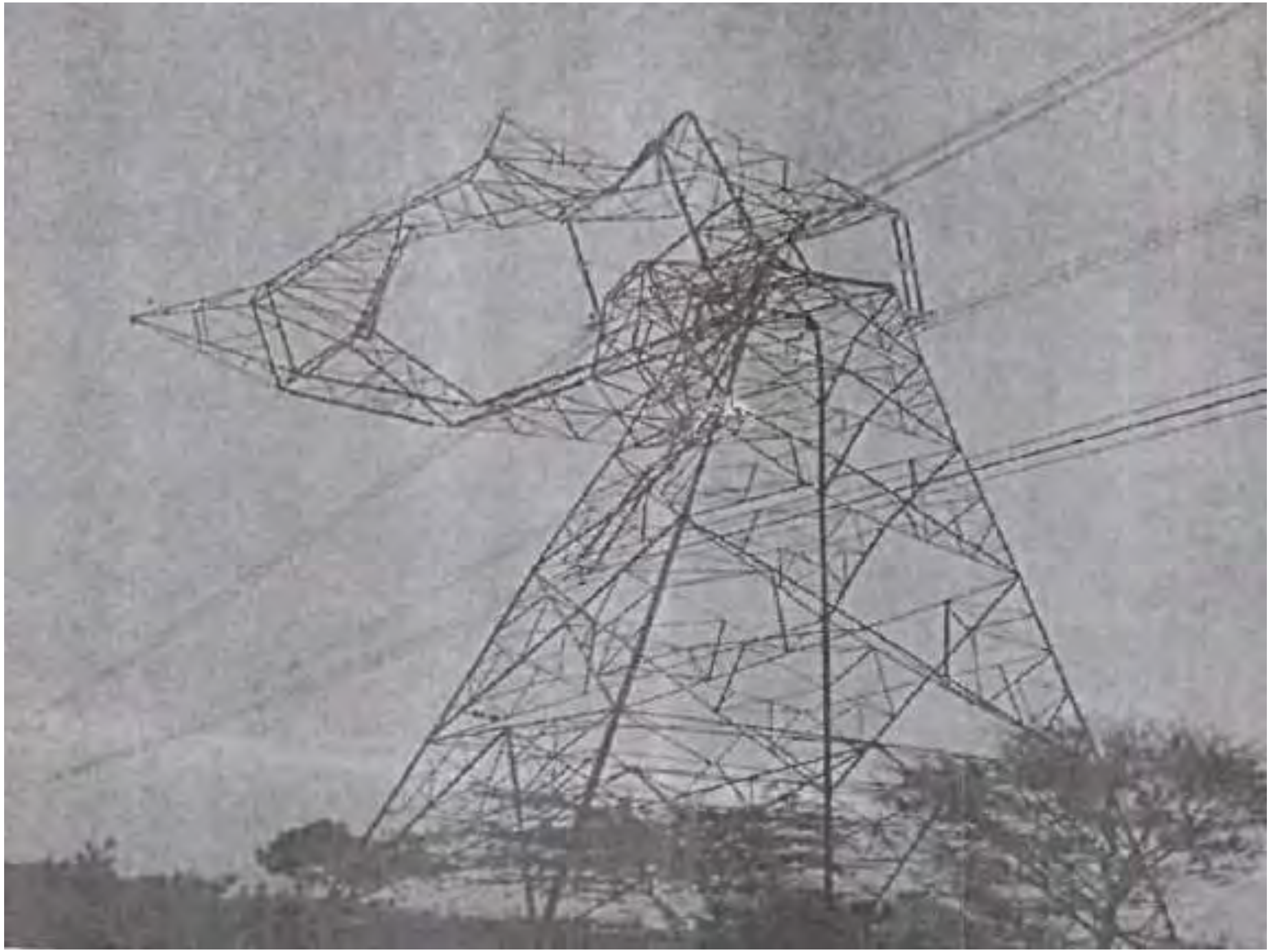
Removed bolts & nuts and Tower members

Tower at Location 612

765 KV Jhatikara-Bhiwani Transmission Line of POWERGRID

Date of Failure/ Commissioning		06.05.2021/01.10.2012
No. of Towers failed	Tension tower	0
	Suspension tower	1
	Total	1
Observations		• Delta Configuration • Quad ACSR Bermisis Conductor • Line is designed as per IS 802:1995 and Wind Zone-4 • Tower is designed with Double I-V-I insulator string • Tower at location no. 59 (33/3) (A+0) has been damaged from the cross arm level • Previous failure on 16.05.2018- one tower failed (suspension type)- location no. 17 (A+0). • **All strengthening**, including as suggested by Manitoba Hydro, **has been completed** at the failed site location.
		Reason Given by Utility :- Highly localized Thunderstorm with high speed wind

Tower at location 59 (33/3)



+-800 KV HVDC Agra-BNC Transmission Line of POWERGRID

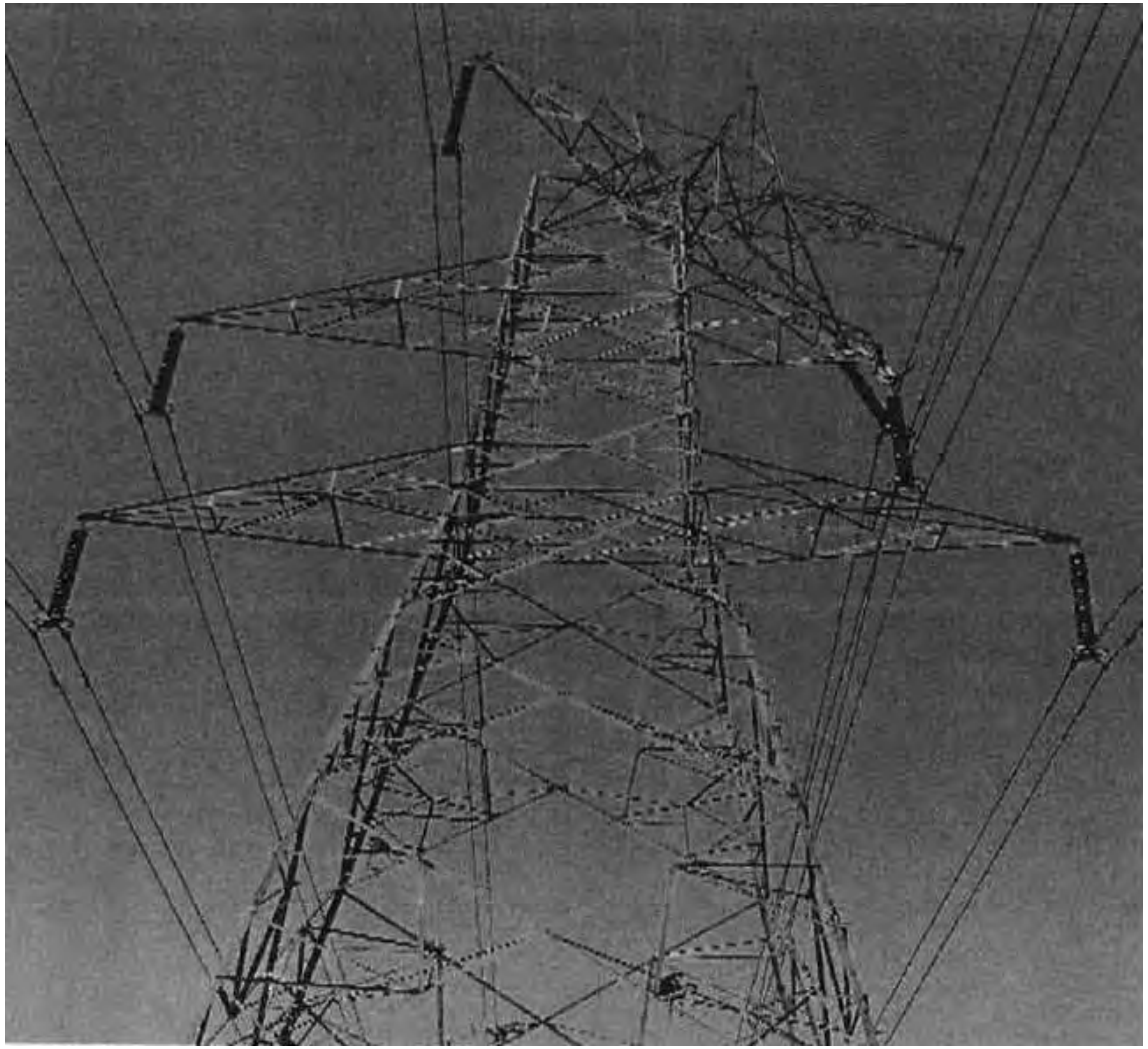
<table>
<tr><th colspan="2">Date of Failure/ Commissioning</th><th>10.05.2021/ Nov 2015</th></tr>
<tr><td rowspan="3">No. of Towers failed</td><td>Tension tower</td><td>0</td></tr>
<tr><td>Suspension tower</td><td>1</td></tr>
<tr><td>Total</td><td>1</td></tr>
<tr><td colspan="2">Observations</td><td>• Cross Arm of Pole-II at location no. 3118 was found damaged
• Hexa ACSR Lapwing Conductor
• Line is designed as per IS 802:1995 and Wind Zone-4
• Tower is designed with Y string having Glass insulator.
• Last failure inline on 2.05.2018 (Agra Region) at location no. 4328,4347,4348 (DD+25)</td></tr>
<tr><td colspan="2"></td><td>Reason Given by Utility :- High Speed Thunderstorm</td></tr>
</table>

Tower at location 3118

400 KV Raipur-Korba Transmission line of POWERGRID

Date of Failure/ Commissioning		11.05.2021/01.07.2011
No. of Towers failed	Tension tower	0
	Suspension tower	1
	Total	1
Observations		• ACSR Moose Conductor • Line is designed as per IS 802: 1995 and Wind Zone-2 • The ‘DA’ type towers of this line were designed with Single “I” porcelain insulator string. • At location no. 303 (DA+0) both of top cross arms and one middle cross arm of the tower got damaged • At location no. 302 (DA+0) insulator de-capping occurred in top phase.
		Reason Given by Utility :- Due to lightining decapping of insulator at location no. 302. high speed wind coupled with sudden jerk due to decapping resulted in failure of cross arms.

Tower at location 303



765 KV D/C Wardha-Aurangabad Transmission line of POWERGRID

Date of Failure/ Commissioning		27.05.2021/ July 2014
No. of Towers failed	Tension tower	0
	Suspension tower	5
	Total	5
Observations		• Hexa Zebra ACSR Conductor • Line is designed as per IS 802: 1995 and Wind Zone-2 • The Tower is designed with Double I String having Glass insulator. • Tower at location no. 321 (DA+3) collapsed. • Peak of the tower at location no. 322 (DA+6) was damaged. • Tower at location no. 319 and 320 got buckled from middle cross arm. • At tower location 318, Top CKT-II cross arm got damaged. • This is first incident of failure of towers in this line. • Reliability Level
		Reason Given by Utility :- High speed Windstorm/ Thunderstorm

Tower at location 321

Partial damaged towers

Tower location 318

Tower location 319

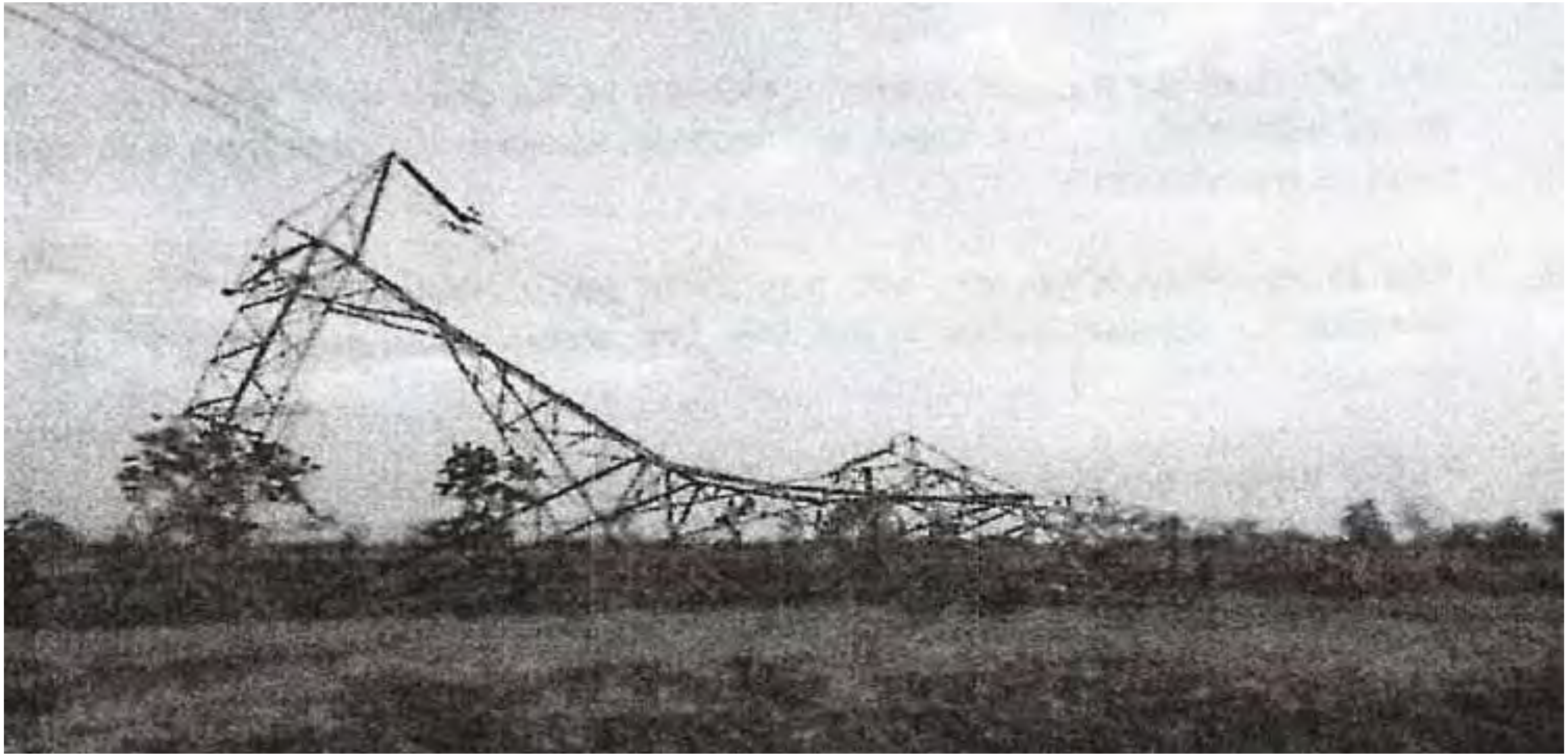
Tower location 320

Tower location 322

400 KV Korba-Bhilai-1 Transmission Line of POWERGRID

Date of Failure/ Commissioning		30.05.2021/03.01.1983
No. of Towers failed	Tension tower	0
	Suspension tower	1
	Total	1
Observations		• Line is designed as per IS 802:1977 • Horizontal Configuration • Suspension towers are designed with Single “I” Insulator Strings • Tower at location no. 320 (A+3) has bee collapsed from stub level. • 2^{nd} instance of failure in line. • 1^{st} failure in 2009
		Reason Given by Utility :- Highly Localized Thunderstorm with high speed wind

Tower at location 320



400 KV D/C (Quad) Kaithal-Baghpat transmission line of POWERGRID

<table>
<tr><th colspan="2">Date of Failure/ Commissioning</th><th>08.07.2021/ Nov 2010/ LILO of Kaithal Meerut in Baghpat done in 2016</th></tr>
<tr><td rowspan="3">No. of Towers failed</td><td>Tension tower</td><td>0</td></tr>
<tr><td>Suspension tower</td><td>4</td></tr>
<tr><td>Total</td><td>4</td></tr>
<tr><td colspan="2">Observations</td><td>• Tower is located in LOOP in portion of 400 kV Kaithal-Baghpat transmission line.
• Line is designed as per IS:802 1995 and Wind Zone 4.
• Reliability Level-I used for designing these towers
• As highlighted by utility, as per NBC map-2016 location lies in WZ-5.
• The tower is designed for Quad ACSR Moose conductor with double I string having porcelain disc insulators. At present, the line is having polymer insulators.
• Tower at location no. 389(DA+0) has collapsed.
• Tower at location no. 388 (DA+0) : Earth wire peak of CKT-I side has damaged.
• Tower at location no. 390 (DA+0) : Both earth wire peak damaged
• Tower at location no. 391 (DA+0) : Middle cross arm of CKT-II damaged.
• Material Test report awaited.</td></tr>
<tr><td colspan="2"></td><td>Reason Given by Utility :- High speed windstorm/ thunderstorm</td></tr>
</table>

Tower at location 389

Partial damaged towers

Tower location 388

Tower location 390

Tower location 391

400 KV Kishenpur-New Wangpoh CKT 3&4 Transmission Line of POWERGRID

Date of Failure/ Commissioning		23.10.2021/29.07.2017
No. of Towers failed	**Tension tower**	1
	Suspension tower	0
	Total	1
Observations		• Twin ACSR Moose conductor • Tower is designed as per IS 802: 1995 and Wind Zone-2 • Tower is having Porcelain Disc insulators • Tower at location 145 (DC+3) has collapsed • A wide crack adjacent to location no. 144 was seen which indicates gradual land sliding around location 144.
		Reason Given by Utility :- The gradual sliding of landmass at location no. 144 has led to increases tension between span 144-145 causing excess loading on tower no. 145. During Hailstorm, heavy winds and contraction of conductor due to sudden fall in temperature on the day of incident has further aggravated the stress in tower at location no. 145 which caused its failure.

Tower at location 389

Fig-I Leg-A

Fig-II Leg-B

Fig-III Leg-C

Fig-IV Leg-D

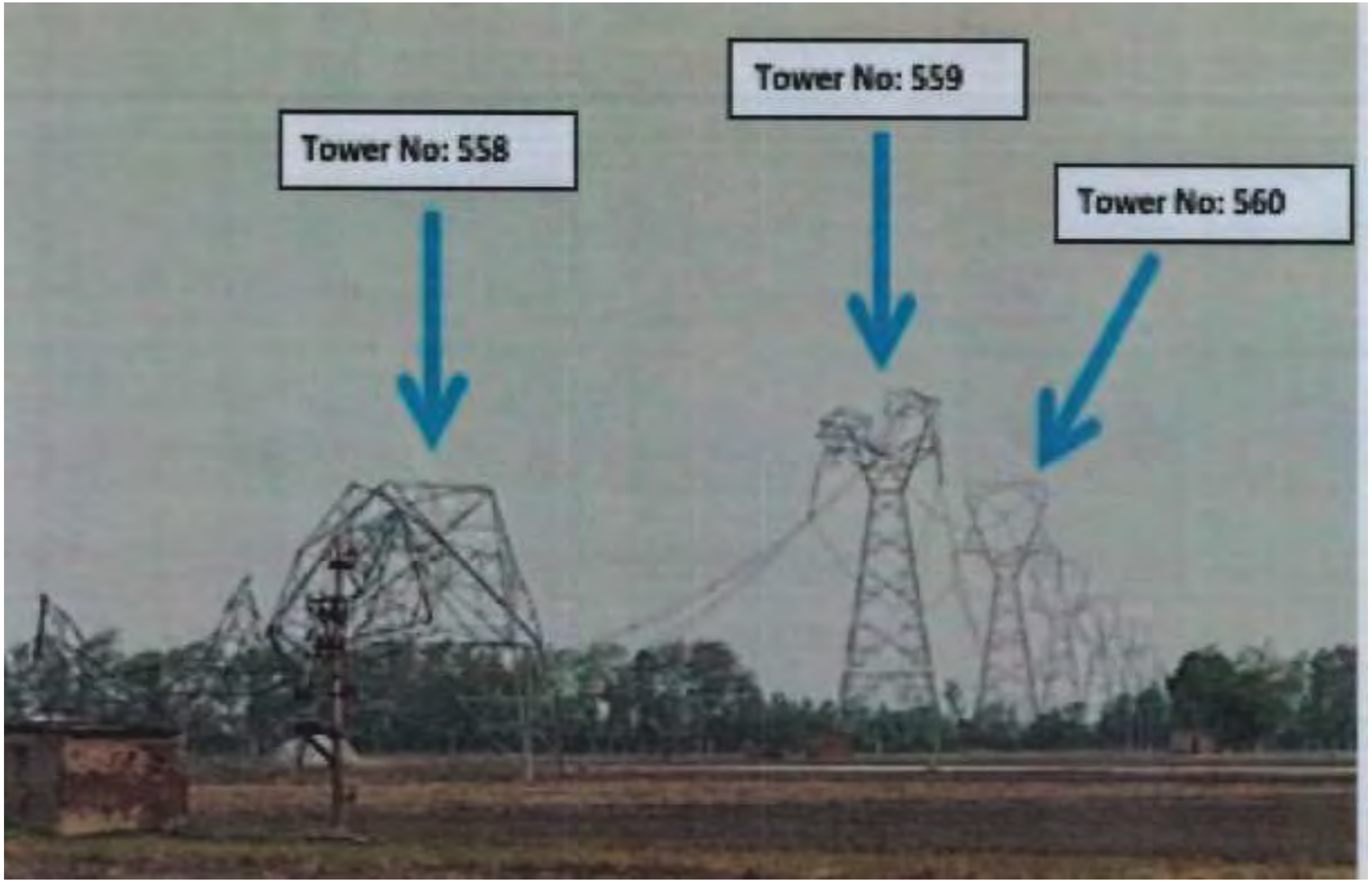
Cracks near Tower at location no. 144

Bending of members of Tower at location no. 144

765 KV Meerut-Moga Transmission Line of POWERGRID

Date of Failure/ Commissioning		10.06.2021/ May 2015
No. of Towers failed	Tension tower	0
	Suspension tower	3
	Total	3
Observations		• Delta Configuration towers • Line is designed as per IS:802 1995 and Wind Zone 4 • Quad ACSR Bermisis Conductor • Tower is designed with Double I-V-I insulator string • Tower at location no. 558 (SA+0) has been collapsed • Cross arm of Tower at location no. 559 (SA+3) has damaged • Peak of the Tower at location no. 560 (SA+3) has damaged
		Reason Given by Utility :- High speed windstorm/ thunderstorm

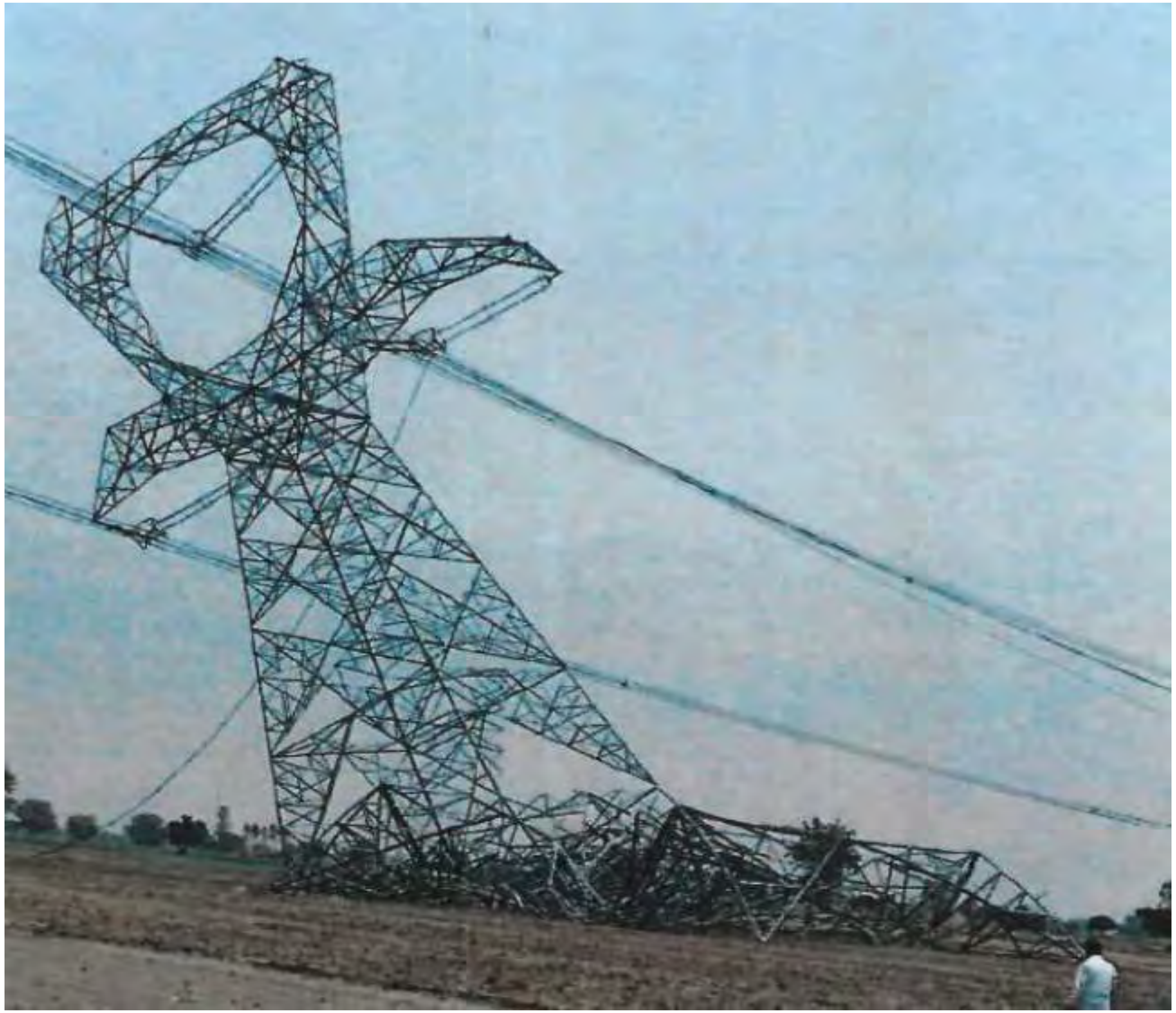
Tower at location 558, 559 & 560



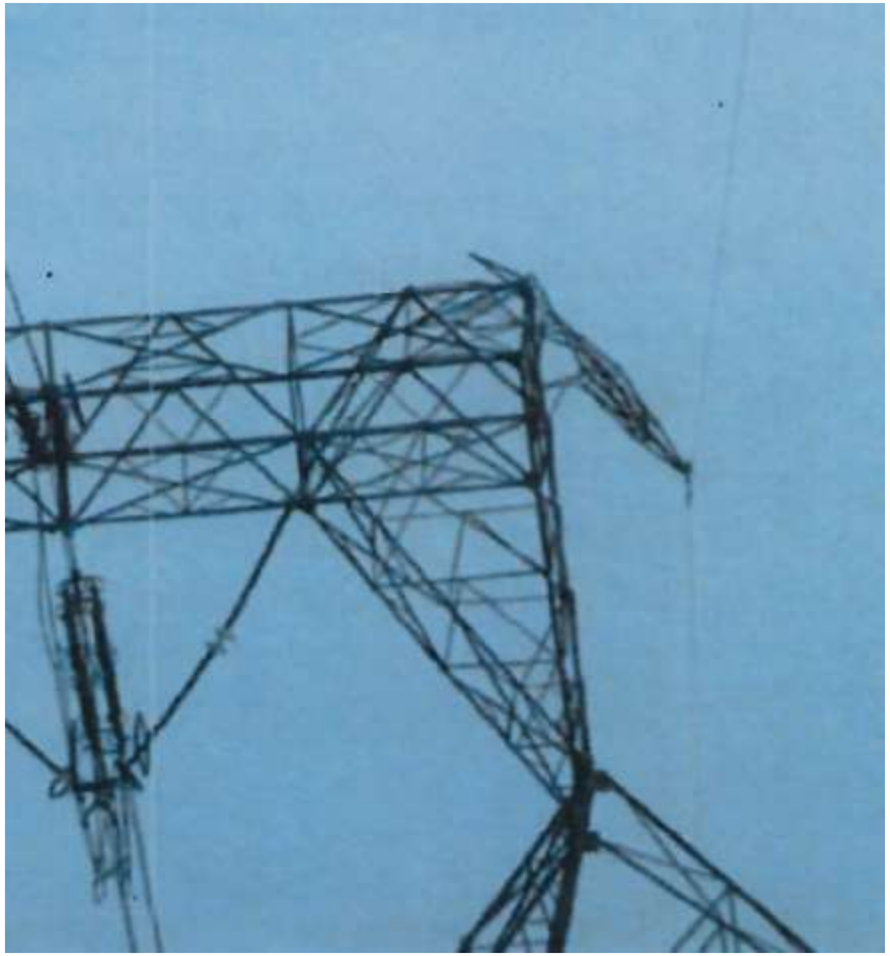
765 KV Moga-Bhiwani Transmission Line of POWERGRID

Date of Failure/ Commissioning		12.06.2021/ 01.06.2012
No. of Towers failed	Tension tower	3
	Suspension tower	
	Total	3
Observations		• Line is designed as per IS:802 1995 and Wind Zone 4 • Quad ACSR Bermisis Conductor • Delta Configuration • Type B Tower is designed with Double V-V-V insulator string • One tower at location no. 293 (B +25) has collapsed • Earth peaks of adjacent towers at location no. 292 and 294 has damaged
		Reason Given by Utility :- Highly Localized Windstorm with high speed wind

Tower at location 293



Tower at location 292 & 294



220 KV Amarkantak-Panagar/SGTPS Birsinghpur of MPPTCL

Date of Failure/ Commissioning		21.09.2021/ 1996
No. of Towers failed	Tension tower	
	Suspension tower	2
	Total	2
Observations		• Located in Wind Zone 4 • Line is designed as per IS:802 1977 • ACSR Zebra Conductor in Vertical configuration. • No damage to foundation reported by utility • Detailed failure report, photographs, Material test report, wind speed data etc. awaited from MPPTCL.
		Reason Given by Utility :- heavy cyclonic wind & thunderstorm

400 KV D/C Malwa TPH (SSTPH)-Pithampur Ckt I&II line of MPPTCL

Date of Failure/ Commissioning		29.05.2021/ 2013
No. of Towers failed	Tension tower	0
	Suspension tower	5
	Total	5
Observations		• Tower located in Wind Zone 3 • Line is designed as per IS:802 1977- medium wind pressure. • Twin Moose ACSR Conductor in vertical configuration. • **Line failed in 2019, 2020 & in 2021- different locations.**
		Reason Given by Utility :- Heavy wind storm

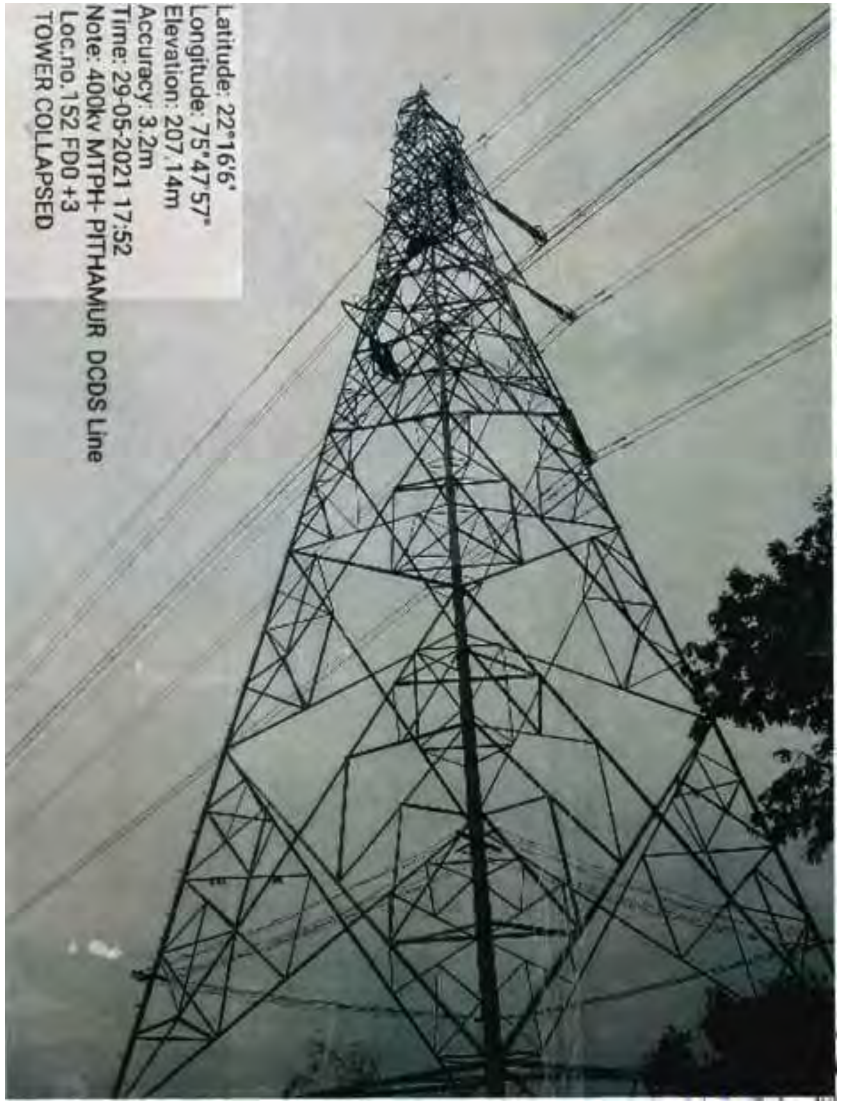
Tower at location 148

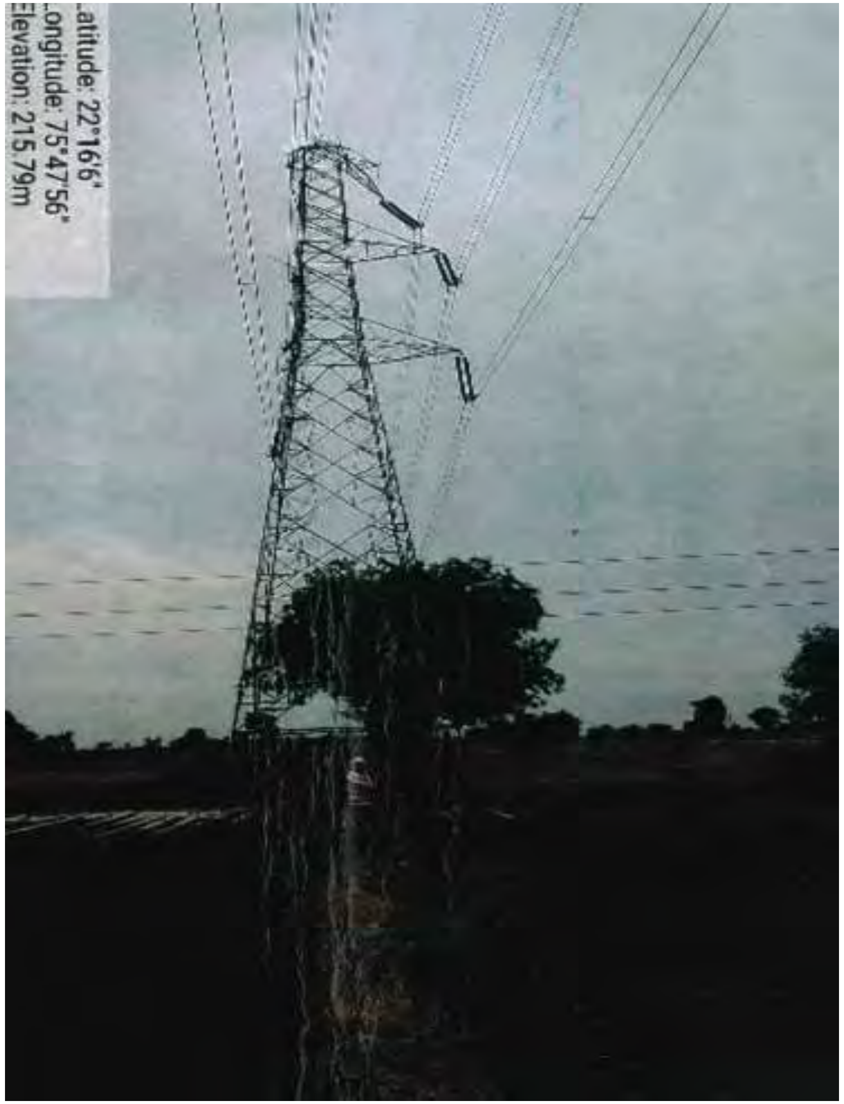
Tower at location 149

Tower at location 150

Tower at location 151

Tower at location 152





MADHYA PRADESH POWER TRANSMISSION COMPANY LIMITED

Abstract of Tower collapse in MPPTCL from Apr-19 to Mar-21

Voltage Level	No of affected lines	Suspension Towers	Tension Towers	Total Towers
400 kV	5	37	6	43
220 kV	6	21	2	23
Total	11	58	8	64

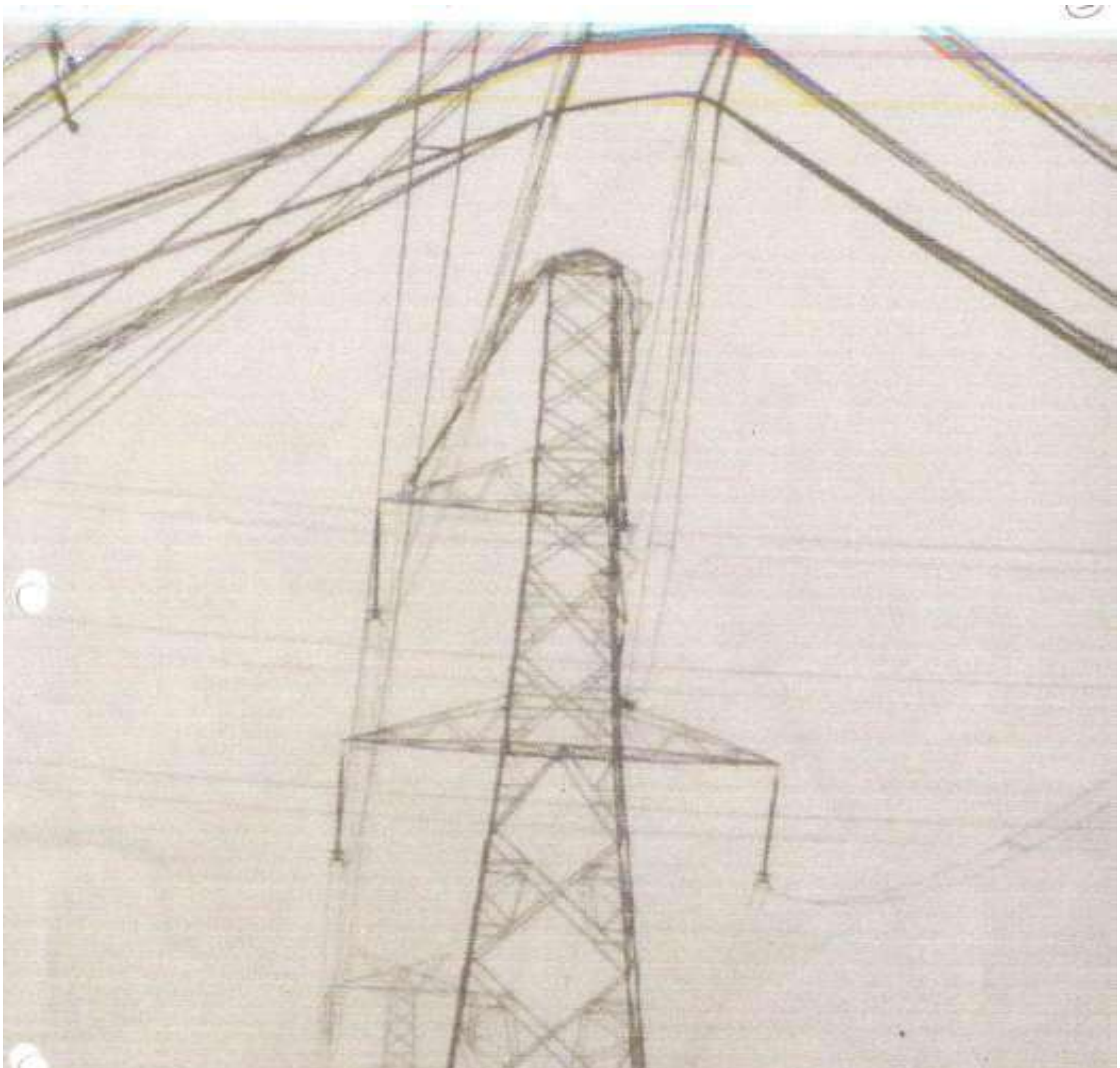
400 kV Malwa Pithampur DCDS line failed four times.

DETAILS OF FD-SERIES TOWERS IN MPPTCL

Sr. No.	Name of line	Route length	Total Tower	Total Suspn. Towers	Collapsing of Suspension Towers				Total Tension Towers	Collapsing of Tension Towers			
					2019	2020	2021	Total		2019	2020	2021	Total
1	400kV Kirnapur LILO	2.06	10	1	--	--	--	0	9	--	--	--	0
2	400 KV Birsinghpur - Katni	117.63	324	210	--	--	--	0	114	--	--	--	0
3	400 KV Katni - Damoh(PGCIL)	117.3	316	250	--	--	--	0	66	--	--	--	0
4	400kV Katni-Damoh (Chrged on 220kV)	9.95	31	18	--	--	--	0	13	--	--	--	0
5	400 KV Bhopal-Bina	138.41	363	310	--	--	--	0	53	--	--	--	0
6	400 KV Sarni-Seoni	43.75	130	1	--	--	--	0	129	--	--	--	0
7	400 KV Sarni-ISP	191.33	535	10	--	--	--	0	525	--	--	--	0
8	400 kV SSTPH-Pithampur DCDS	136	397	301	22	6	5	33	96	4	1	0	5
9	400 kV Chhegaon-Julwania DCDS	113.64	340	270	--	--	--	0	70	--	--	--	0
10	400 kV SSTPH-Chhegaon	52.22	158	120	--	--	--	0	38	--	--	--	0
11	400 kV Indore(Hatuniya)-Pithampur	63.55	193	145	--	--	--	0	48	--	--	--	0
12	400 kV Nagda-Badnawar	53.62	145	113	--	--	--	0	32	--	--	--	0
13	400 kV Badnawar-Rajgarh	51.52	137	116	--	--	--	0	21	--	--	--	0
14	400 kV Rajgarh-SSP	113.68	305	232	4	0	0	4	73	1	0	0	1
Total		1204.66	3384	2097	26	6	5	37	1287	5	1	0	6

1. 400kV Malwa TPH – Pithampur

- Date of Failure: 16/04/2019, Commissioning: 2013
- Line designed as per IS 802:1977, Wind Zone Medium.
- Conductor: Twin Moose, Insulator: I String
- Number of Tower collapsed: 2 numbers Suspension Towers.
- Reason of Failure: Collapse of 765kV Khandwa Dhule Transmission line of M/s Khargone Transmission Corporation Limited.
- Excessive loading on our Transmission Line resulting into partial damage of tower.



Tower at

2. 400kV Malwa TPH Pithampur

- **Date of Failure: 02/06/2019, Commissioning: 2013**
- **Line designed as per IS 802:1977, Wind Zone: Medium**
- **Conductor: Twin Moose, Insulator: I String**
- **Number of Tower collapsed: 20 numbers Suspension tower and 4 numbers Tension towers**
- **Reason of Failure: Cyclonic circulation in the area resulting into collapse of location number 159 to 168 across the line in south direction and 126 to 139 across the line in north direction.**
- **Collapse pattern suggests presence of strong cyclonic circulation.**

2. 400kV Malwa TPH Pithampur

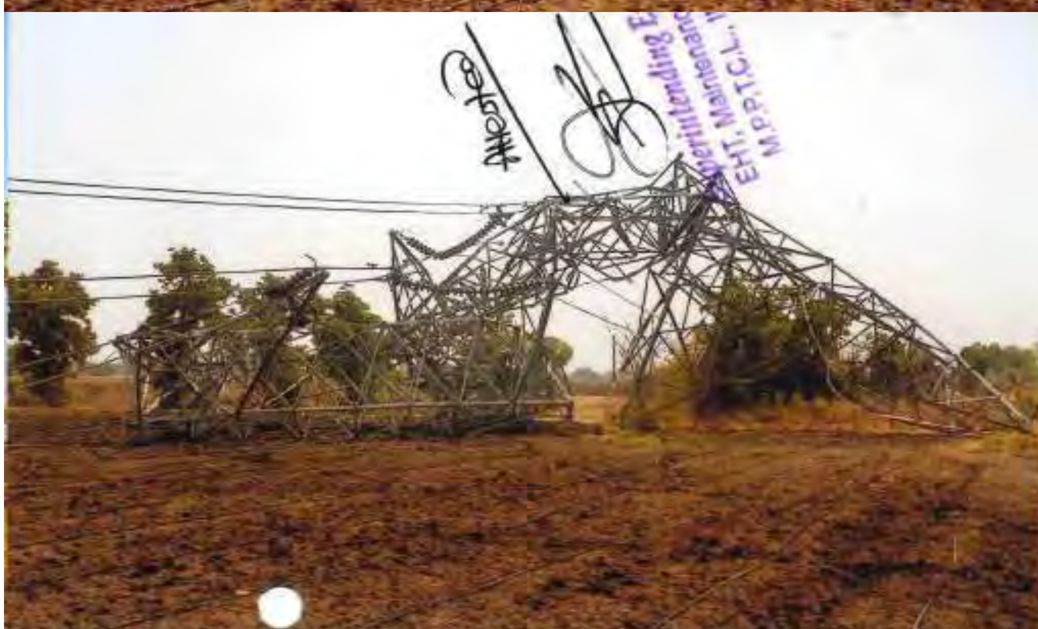
- **Our Team of Experts along with Design Expert visited to investigate the cause of failure of structures.**
- **The committee opined that structure failure was due to heavy cyclonic circulation in the area.**
- **The wind data of the local area also indicates strong wind presence.**
- **We have taken up the matter with Designer for strengthening the design as per IS 802: 1995**
- **Accordingly the strengthening of tower has been designed by our designer.**
- **MPPTCL will take up the strengthening work of all suspension towers of this design in a phased manner.**

Location Number 126

Location Number 127

Location Number 128

Location Number 129



Location Number 130

Location Number 131

Location Number 132

Location Number 133

Attested

Location Number 134

Location Number 135

Location Number 136

Location Number 137

Location Number 138

Location Number 139

Location Number 159

Location Number 160

Location Number 161

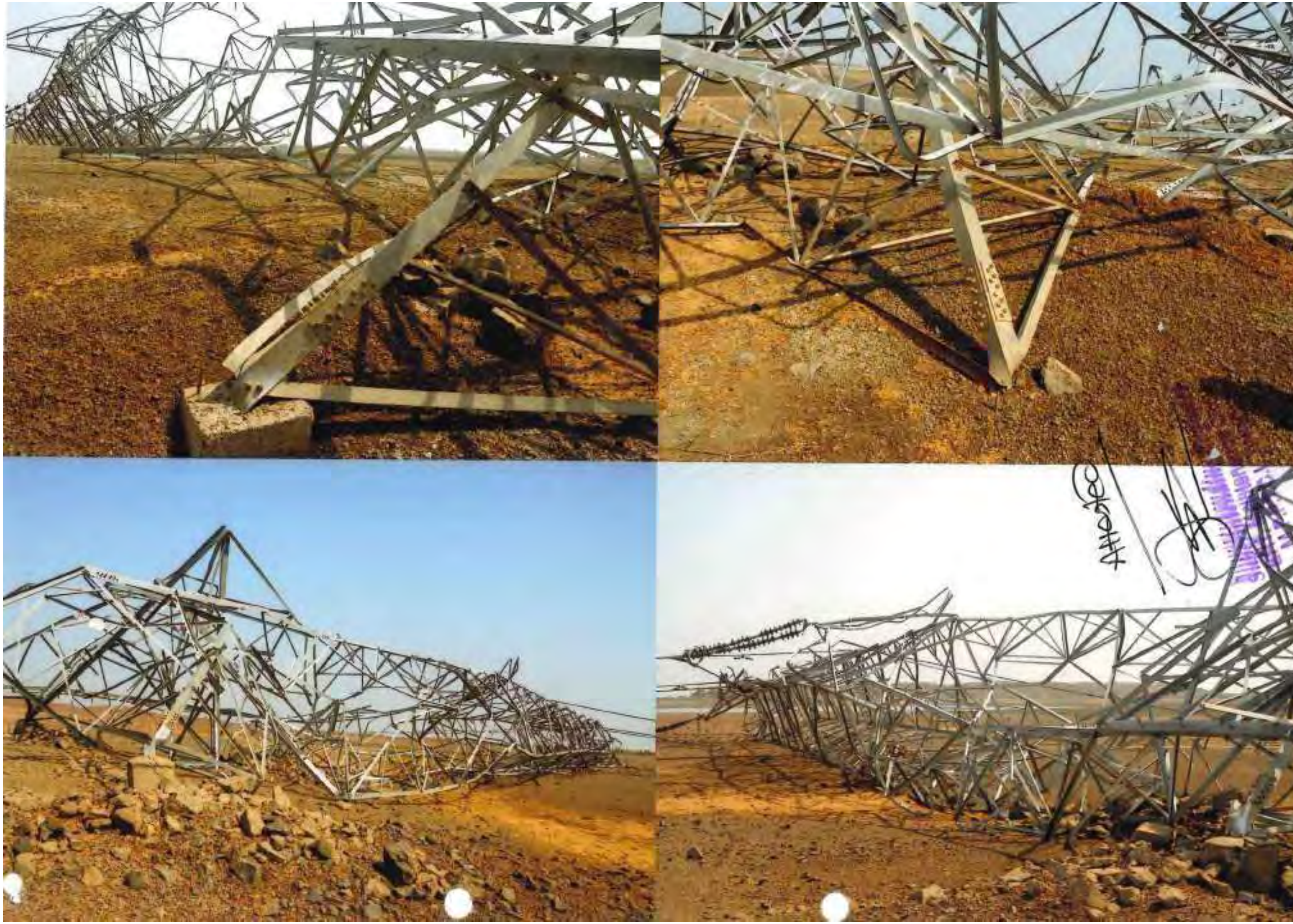
Location Number 162

Location Number 163

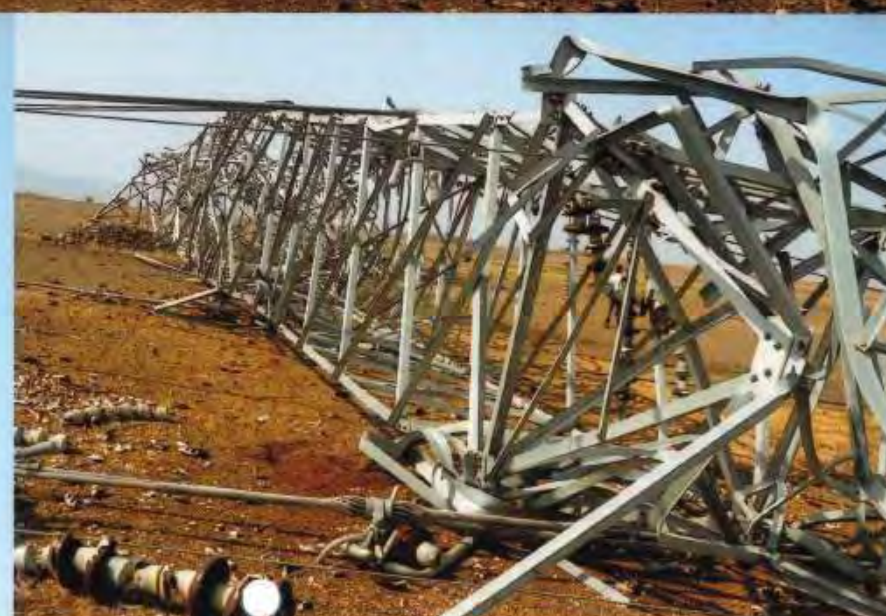
Location Number 164

Attested

Location Number 165



Location Number 166



Location Number 167

Location Number 168

Material report

Particulars	Specification	Result
Yield Stress	Min 350	334
% Elongation MS	Min 23	18.8,
% Elongation HT	Min 22	17.3, 18.6
Tensile Strength HT	Min 490	484
Bend Test	Should Pass	Pass
Carbon	Max 0.2	Within Limits
Sulphur	Max 0.045	Within Limits
Phosphorus	Max 0.045	Within Limits
Manganese	Max 1.55	Within Limits
Silicon	Max 0.45	Within Limits

3. 400kV Malwa TPH Pithampur

- **Date of Failure: 26/03/2020, Commissioning: 2013**
- **Line designed as per IS 802:1977, Wind Zone: Medium**
- **Conductor: Twin Moose, Insulator: I String**
- **Line designed as per IS 802:1977**
- **Number of Tower collapsed: 6 numbers Suspension and 1 number Tension tower.**
- **Reason of Failure: Cyclonic circulation in the area resulting into collapse of location number 13 to 19.**
- **MPPTCL will take up the strengthening work of all suspension towers of this design.**

Location Number 13

Location Number 14

Location Number 15

Location Number 16

Location Number 17

Location Number 18

Location Number 19

Material report

Particulars	Specification	Result
Yield Stress HT	Min 350	Within Limits
% Elongation MS	Min 23	Within Limits
% Elongation HT	Min 22	Within Limits
Tensile Strength HT	Min 490	Within Limits
Bend Test	Should Pass	Pass
Carbon	Max 0.2	Within Limits
Sulphur	Max 0.045	Within Limits
Phosphorus	Max 0.045	Within Limits
Manganese	Max 1.55	Within Limits
Silicon	Max 0.45	Within Limits

4. 400kV Malwa TPH Pithampur

- **Date of Failure: 29/05/2021**
- **Year of Commissioning: 2013**
- **Wind Zone: Medium**
- **Line designed as per IS 802:1977**
- **Number of Tower collapsed: 5 numbers Suspension towers.**
- **Reason of Failure: Cyclonic circulation in the area resulting into collapse of location number 148 to 152.**
- **Line towers also collapsed in 2019 and 2020.**
- **MPPTCL will take up the strengthening work of all suspension towers of this design.**

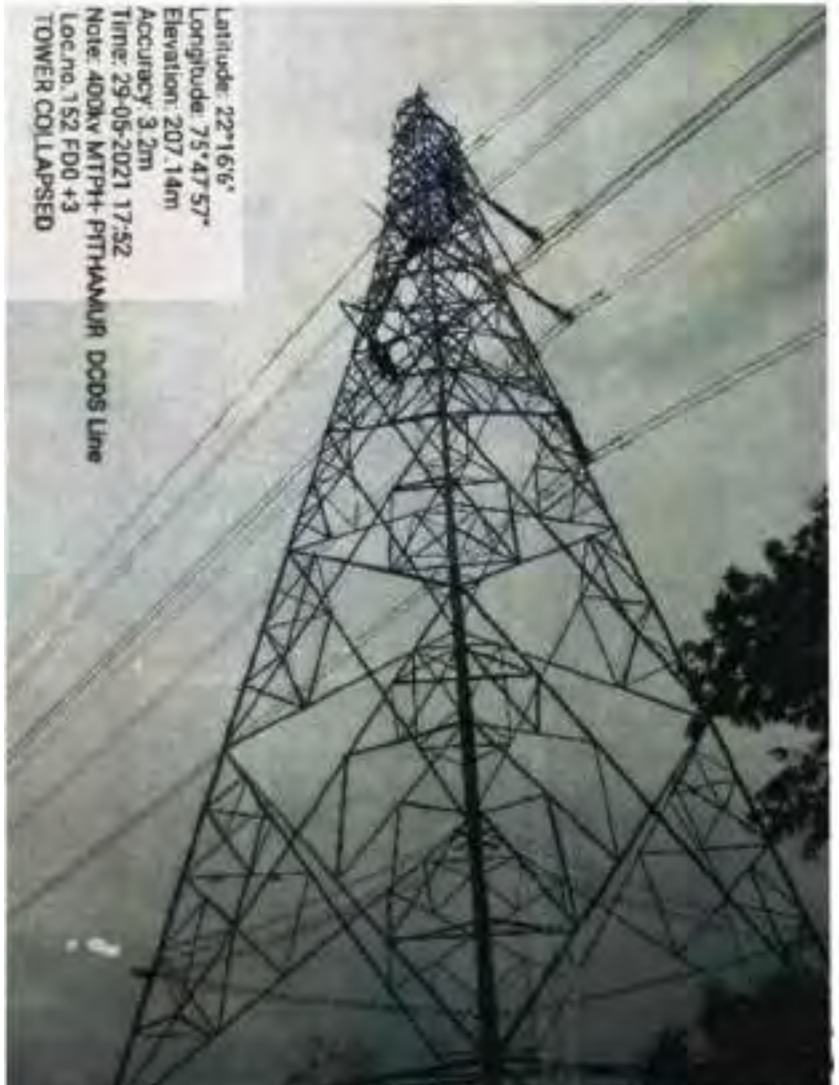
Tower at location 148

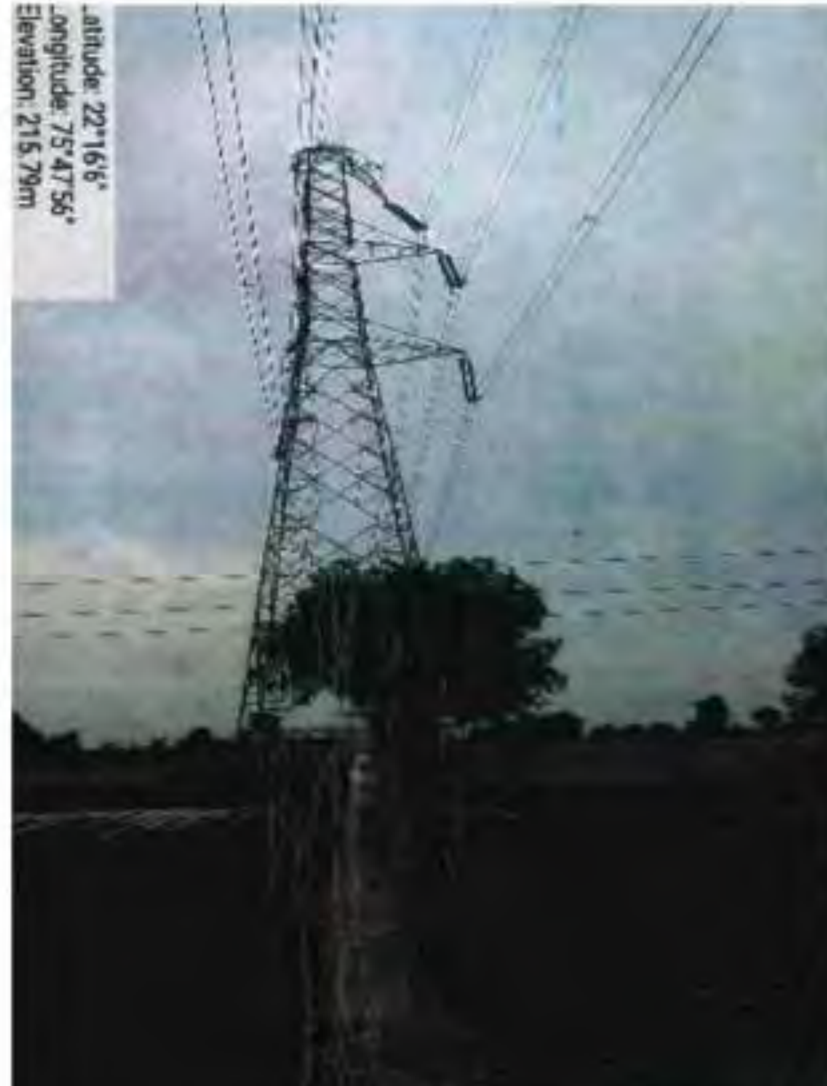
Tower at location 149

Tower at location 150

Tower at location 151

Tower at location 152





Material report

Particulars	Specification	Result
Yield Stress HT	Min 350	Within Limits
% Elongation MS	Min 23	Within Limits
% Elongation HT	Min 22	Within Limits
Tensile Strength HT	Min 490	Within Limits
Bend Test	Should Pass	Pass
Carbon	Max 0.2	Within Limits
Sulphur	Max 0.045	Within Limits
Phosphorus	Max 0.045	Within Limits
Manganese	Max 1.55	Within Limits
Silicon	Max 0.45	Within Limits

5. 400kV Rajgarh SSP

- **Date of Failure: 11/06/2019**
- **Year of Commissioning: 2002**
- **Wind Zone: Medium**
- **Line designed as per IS 802:1977**
- **Number of Tower collapsed: 4 numbers Suspension and 1 number Tension tower.**
- **Reason of Failure: Cyclonic circulation in the area resulting into collapse of location number 564, 565 and partial damage to 562, 563 & 566.**
- **MPPTCL will take up the strengthening work of all suspension towers of this design.**

Tower at location 562

Tower at location 563

Tower at location 564

Tower at location 565

Tower at location 566

Material report

Particulars	Specification	Result
Yield Stress HT	Min 350	Within Limits
% Elongation MS	Min 23	Within Limits
% Elongation HT	Min 22	Within Limits
Tensile Strength HT	Min 490	Within Limits
Carbon	Max 0.2	Within Limits
Bend Test	Should Pass	Pass
Sulphur	Max 0.045	Within Limits
Phosphorus	Max 0.045	Within Limits
Manganese	Max 1.55	Within Limits
Silicon	Max 0.45	Within Limits

Strengthening of Towers

- **400 kV Towers designed as per IS 802: 1977 had been used in 14 Transmission Lines.**
- **Failure of structures observed mostly in 2 Transmission lines namely Malwa - Pithampur and Katni - Damoh, that too in specific areas.**
- **Strengthening of Towers proposed in two Transmission lines (569 numbers Suspension towers).**
- **Key Members (Main Leg) can not be replaced.**
- **Availability of shutdown to replace members of Cage and Cross Arm.**

6. 220kV Omkareshwar Barwaha Tap Nimrani

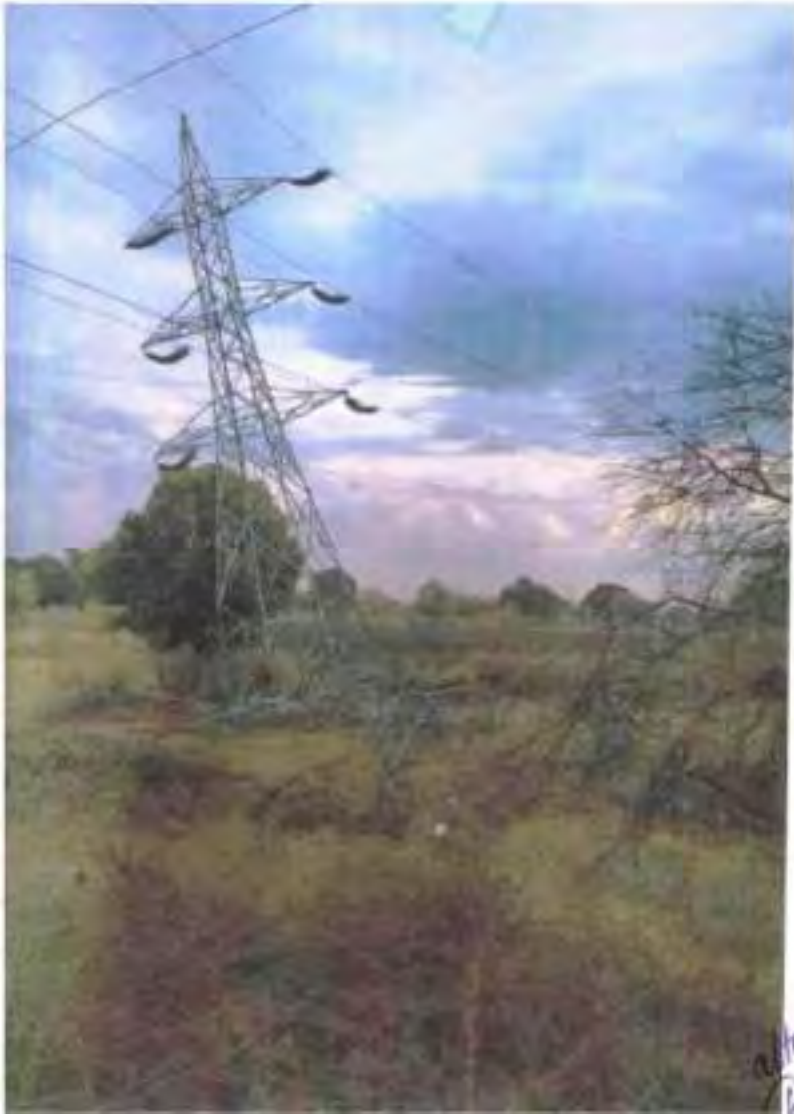
- **Date of Failure: 16/04/2019**
- **Year of Commissioning: 1982**
- **Wind Zone: Medium**
- **Line designed as per IS 802:1977**
- **Number of Tower collapsed: 1 numbers Suspension**
- **Reason of Failure: Collapse of 765kV Khandwa Dhule line of M/s Khargone Transmission Corporation Limited.**
- **This resulted in excessive loading on our Transmission Line resulting into partial damage of tower.**

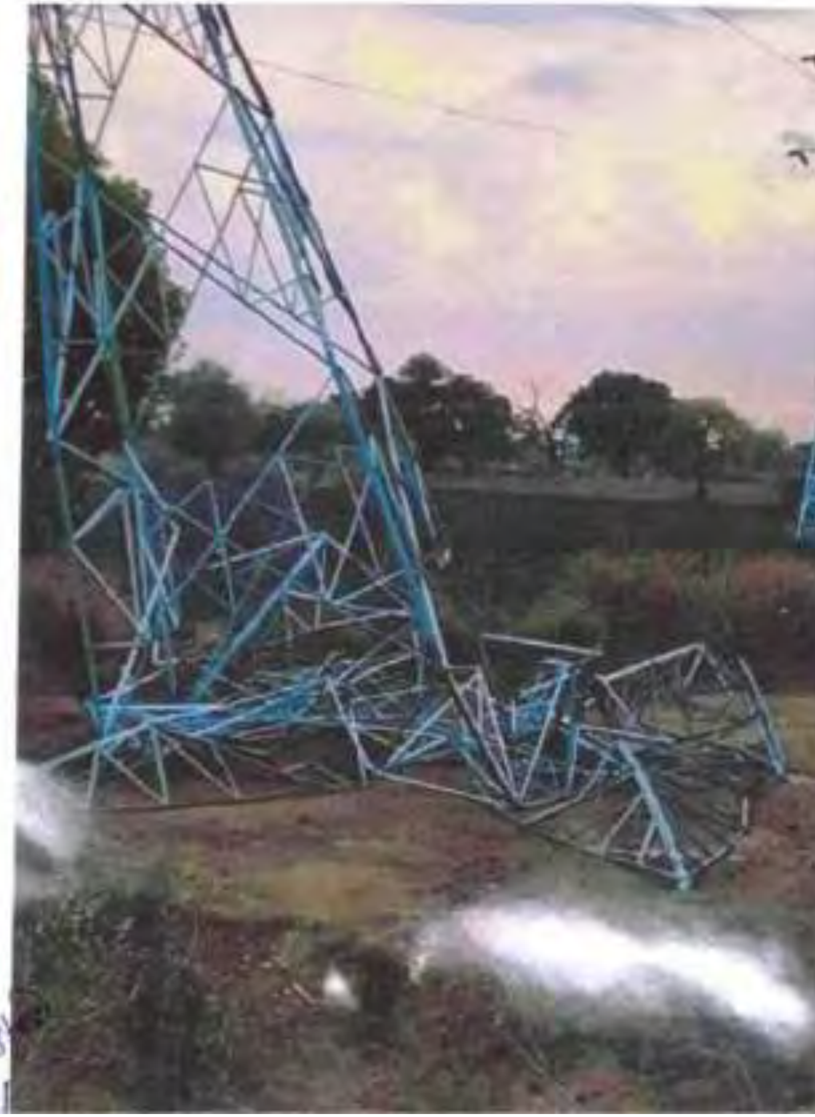
Location Number 22

7. 220kV Jabalpur Narsinghpur

- **Date of Failure: 13/06/2019**
- **Year of Commissioning: 1962/2019**
- **Line designed as per IS 802:1977 Wind Zone Medium.**
- **Collapsed Tower designed as per IS 802:1995 and Wind Zone 4.**
- **Number of Tower collapsed: 1 numbers Suspension location bottom portion with +10M Extension.**
- **Reason of Failure: Heavy wind and Thunderstorm in the area.**

Tower at location 11A





Material report

Particulars	Specification	Result
Yield Stress	Min 250	Within Limits
% Elongation	Min 23	Within Limits
Tensile Strength	Min 410	Within Limits
Carbon	Max 0.23	Within Limits
Bend Test	Should Pass	Pass
Sulphur	Max 0.045	Within Limits
Phosphorus	Max 0.045	Within Limits
Manganese	Max 1.5	Within Limits
Silicon	Max 0.4	Within Limits

8. 220kV Malanpur Auraiya & Mehgaon Adani

- **Date of Failure: 28/05/2020**
- **Year of Commissioning: 1993**
- **Wind Zone: Medium**
- **Line designed as per IS 802:1977**
- **Number of Tower collapsed: 11 numbers Suspension location from 14 to 24.**
- **Continuous record of wind speed is not available with IMD.**
- **Reason of Failure: Heavy Thunderstorm and Cyclone in the area.**

Tower at location 14

Tower at location 15

Tower at location 17

Tower at location 18

Tower at location 19

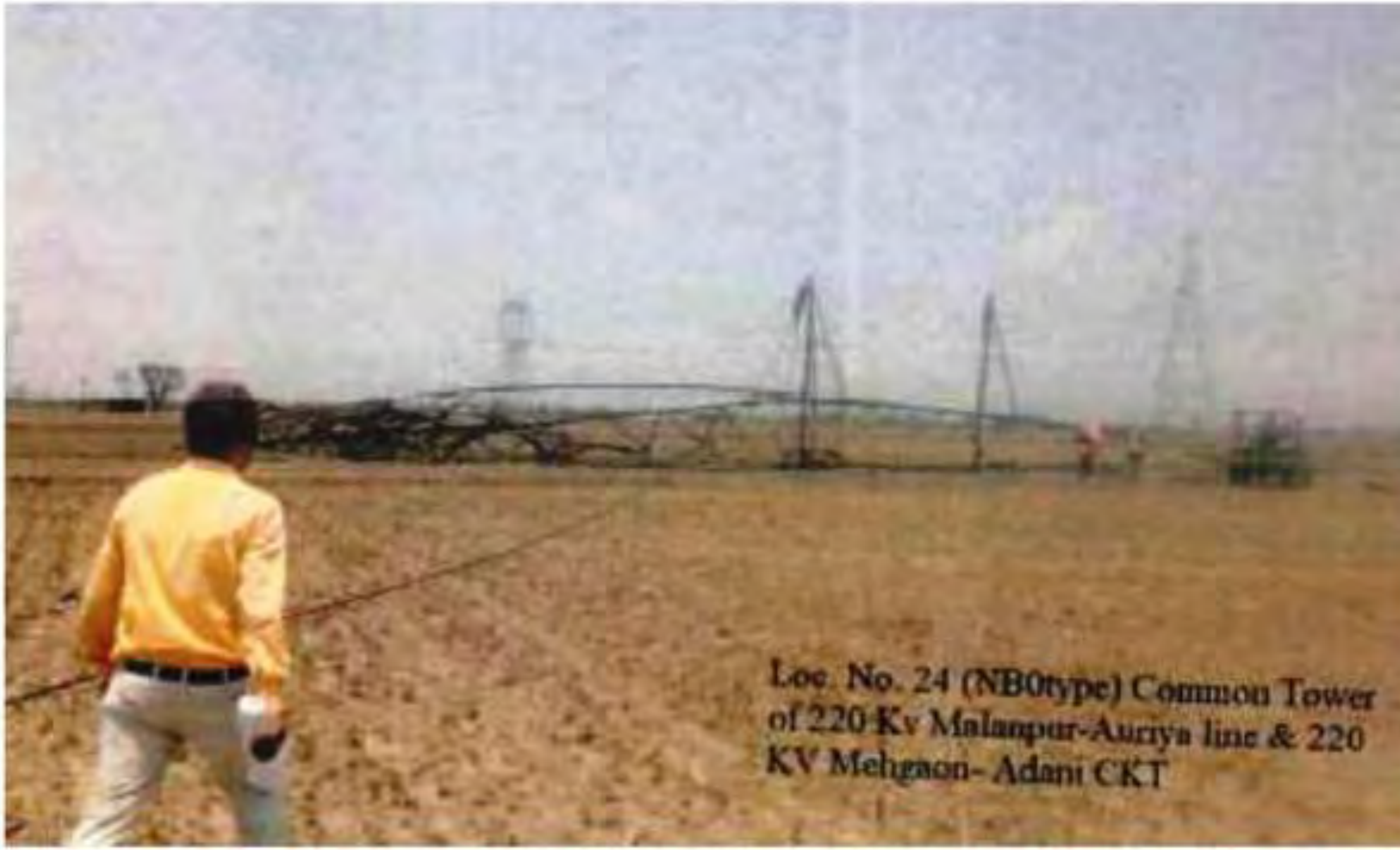
Tower at location 20

Tower at location 21

Tower at location 22

Tower at location 23

Tower at location 24



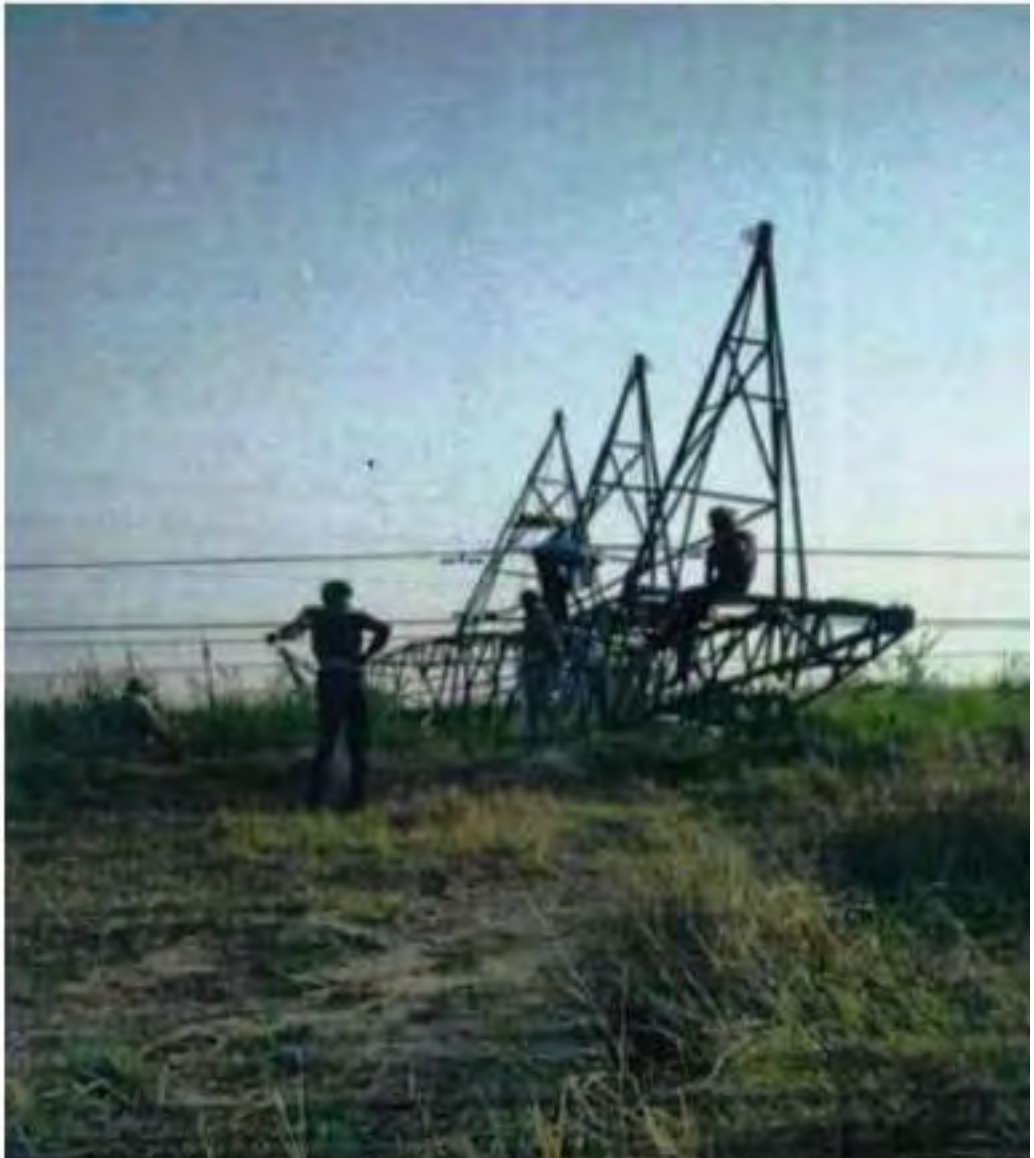
Material report

Particulars	Specification	Result
Yield Stress	Min 250	Within Limits
% Elongation	Min 23	Within Limits
Tensile Strength	Min 410	372
Carbon	Max 0.23	Within Limits
Bend Test	Should Pass	Pass
Sulphur	Max 0.045	Within Limits
Phosphorus	Max 0.045	Within Limits
Manganese	Max 1.5	Within Limits
Silicon	Max 0.4	Within Limits

9. 220kV Malanpur Morena

- Date of Failure: 29/05/2020
- Year of Commissioning: 2017
- Wind Zone: Medium
- Line designed as per IS 802:1995
- Number of Tower collapsed: 3 numbers Suspension location.
- Continuous record of wind speed is not available with IMD.
- Reason of Failure: Heavy Thunderstorm and Cyclone in the area.

Tower at location 31



Tower at location 32

Tower at location 33

Material report

Particulars	Specification	Result
Yield Stress	Min 250	Within Limits
% Elongation	Min 23	Within Limits
Tensile Strength	Min 410	Within Limits
Carbon	Max 0.23	Within Limits
Bend Test	Should Pass	Pass
Sulphur	Max 0.045	Within Limits
Phosphorus	Max 0.045	Within Limits
Manganese	Max 1.5	Within Limits
Silicon	Max 0.4	Within Limits

10. 220kV Malanpur PGCIL

- **Date of Failure: 29/05/2020**
- **Year of Commissioning: 2010**
- **Wind Zone: 4**
- **Line designed as per IS 802:1995**
- **Number of Tower collapsed: 3 numbers Suspension location and 2 numbers Tension location.**
- **Continuous record of wind is not available with IMD.**
- **Reason of Failure: Heavy storm and Cyclone in the area.**
- **As may be seen total 19 towers damaged in the area of different transmission lines. This indicates presence of strong cyclonic wind resulting into damage.**

Tower at location 90

Tower at location 91

Tower at location 92

Tower at location 93

Tower at location 94

Material report

Particulars	Specification	Result
Yield Stress	Min 250	Within Limits
% Elongation	Min 23	Within Limits
Tensile Strength	Min 410	Within Limits
Carbon	Max 0.23	Within Limits
Bend Test	Should Pass	Pass
Sulphur	Max 0.045	Within Limits
Phosphorus	Max 0.045	Within Limits
Manganese	Max 1.5	Within Limits
Silicon	Max 0.4	Within Limits

11. 220kV Amarkantak SGTPS Birsinghpur/ Panagar

- **Date of Failure: 21/09/2021**
- **Year of Commissioning: 1996**
- **Wind Zone: Medium**
- **Line designed as per IS 802:1977**
- **Number of Tower collapsed: 2 numbers Suspension location collapsed.**
- **Reason of Failure: Heavy cyclonic wind and Thunderstorm in the area.**

Location Number 84

Location Number 85

Material report

Particulars	Specification	Result
Yield Stress	Min 250	Within Limits
% Elongation	Min 23	Within Limits
Tensile Strength	Min 410	Within Limits
Carbon	Max 0.23	Within Limits
Bend Test	Should Pass	Pass
Sulphur	Max 0.045	Within Limits
Phosphorus	Max 0.045	Within Limits
Manganese	Max 1.5	Within Limits
Silicon	Max 0.4	Within Limits

CONCLUSION

- **In recent years , there is increase in tower collapse incidences in the country.**
- **Major cause of failure of Transmission Tower may be attributed to cyclonic weather conditions.**
- **Collapse of Towers can also be attributed to ageing of structures.**
- **Due to climatic changes, wind pattern and intensity also changed which in turn is affecting the old design towers.**
- **Strengthening of Old Design towers is the possible solution to avoid damage although there are inherent problems of funding and shutdown associated with it.**

THANK YOU

REPORT

OF

DAMAGED/COLLAPSED TOWERS/CONDUCTORS

OF

765 KV ANTA-PHAGI LINE (CKT. II)

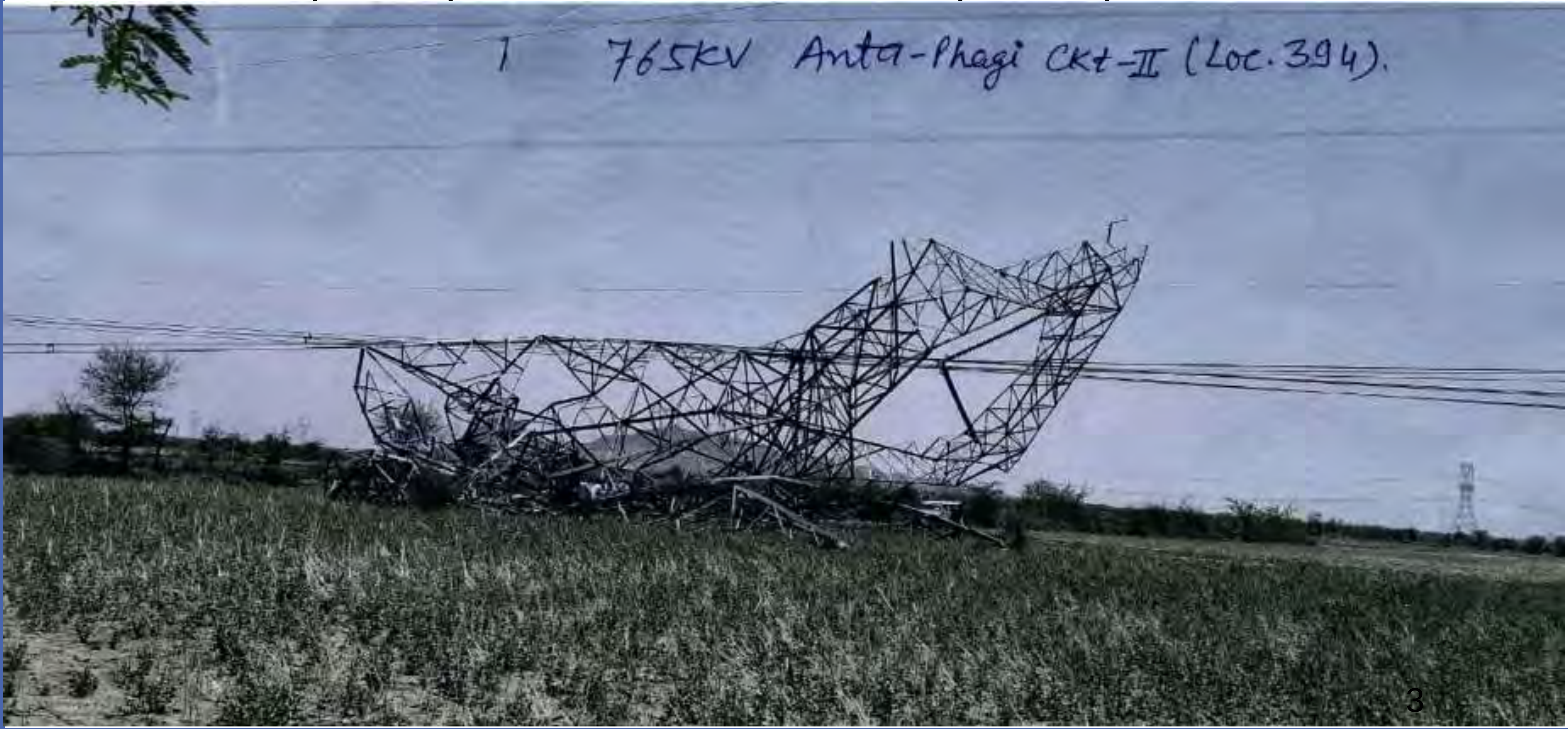
REPORT OF DAMAGED / COLLAPSED TOWERS OF 765 KV ANTA-PHAGI LINE (CKT.II)- LOCATION NO. 72/1 (TTA+3)

- Probable cause of failure:

Non-strengthening of towers by replacement of members with higher section and non-providing additional members.

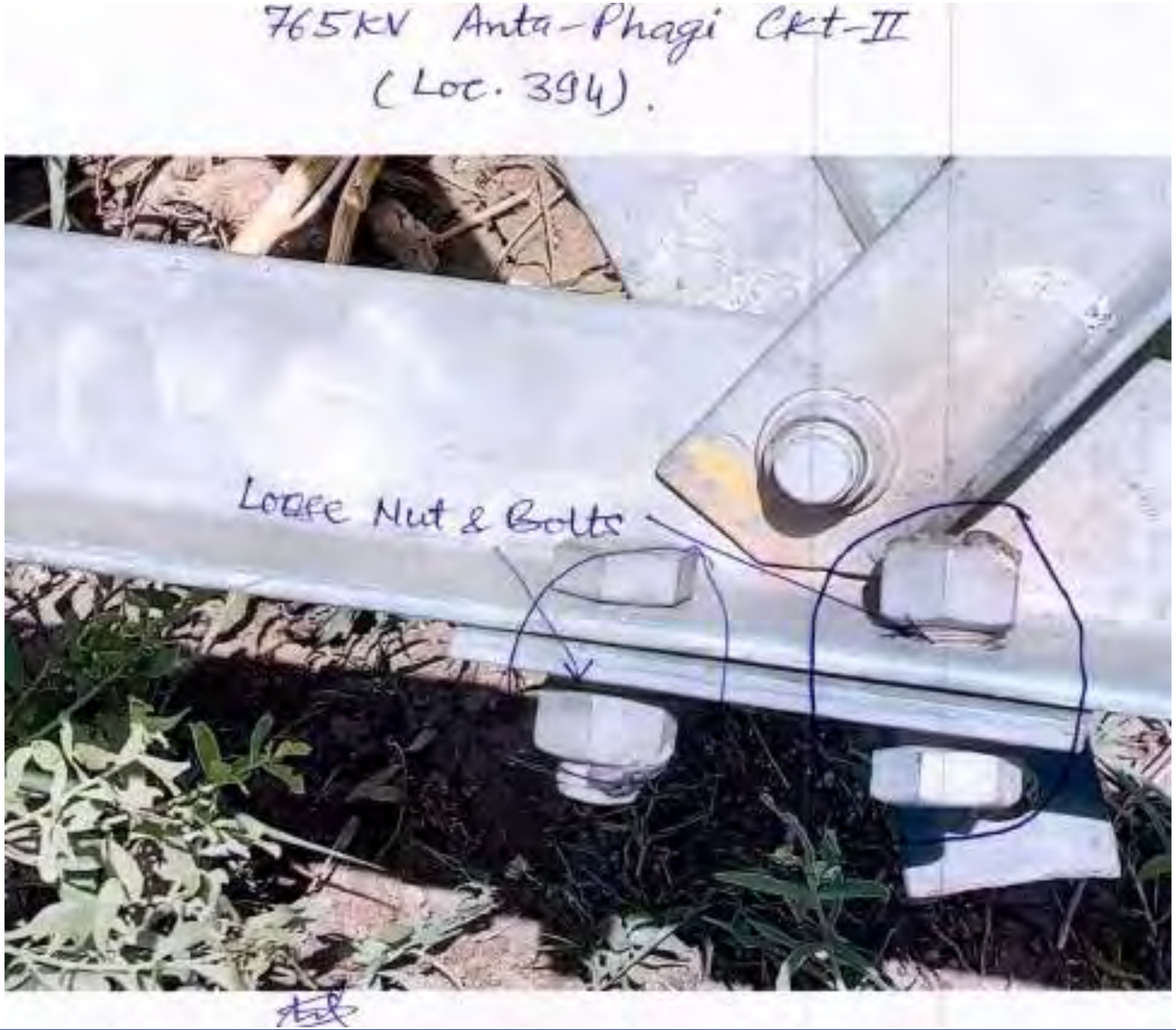
Few photographs are in the upcoming slides

REPORT OF DAMAGED / COLLAPSED TOWERS OF 765 KV ANTA-PHAGI LINE (CKT.II)- LOCATION NO. 72/1 (TTA+3)



REPORT OF DAMAGED / COLLAPSED TOWERS OF 765 KV ANTA-PHAGI LINE (CKT.II)- LOCATION NO. 72/1 (TTA+3)

REPORT OF DAMAGED / COLLAPSED TOWERS OF 765 KV ANTA-PHAGI LINE (CKT.II)- LOCATION NO. 72/1 (TTA+3)



REPORT OF DAMAGED / COLLAPSED TOWERS OF 765 KV ANTA-PHAGI LINE (CKT.II)- LOCATION NO. 61/0 {Loc No. 355}(TTC+3)

- All four conductors of Y-phase with tension strings, extension links and connecting plates with two members marked as APC 373 detached from tower main body and fell down towards location No. 356. Due to this detachment, top portion of tower bent in opposite direction towards location No. 354).
- While inspecting all four tension strings, it was observed that there is no flash over mark on Discs, which shows that there is no electrical reason of failure.
- Lower portion of the tower is found in good condition.

REPORT OF DAMAGED TOWER OF 765 KV ANTA-PHAGI LINE (CKT.II)- LOCATION NO. 61/0 {Loc No 355} (TTC+3)

REPORT OF DAMAGED / COLLAPSED TOWERS OF 765 KV ANTA-PHAGI LINE (CKT.II)- LOCATION NO. 61/0 {355} (TTC+3)

ENQUIRY REPORT OF DAMAGED TOWERS / CONDUCTORS OF 765 KV ANTA-PHAGI LINE (CKT. II) -RECOMMENDATION OF THE COMMITTEE

1. 765 kV single circuit A-Type tower strengthening is required as per PGCIL pattern.
2. If the soil surrounding the chimney top is above the chimney top level, extension of chimney should be done to protect the stub from rusting, coping if damaged or not done, should be properly done.
3. ACDs (Anti Climbing Devices), if not provided or have been stolen, should be provided now.
4. All the Tower members and plates must be fitted with nut and bolts of proper size. No any hole should be remained empty.
5. Over size or loose nut & bolts must be replaced by proper size nut & bolts and proper tightening should be done.
6. All the towers must be checked thoroughly regarding tightening all its members and plates.

8. Missing members If any must be provided by new members with same section and type of steel (MS/HT).
9. If revetment at any location is required, it should be done immediately.
10. The representative of the firm may be called in the field and in his presence fitting of spacers should be checked so frequent loosening of spacers should be resolved.
11. If any sub-conductor of the quadruple bundle of 765 kV line is repaired/replaced, the tension of all four sub-conductors must be equalized to avoid the damage of conductors due to spacers.
12. Corona rings where ever not provided on the lines must be provided immediately.

THANK YOU

Details of Transmission line towers failed / damaged in May 2020

Line Name	Utility	Suspension Towers	Tension Towers	No. of Towers affected
765 kV Lalitpur- Fatehabad (Agra) Ckt-I	UPPTCL	2	0	2
765 kV Lalitpur- Fatehabad (Agra) Ckt-II	UPPTCL	7	1	8
Total	UPPTCL	9	1	10

During heavy Thunderstorm in the month of May- 2020, 10 towers of 765kV Lalitpur - Fatehabad lines got damaged on 03.05.2020 and 28.05.2020

These both Lines were constructed and commissioned by PGCIL under LTS project in Oct. 2016 and April 2017 respectively.

S.NO	T.NO	DAMAGE PART
C-I		
1	146	Peak Damaged
2	147	Full Tower Damaged
C-II		
1	161	Full Tower Damaged Excluding +6 Section
2	162	Full Tower Damaged
3	163	Full Tower Damaged
4	164	Full Tower Damaged
5	179	Peak Damaged
6	180	X-Arm Damaged
7	181	Full Tower Damaged
8	182	Damaged Upto K-Frame

765 kV Lalitpur- Fatehabad (Agra) Ckt-I Transmission Line

Commissioning date	01/10/2016
Date of Failure	03/05/2020
Date of restoration	21/05/2020
Tower No and Type	146 (A+0)
Observations	Tower Configuration :- Horizontal Conductor Type :- Quad Bersimis ACSR OPGW peak of this tower had damaged. Line designed as per Wind Zone-4 Reason :- Tower was collapsed due to the high speed localized thunderstorm in this area.

765 kV Lalitpur- Fatehabad (Agra) Ckt-I Transmission Line

Commissioning date	01/10/2016	
Date of Failure	03/05/2020	
Date of restoration	21/05/2020	
Tower No and Type	147 (A+6)	
Observations	Tower Configuration :- Horizontal Conductor Type :- Quad Bersimis ACSR ➡ This tower collapsed in the direction of perpendicular to the transmission line. Line designed as per Wind Zone-4 ➡ Complete tower had been collapsed but foundation safe. Reason :- Tower was collapsed due to the high speed localized thunderstorm in this area.	

765 kV Lalitpur- Fatehabad (Agra) Ckt- II Transmission Line

Commissioning date	11/04/2017
Date of Failure	03/05/2020
Date of restoration	29/06/2020
Tower No and Type	161 (A+6)
Observations	Tower Configuration :- Horizontal Conductor Type :- Quad Bersimis ACSR ➡ This tower collapsed above 0+6 mtr in the inclination of the transmission line. Foundation not damaged. Line designed as per Wind Zone-4 Reason :- Tower was collapsed due to the high speed localized thunderstorm in this area.

765 kV Lalitpur- Fatehabad (Agra) Ckt-II Transmission Line

Commissioning date	11/04/2017
Date of Failure	03/05/2020
Date of restoration	29/06/2020
Tower No and Type	162 (A+6)
Observations	Tower Configuration :- Horizontal Conductor Type :- Quad Bersimis ACSR This tower collapsed in the inclination of the transmission line. Foundation not damaged. Line designed as per Wind Zone-4 Reason :- Tower was collapsed due to the high speed localized thunderstorm in this area.

765 kV Lalitpur- Fatehabad (Agra) Ckt-II Transmission Line

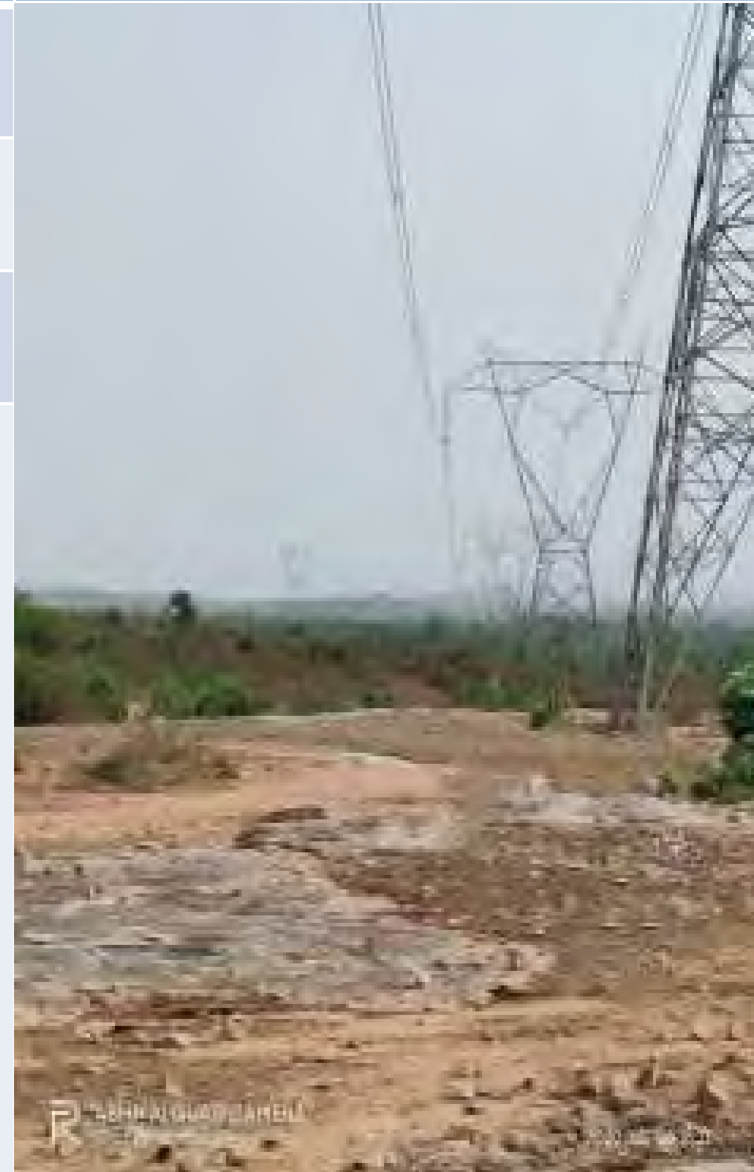
Commissioning date	11/04/2017
Date of Failure	03/05/2020
Date of restoration	29/06/2020
Tower No and Type	163 (A+0)
Observations	Tower Configuration :- Horizontal Conductor Type :- Quad Bersimis ACSR ➡ This tower collapsed in the direction of perpendicular to the transmission line and all 4 stub were also found to be damaged. Line designed as per Wind Zone-4 Reason :- Tower was collapsed due to the high speed localized thunderstorm in this area.

765 kV Lalitpur- Fatehabad (Agra) Ckt-II Transmission Line

Commissioning date	11/04/2017
Date of Failure	03/05/2020
Date of restoration	29/06/2020
Tower No and Type	164 (D+3)
Observations	Tower Configuration :- Horizontal Conductor Type :- Quad Bersimis ACSR ➡ This tower collapsed in the direction of inclination/ perpendicular to the transmission line and 1 No. stub was also found to be damaged. Line designed as per Wind Zone-4 Reason :- Tower was collapsed due to the high speed localized thunderstorm in this area.

765 kV Lalitpur- Fatehabad (Agra) Ckt-II Transmission Line

Commissioning date	11/04/2017
Date of Failure	28/05/2020
Date of restoration	29/06/2020
Tower No and Type	179 (A+3)
Observations	Tower Configuration :- Horizontal Conductor Type :- Quad Bersimis ACSR ➡ EW peak damage at this tower due to tension in conductor. Line designed as per Wind Zone-4 Reason :- Tower was collapsed due to the high speed localized thunderstorm in this area.



765 kV Lalitpur- Fatehabad (Agra) Ckt-II Transmission Line

Commissioning date	11/04/2017
Date of Failure	28/05/2020
Date of restoration	29/06/2020
Tower No and Type	180 (A+3)
Observations	Tower Configuration :- Horizontal Conductor Type :- Quad Bersimis ACSR ➡ Cross arm of This tower damage due to tension in the conductor. Line designed as per Wind Zone-4 Reason :- Tower was collapsed due to the high speed localized thunderstorm in this area.

765 kV Lalitpur- Fatehabad (Agra) Ckt-II Transmission Line

Commissioning date	11/04/2017
Date of Failure	28/05/2020
Date of restoration	29/06/2020
Tower No and Type	181 (A+9)
Observations	Tower Configuration :- Horizontal Conductor Type :- Quad Bersimis ACSR ➡ This tower collapsed in the direction of perpendicular to the transmission line. Line designed as per Wind Zone-4 Reason :- Tower was collapsed due to the high speed localized thunderstorm in this area.

765 kV Lalitpur- Fatehabad (Agra) Ckt-II Transmission Line

Commissioning date	11/04/2017	
Date of Failure	28/05/2020	
Date of restoration	29/06/2020	
Tower No and Type	182 (B+6)	
Observations	Tower Configuration :- Horizontal Conductor Type :- Quad Bersimis ACSR K portion of this tower had collapsed. Line designed as per Wind Zone-4 Reason :- Tower was collapsed due to the high speed localized thunderstorm in this area.	

To find out the root cause of failure of tower, IIT Kanpur was requested to examine the cause of failure.

IIT Kanpur had submitted report and found in analysis that 22 members of A type Tower and 16 members of D Type Tower have slenderness ratio greater than unity and recommended additional back-to-back angles, channels and plate as appropriate to the failed members and adopting HT steel of the strengthening of these failed towers.

These reports already sent to Design section of UPPTCL and Power grid in April, 2021.

KPTCL

FAILURE OF 220KV KAPNOOR-SHAHBAD-SHAHPUR D/C LINE AT LOC NO 389 & 390

DETAILS OF TRANSMISSION LINE

1	**Name of Tr line**	**220kV Kapnoor-Shahbad-Shahpur D/C line**
2.	Length of line(Km)	220kV Shahpur-Kapnoor- 101.94Km 220kV Shahbad-Kapnoor-52.60Kms
3.	Type of configuration	D/C
4.	No of towers and type of towers failed	Two (Tension)
5.	Tower Loc No	389(DB+18), 390(DB+15)
6.	Name and size of conductor	Drake , 28.13mm dia
7.	No of sub-conductors per bundle and bundle spacing	NIL
8.	Number and size of conductor	1
9.	Type of insulator in use	Porcelain, 120kN
10	Configuration of insulator	Tension
11	No of insulator per string and no of strings per phase	16 Nos, Double tension strings

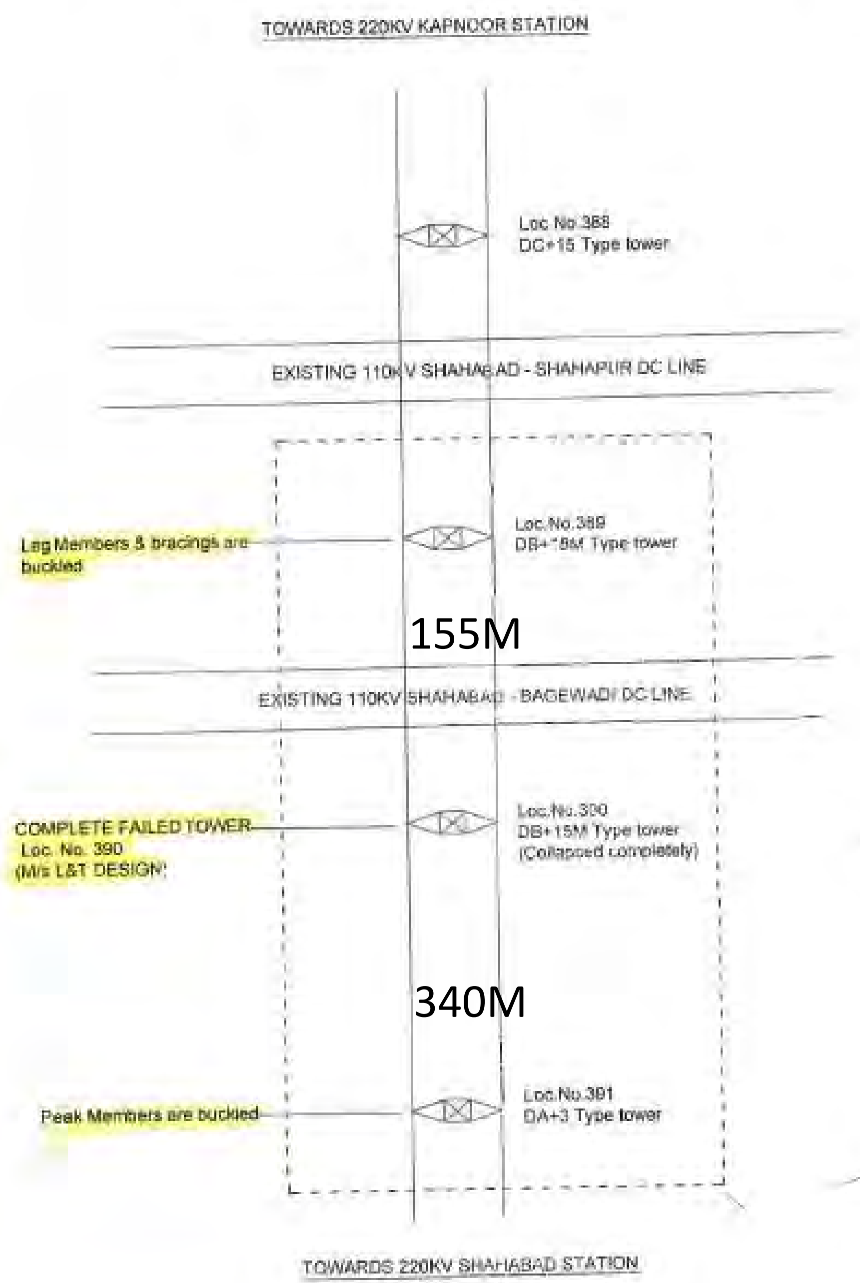
12	Year of construction/commissioning	2003
13	Executing Agency	M/s Deepak Cable(India) Limited
14	Weather condition on date of failure	Rainy & stormy wind(Whirl wind around the area)
15	Terrain category	1
16	Wind zone and velocity of wind	Medium wind, 43Kg/sqmm
17	Details of earthing of tower	Pipe type
18	Line designed as per IS 802	IS 802, 1977
19	The agency who designed the line	L&T
20	Any special consideration in design	NIL
21	Date and time of occurrence/discovery of failure	17.04.2020, 17:15 Hrs
22	Any missing member found before/after failure of towers	Nil
23	Condition of foundation after failure	Intact

24	**Brief Description of failure**	**On 17.04.2020 at 17:15HRs the 220kV line tripped on DPR at both ends. On inspection it was found that tower no 390(DB+15) was collapsed and T.No 389(DB+18) main leg member damaged due to heavy rain and whirl wind.**
25	Probable cause of failure	➢ Towers designed as per IS 802:1977 in which only transverse load(wind in 0 deg) was considered for calculation of wind load on conductor, insulator, ground wire and tower body. Hence these towers are vulnerable to high wind loads. ➢ Span length between loc 389(DB+18) to 390(DB+15) was 155M & between Loc No 390 (DB+15)to 391 (DA+3)was 340M. In case of towers with higher body extensions such as +15M, +18M & +24M, the wind load is the major governing factor under normal condition. Hence in order to compensate the higher wind pressure, the wind spans are generally reduced such that, the total wind load (wind on conductor, insulator string) on the tower remains same as original design. As long as the wind is with in permissible limits, the tower sustains the load. In the instant case, the wind span is found to be on the higher side and hence more wind loads have acted on the tower No 390. Heavy whirl wind which passed through this stretch acted on weakened tower which could not resist the heavy wind.

26	Details of previous failure of line/tower	4 nos of 220kV tower failed in 21.05.2010.(Loc no 522 to 526) 2 No of 220kV failed on 10.04.2012(Loc no 404 to 405)

in Kalaburgi Dist.

ANNEXURE-A



B

TREE FELLING IN SURROUNDING AREA DUE TO WHIRL WIND

WIND SPEED DATA

[illegible]

Sl.No	Date	Time	Wind Speed (km/hour)
1	17-04-20	9:45	2.78
2	17-04-20	9:00	2.9
3	17-04-20	[illegible]	[illegible]
4	17-04-20	9:30	0
5	17-04-20	[illegible]	[illegible]
6	17-04-20	10:00	0
7	17-04-20	10:15	[illegible]
8	17-04-20	10:15	1.21
9	17-04-20	10:45	0
10	17-04-20	11:00	1.8
11	17-04-20	11:12	1.44
12	17-04-20	11:15	2.56
13	17-04-20	11:45	1.8
14	17-04-20	12:00	2.38
15	17-04-20	12:15	3.98
16	17-04-20	12:30	3.61
17	17-04-20	12:45	3.60
18	17-04-20	13:00	1.8
19	17-04-20	13:15	3.10
20	17-04-20	13:30	2.78
21	17-04-20	13:45	2.03
22	17-04-20	14:00	3.96
23	17-04-20	14:15	2.38
24	17-04-20	14:30	2.38
25	17-04-20	14:45	1.3
26	17-04-20	15:00	1.8
27	17-04-20	15:15	2.58
28	17-04-20	15:30	3.60
29	17-04-20	15:45	3.02
30	17-04-20	16:00	3.21
31	17-04-20	16:15	4.89
32	17-04-20	16:30	5.04
33	17-04-20	16:45	6.17
34	17-04-20	17:00	6.17
35	17-04-20	17:15	4.6
36	17-04-20	17:30	7.61
37	17-04-20	17:45	[illegible]
38	17-04-20	18:00	[illegible]
39	17-04-20	18:15	4.11
40	17-04-20	18:30	8.01
41	17-04-20	18:45	3.50
42	17-04-20	19:00	2.88
43	17-04-20	19:15	2.98
44	17-04-20	19:30	2.21
45	17-04-20	19:45	3.24
46	17-04-20	20:00	6.12
47	17-04-20	20:15	4.52
48	17-04-20	20:30	2.58

Sl.No	Date	Time	Wind Speed (km/hour)
49	17-04-20	20:45	0
50	17-04-20	21:00	0
51	17-04-20	21:15	0
52	17-04-20	21:30	0.12
53	17-04-20	21:45	0.12
54	17-04-20	22:00	0
55	17-04-20	22:15	0
56	17-04-20	22:30	0
57	17-04-20	22:45	0
58	17-04-20	23:00	0
59	17-04-20	23:15	5.17
60	18-04-20	23:30	1.44
61	18-04-20	23:45	1.44
62	18-04-20	0:00	0
63	18-04-20	0:15	0
64	18-04-20	0:30	0
65	18-04-20	0:45	0
66	18-04-20	1:00	0
67	18-04-20	1:15	0
68	18-04-20	1:30	2.16
69	18-04-20	1:45	2.15
70	18-04-20	2:00	1.44
71	18-04-20	2:15	1.07
72	18-04-20	2:30	[illegible]
73	18-04-20	2:45	[illegible]
74	18-04-20	3:00	3.46
75	18-04-20	3:15	[illegible]
76	18-04-20	3:30	0
77	18-04-20	3:45	1.48
78	18-04-20	4:00	1.08
79	18-04-20	4:15	0
80	18-04-20	4:30	0
81	18-04-20	4:45	0
82	18-04-20	5:00	0
83	18-04-20	5:15	0
84	18-04-20	5:30	0
85	18-04-20	5:45	0
86	18-04-20	6:00	0
87	18-04-20	6:15	0
88	18-04-20	6:30	0
89	18-04-20	6:45	0
90	18-04-20	7:00	0
91	18-04-20	7:15	0
92	18-04-20	7:30	0
93	18-04-20	7:45	0
94	18-04-20	8:00	0
95	18-04-20	8:15	0
96	18-04-20	8:30	0

Remedial Measures

- The failed “DB+15” tower was replaced by 220kV “DD+15” at loc No 390.
- “DB+18” tower was provided at location no 389.
- The Buckled peak members of the tower at location no 391 (DA+3) was replaced.

THANK YOU

Sterlite Power

Jabalpur-Bina
Tower failure Report

Dr Deepak Lakhapati

9 th June 2019

Sterlite Power

Jabalpur-Bina – Towers collapsed on the evening *at 16:34 hours on 07th June, 2019* due to localised stormy wind, Line was in service since *30th JUNE 2015*

LOCAL NEWS OF INCIDENCE


प्रकृति का कहर • तेंदूखेड़ा सहित आसपास के इलाकों में आफत बनकर आई आंधी ने किया भारी नुकसान

आंधी-बारिश से तेंदूखेड़ा में तबाही, हाइटेंशन लाइन के 3 टॉवर गिरे, आकाशीय बिजली से बच्ची की मौत

सड़क पर पोल सहित बिजली के तार गिरे, घरों के छप्पर उड़े, आकाशीय बिजली गिरने से भैंस की मौत, 11केवी लाइन के भी 23 खंभे गिरे

बूंदाबांदी और बादलों के कारण 1.6 डिग्री नीचे आया दिन का तापमान, रात का बढ़ा

पथरिया: आकाशीय बिजली गिरने से बालिका की मौत

दिनभर उमस भरी गर्मी ने लोगों की बेचैनी बढ़ाई

LOCAL NEWS OF INCIDENCE

Weekend पत्रिका दमोह

कई पेड़ों सहित टीन टप्पर उड़े

डेढ़ घंटे की आंधी ने डेढ़ लाख केवी के तीन खंभे ढहाए, गाज गिरने से भैंस की मौत

अब रजिस्ट्रेशन के लिए भटक रहे किसानों का भुगतान अटका

व्यापारियों ने रजिस्ट्रेशन होने से पहले ही किसानों से खरीद ली प्याज

कुएं में मिला महिला का शव, 5 जून से थी लापता

LOCAL NEWS OF INCIDENCE


दमोह

जान जोखिम में डालकर कुएं से पानी निकालने मजबूर ग्रामीण

भगवान की लीलाओं को भाव से समझा जा सकता है : रवि कृष्ण

सीएम हेल्पलाइन के प्रकरणों का समय पर हो निराकरण नहीं तो होगी कार्रवाई

तेंदूखेड़ा में झमाझम बारिश के साथ गिरे ओले, गर्मी से मिली राहत

अघोषित बिजली कटौती से लोग हो रहे परेशान

निवर्तमान कलेक्टर को दी विदाई

स्व सहायता समूह के नाम से आए 40 हजार रुपए निकाले

TOWER COLLAPSE

Tower location No. with reference to nearest substation (indicate Name):

Nearest substation is Bina substation (PGCIL)

Location no. 17/9, 17/10, 17/11, 17/12 were totally collapsed and location no. 17/8 is Partially damaged.

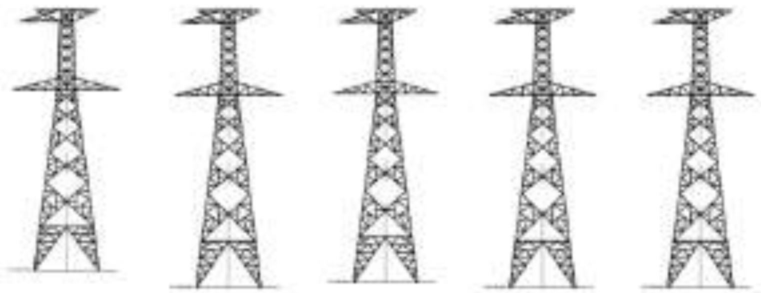
1) Location no. 17/8 (A+0) tower no. 94 - Partially collapsed.

2) Location no. 17/9 (A+3) tower no. 95 - fully collapsed.

3) location no. 17/10 (A+3) tower no. 96 - fully collapsed.

4) location no. 17/11 (A+0) tower no. 97 - fully collapsed.

5) location no. 17/12 (A+9) tower no. 98 - fully collapsed.



17/8	17/9	17/10	17/11	17/12
SA+0	SA+3	SA+3	SA+0	SA+9

TOWER DAMAGES

TOWER DAMAGES

TOWER DAMAGES

Observations

1) *Exceptionally high wind condition prevailed for some time in the area on the day of failure of tower.*
2) *All suspension towers collapsed due to cascading*
3) *All plain area for long distance*
4) *Tower collapse in perpendicular direction pulling down balance towers*

KTL Tower failure Report

Dr Deepak Lakhapati
21 st April ,2019

Sterlite Power

KTL – Towers collapsed on the evening of 16 th April due to localised stormy wind causing damage to PGCIL and MPTCL Transmission lines .

LOCAL NEWS OF INCIDENCE

STORM BRINGS DOWN 3 HIGH TENSION LINE TOWERS IN SANAWAD

SANAWAD

मालवा-निमाड़ : खरगोन में हाइटेंशन लाइन के चार टॉवर, 150 से अधिक बिजली खंभे गिरे, 20 घायल

खरगोन के आली टोकसर में आंधी से हाइटेंशन लाइन का टॉवर धराशायी हो गया।

मालवा-निमाड़ । हमारे प्रतिनिधि

अंचल में कई स्थानों पर आंधी, बारिश और ओलों से नुकसानी का मंजर बुधवार को सामने आया है। खुले में रखा गेहूं भीग गया, फसल प्रभावित हुई और पेड़ धराशायी हो गए। अकेले खरगोन जिले में आंधी की चपेट में 20 से अधिक लोग घायल हो गए। इनमें [illegible] गंभीर घायलों को इंदौर रेफर किया गया। 150 विद्युत खंभे टूट गए। टोकसर में चार हाइटेंशन लाइन टावर धराशायी हो गए। एक टावर की कीमत 80 से 90 लाख है। अधिकांश क्षेत्रों में बिजली गुल रही है।

मंदसौर : जिले में करीब एक हजार हेक्टेयर भूमि पर रबी की फसल भीग गई। इसके अलावा समर्थन मूल्य पर गेहूं खरीदी केंद्रों पर करीब 20 हजार क्विंटल गेहूं भीग गया। शामगढ़ मंडी के केंद्र पर करीब चार हजार क्विंटल गेहूं भीग गए।

बड़वानी : [illegible] में बिजली गिरने से [illegible] बाई (33) पति [illegible] की मौत हो गई। कई ग्रामों में आंधी से 27 मकान क्षतिग्रस्त हुए हैं। 56 गांवों में विद्युत व्यवस्था प्रभावित हुई।

शाजापुर : प्रशासन की टीम गेहूं खरीदी केंद्रों और खेतों में पहुंची। जिले में दो लाख क्विंटल गेहूं खुले में पड़ा है। बारिश से हजारों क्विंटल गेहूं भीग गया।

प्रदेश : नरसिंहपुर, गुना और सागर में ओलों का कहर

जबलपुर/भोपाल (नईदुनिया)। महाकोशल-विंध्य में रविवार से मौसम में [illegible]

नरसिंहपुर जिले के [illegible] तहसील में फसल खराब हुई। शहडोल के [illegible]

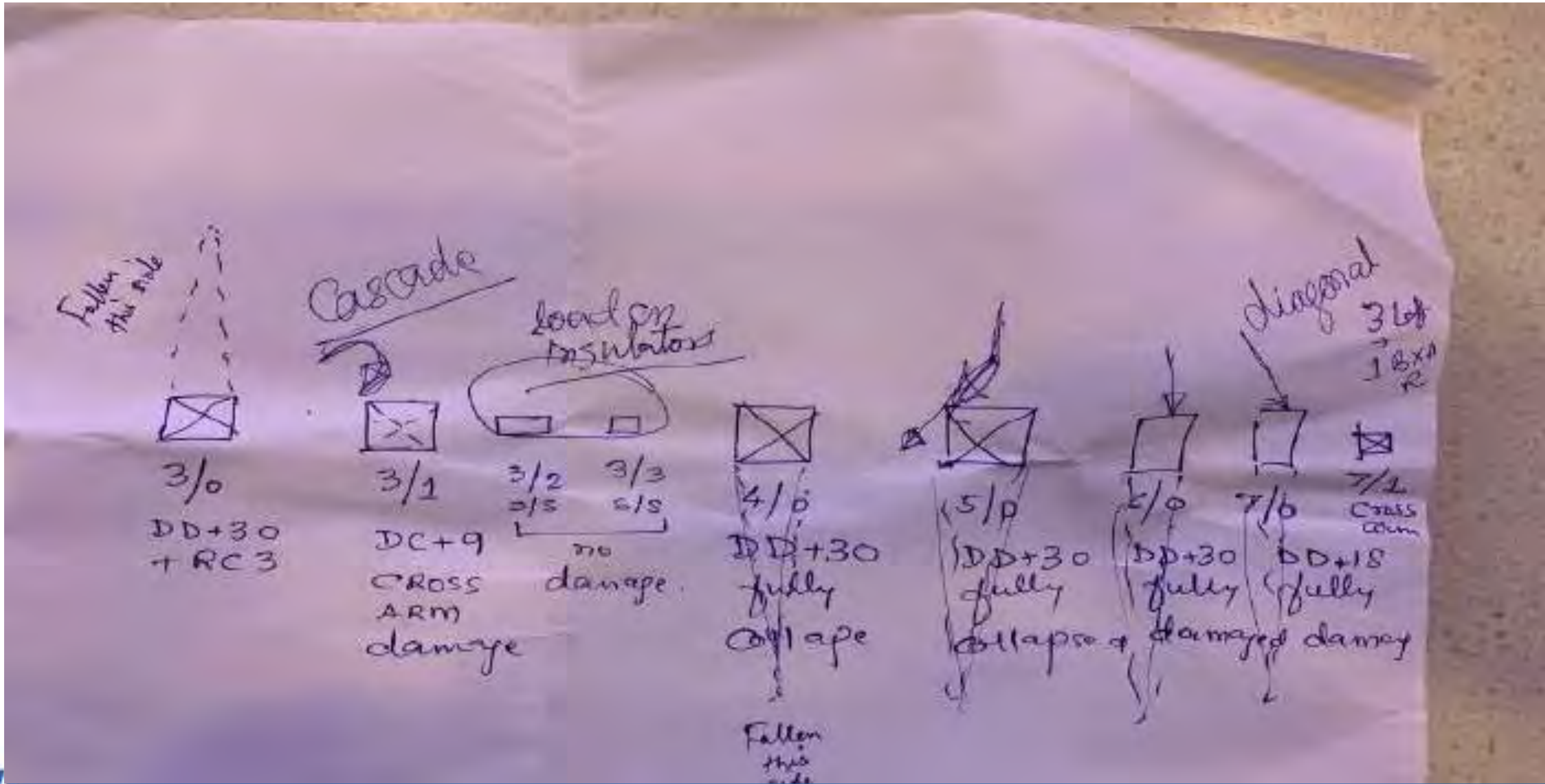
LOCAL NEWS OF INCIDENCE

हाईटेंशन लाइन के तीन टावर खेतों में गिरे, विधायक ने की किसानों से चर्चा

80 लाख रु. खर्च के बाद भी स्टेडियम का निर्माण

जीतू यादव व दो अन्य एक साल के लिए जिलाबदर

DIRECTION OF TOWER FAILURES



PHOTOS OF SITE VISIT ON 18 th and 19 th APRIL ,2019

A) Foundation Damages

B) Tower Damages

C) Hardware fittings damages

FOUNDATION -DAMAGES

FOUNDATION -DAMAGES

FOUNDATION -DAMAGES

TOWER –DAMAGES

TOWER –DAMAGES

TOWER –DAMAGES

TOWER –DAMAGES

TOWER –DAMAGES

TOWER -DAMAGES

TOWER -DAMAGES

HARDWARE FITTINGS –DAMAGES

HARDWARE FITTINGS –DAMAGES

HARDWARE FITTINGS –DAMAGES

SITE VISIT ON 18 TH AND 19 TH APRIL ,2019

SITE VISIT ON 18 TH AND 19 TH APRIL ,2019

SITE OBSERVATIONS

A) 5 Towers (4 nos – DD+30 , 1 – DD+18) towers collapsed perpendicular to the line.

B) Conductors fell on the Powerlines of PGCIL and MPTCL damaging their towers and caused their outage .

C) 2 tower cross-arms damaged as cascading impact .

D) 2 suspension tower earth-wire peaks damaged , and towers are under tension on insulators , need to be supported by guys to prevent possible collapse

E) Stubs are bent at the Chimney, Foundation chimney shall need to be broken for providing the Butt Joints and then additional reinforcement shall be provided to reinforce the chimney .

F) All the hardware fittings got completely damaged ,

G) Panel nos 3,4 &5 , main leg cut and separated .

DMTCL - River changing course in 2019

DM, district authorities camping at site with NDRF team

21 - 24 August 2019

Difficulties during protection of collapsed towers

Difficulties during protection of collapsed towers

हथुआ-बरौली प्रभात

गंडक का कटावी तांडव जारी, टावर पर खतरा बरकरार

कटाव रोकने के लिए डाले जा रहे जियो और सैंड बैग

Prabhat Khabar, Patna Edition, 27th Aug 2019

जद्दोजहद : छठे दिन भी टावर बचाने में जुटे रहे इंजीनियर और मजदूर

गोपालगंज प्रभात

प्रभात खबर

पटना, शुक्रवार

23.08.2019 | 03

गंडक की उग्र कटावी धारा से धीमा पड़ा टावर बचाने का काम

- लाइफ जैकेट में डीएम पहुंचे कटाव स्थल पर, पूरे दिन किया कैंप

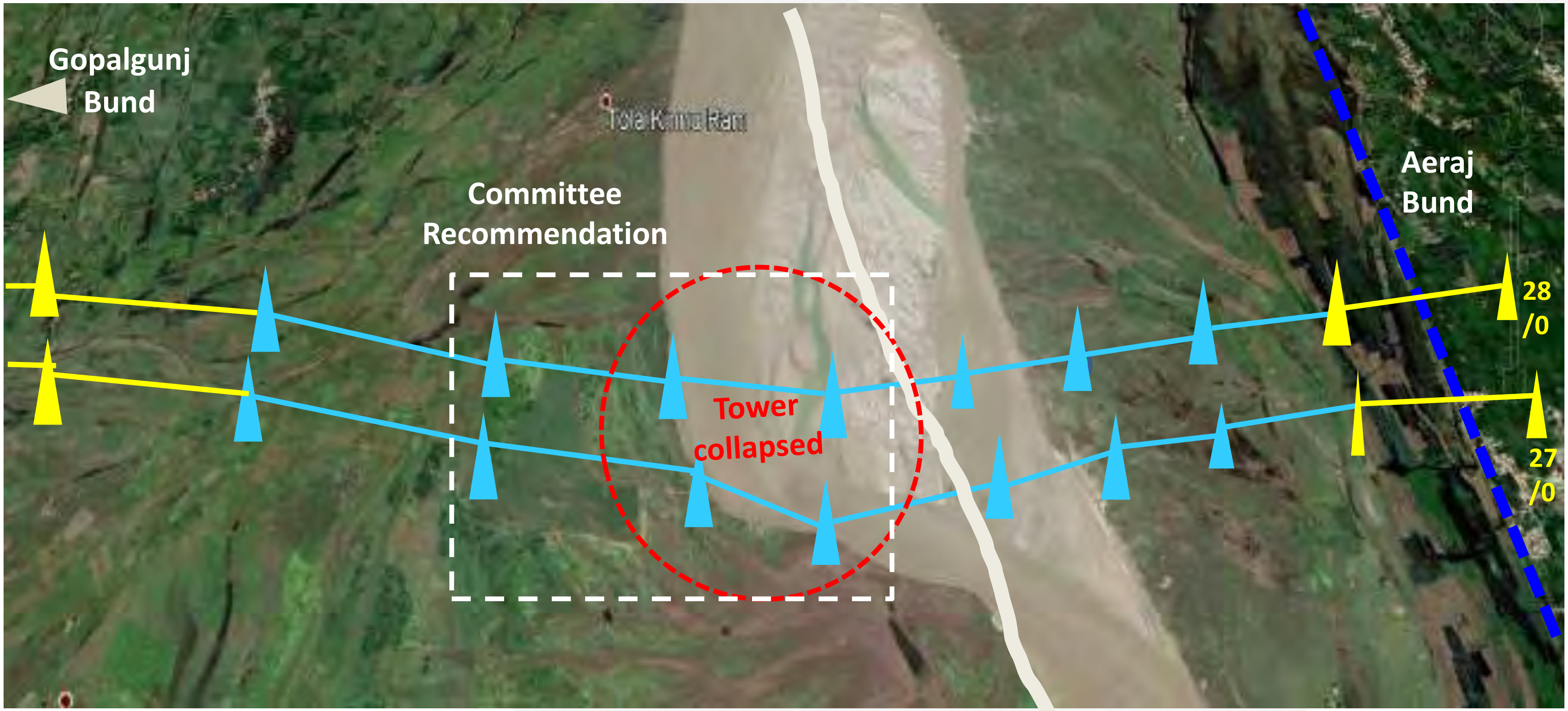
नदी के कटाव की चपेट में टावर

दहेज हत्या में सास-ससुर को सात सालों की कारावास

Committee Recommendation

- All four collapsed tower to be shifted on Pile foundations
- Considering change in river course of Gandaki River , additional two towers also to be shifted to Pile foundations and increase in span may also be considered
- Tower at location no. 27/1 which has titled to be shifted to new pile foundation
- New pile foundations shall be designed considering maximum scour depth as per IRC 78:2014
- DMTCL to take up with relevant government agencies to take up dredging or any other protection measures at suitable places in river to control washing away of the river bank and protect the transmission line

Status of Committee recommendation



Committee recommended – 6 Pile foundations
DMTCL has moved 10 towers to Pile foundations

Further , DMTCL has also increased the Span from Avg. 450m to Avg. 650m

As a result the first open cast foundation has been moved to 2 kms from the Gopalgunj side bank and 1 km from the Aeraj side Bank

Interim measures for restoration

- The LILO section of DMTCL was restored through Emergency Restoration System in the month of March 2020 (within 7 to 8 months period) *{6 ERS systems also got washed away by nature fury during restoration}*
- A temporary solution, a single circuit - single conductor solution was implemented which ensured power flow to the northern districts of Bihar
- Further, amidst Covid and unprecented flooding's in the region in the month of March 2020, complete scheme incorporating all recommendation of the Committee on Tower Failures was implemented and line was charged restoring the complete power supplies

Raichur – Sholapur Transmission Company Private Limited.

Presentation on
Raichur to Sholapur 765KV, Quad S/C Transmission Line.

INTRODUCTION

Raichur Sholapur Transmission Company Private Limited (RSTCPL) is a consortium company of three companies namely, Patel Engineering Limited, Mumbai (Lead Partner); Simplex Infrastructures Limited, Kolkata; and BS Transcomm Limited, Hyderabad. RSTCL has won the bid in Dec 2011 on BOOM basis as a Transmission Service Provider (TSP) to construct Raichur-Sholapur 765 kV Single Circuit Transmission Line – 1, forming the transmission system associated with Krishnapattnam UMPP – Synchronous Interconnection between Southern Region and Western Region (Part-B), in response to an invitation by REC Transmission Projects Company Ltd.

DESCRIPTION OF THE PROJECT

The Project consists of construction of 765 kV Single Circuit Transmission Line-2 between Raichur and Sholapur, forming the transmission system associated with Krishnapattnam UMPP – Synchronous interconnection between Southern Region and Western Region (Part-B). The utilization of transmission line will depend upon the load demand and power availability. The line length is about 210 km.

The line commences from Power Grid’s 765/400 kV substation near Askihal Village, Raichur District, Karnataka State;

And

Terminates at Power Grid’s 765/400 kV substation near Limbi Chincholi Village, Solapur District, Maharashtra State.

Around 180 km of the line lies in Karnataka, while the balance line portion is in Maharashtra

Report On Raichur Sholapur 765 Kv S/C Quad transmission line Tower Collapse.

On 03.06.2019 we came to know of an astonishing damage by act of God to the 765 KV Raichur – Sholapur transmission line.

Tower Collapse-:

- On 3rd June-2019 Due to heavy Rain, Thunder & Twisting Wind our 07 nos. Tower Collapse.

Detail Of Tower Collapsed

Sr.no	Tower No.	Type of tower	Remark
1	431 Foundation Damaged	A+3	Jewergi K
2	432 Foundation Damaged	A+3	Jewergi K
3	433 Foundation Damaged	A+0	Jewergi K
4	431 Fully Damaged	A+3	Jewergi K
5	432 Fully Damaged	A+3	Jewergi K
6	433 Fully Damaged	A+0	Jewergi K
7	434 Partially Damaged	A+0	Jewergi K
8	435 Partially Damaged	A+3	Bablad
9	436 Partially Damaged	A+0	Bablad
10	437 Partially Damaged	B+0	Bablad
11	**Stringing done from Tower No. 431 to Tower No. 439, 3.124 Km**		

We get the information of our Line Tripping On 3rd of June-2019, at 17:54, Our Maintenance team reach the spot to find out the reasons for Line Tripping But due to heavy rain, wind & Lightning they are not able to get down from their Vehicle. But from Inside the Vehicle they saw that some towers are collapsed. **Next day Our Maintenance team found that 07 No's tower were** collapsed as per above mention table. Not only Our tower but GESCOM Surrounding area Poles, Many trees are also damaged.

- RSTCPL is having experience staff & they are well aware of tools, devices & equipment which are used in transmission Line, Knowing the situation we immediately deployed the team & started the removing collapsed tower to clear the site the location to construct the new tower.
- It was very difficult task as it was the rainy season & we are not getting full day to work, also because of Black Cotton Soil, water Logged ground, Vehicle movement was very difficult in monsoon season. Moreover The Tower was collapsed in Border Line of Karnataka & Maharashtra (431,432,433,434 in Karnataka & 435,436 & 437 are in Maharashtra.)

Material Test Report-:

- As require by CEA/SRPC & to know the material quality we tested few member from tower parts in CPRI Bangalore. We took the samples randomly from the debris of collapsed tower.

CENTRAL POWER RESEARCH INSTITUTE

CPRI

TEST REPORT

Test Report Number	CPRI/BLR/MED/M/SC/19T0041, Dated: 28.08.2019
Name & Address of the Customer	RAICHUR SHOLAPUR TRANSMISSION COMPANY PVT. LTD. Plot No. 8, Survey No. 20/A, above VKG TATA Showroom, Gunj Area, Hyderabad Road, YADGIR -585 -201, Karnataka Ref. Email & Letter No. RSTCPL/Motor/Test/CPRI/07 Dated: 30.07.2019
Name & Address of the Manufacturer	Nil
Particulars of Sample Tested	Angle Sections of 765 kV S/C QUAD Transmission Line Tower Raichur to Sholapur Inter-Regional Line
Condition of Sample on Receipt	: Galvanized
Type	: Nil
Designation	: Nil
Serial Number	: Marked "HSB SA"
Number of samples Tested	: Eleven
Date(s) of Test(s)	: 27.08.2019
CPRI Sample(s) Code No	: [illegible] (1 to 11)
Particulars of Tests Conducted	: Tensile Test
Test in accordance with Standard/ Specification	As per IS 1608 (Part-1) : 2018 / ISO 6892-1 : 2016
Sampling Plan	Not Applicable
Customer's requirement	Nil
Deviation if any	Nil
Name of the Witnessing Persons	
Customer's representatives	: None
Other than customer's representatives	None
Test / Calibration subcontracted with address of the laboratory	: None
Documents constituting this Report (in words)	
Number of Sheets	Three
Number of Oscillograms	: Nil
Number of Graphs	: Nil
Number of Photos	Nil
Number of Test Circuit Diagrams	Nil
Number of Drawings	Nil

(B.M. VARADARAJU)
Test Engineer

(Dr. M. SELVARAJ)
Joint Director
Approved by

MECHANICAL ENGINEERING DIVISION
P.B. NO. 8066, SADASHIVANAGAR P.O.
PROF. SIR C.V. RAMAN ROAD, BANGALORE - 560 080, INDIA
Tele Fax: +91 (80) [illegible]

CENTRAL POWER RESEARCH INSTITUTE

CPRI

TEST REPORT

TEST RESULTS

Test Report No. CPRI/BLR/MED/SC19T0311, Dated: 28.08.2019

1. Description of the Sample : Angle Sections of 765 kV S/C QUAD Transmission Line Tower Raichur to Sholapur Inter-Regional Line
2. Marked : "B 32 SA"
3. Condition : Galvanised
4. Type of Test : Tensile Test
5. Ref. Standard of Test : As per IS 1608 (Part 1): 2018 / ISO 6892-1: 2016
6. Room Temperature : 20.5 Deg. C

Test Results

Sl. No.	Sample Code	Memb. No	Angle Section Size (mm)	Size of Specimen Avg. Width (mm)	Avg. Thick (mm)	Area (sqmm)	Orig. G.L (mm)	Yield Load (kN)	Ult. Load (kN)	Yield Stress (MPa)	Ult. Stress (MPa)	Final GL (mm)	Elongation (%)
1	S0180 (1)	B 32 SA 135H	130x130x12	28.00	12.14	339.82	104.14	152.04	190.28	447	560	132.18	26.93
2	S0180 (2)	B 32 SA 135	75x75x6	26.24	5.76	151.14	69.72	63.70	86.84	421	575	87.56	25.59
3	S0180 (3)	B 32 SA 85	55x55x4	26.16	4.40	115.06	59.94	50.23	85.33	437	463	74.36	24.06
4	S0180 (4)	B 32 SA 805	70x70x5	26.14	5.30	138.85	66.72	56.63	74.03	386	491	86.18	31.10
5	S0180 (5)	B 32 SA 287	60x60x4	26.22	4.12	108.03	57.59	38.64	60.62	358	588	76.88	33.74
6	S0180 (6)	B 32 SA 73	60x60x4	26.12	4.42	116.45	53.88	43.19	57.22	365	486	78.48	31.72
7	S0180 (7)	B 32 SA 390H	120x120x8	28.00	8.14	227.92	85.72	97.36	121.86	427	535	110.10	28.44
8	S0180 (8)	B 32 SA 281H	100x100x8	28.00	8.18	229.04	85.80	98.39	131.36	430	572	111.46	29.91
9	S0180 (9)	B 32 SA 300H	120x120x8	28.00	7.84	219.52	83.68	91.82	116.37	418	530	109.10	30.38
10	S0180 (10)	B 32 SA 23	80x80x6	26.20	6.04	158.25	69.68	63.85	86.47	403	546	86.80	24.57
11	S0180 (11)	B 32 SA 432	60x60x4	26.24	4.42	115.98	60.88	45.61	56.92	389	491	80.60	32.38

(B.M.VARADARAJU)
Test Engineer

MECHANICAL ENGINEERING DIVISION
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CENTRAL POWER RESEARCH INSTITUTE

CPRI

TEST REPORT

Test Report No.	: CPRI [illegible] Date: 09.09.2019
Name & Address of the Customer	: M/s. [illegible] Transmission Company Pvt Ltd. Plot No.[illegible], Survey No.[illegible], Above [illegible] TATA Showroom, [illegible] Area, Hyderabad Road, [illegible]-[illegible]
Ref. Letter No. & Date	: [illegible] dated [illegible].2019
Name & Address of the Supplier	: ---
Particulars of sample tested	: Tower Collapse Angle Material Testing for [illegible] Quad Transmission Line
Condition of Sample on Receipt	: -
Description of test sample	: Tower Collapse Angle Material Testing for [illegible] Quad Transmission Line
Serial Number	: -
Number of samples tested	: Eleven
Date(s) of Test (s)	: 09.09.2019
CPRI sample code no	: MTD/[illegible] 50124 to 50134
Particulars of tests conducted	: Chemical compositional analysis by optical emission Spectrometer.
Standard/specification	: CPRI Test Procedure
Sampling plan	: NA
Customer's requirement	: NA
Deviations if any	: ----
Name of the witnessing persons	
Customer's representatives	: ---
Other than Customer's representatives	: None
Test subcontracted with address of the Laboratory	: NA
Documents constituting This report (in words)	
Number of sheets	: Three
Number of Graphs	: NA
Number of Photos	: NA
Number of Drawings	: NA

(Dr. R. K. [illegible])
Test Engineer

(M. [illegible])
Head of Division

"Sheet 1 of 3"

MATERIALS TECHNOLOGY DIVISION
CENTRAL POWER RESEARCH INSTITUTE
PO NO.8066, SIR C V RAMAN ROAD,
BANGALORE- 560 080, TELEFAX: 080 [illegible]

CENTRAL POWER RESEARCH INSTITUTE

CPRI

Test Report No.: CPRI/BLR/MTD/WS/1.1950027 Date: 09.9.2019

TEST RESULTS

SAMPLE TESTED : Tower Collapse Angle Material Testing for 765kV S/C Quad ... Line

TEST CONDUCTED : Chemical compositional analysis by optical emission Spectrometer

The chemical compositional analysis was carried out using Optical Emission Spectrometer and the average chemical composition obtained on minimum of three readings is reported below

Sl. No	Sample ID	Chemical composition (% by weight)								
		C	Si	Mn	P	S	Cr	Ni	Cu	V
1	MEDMISC1950183(1) Mark No. B 32 SA 1300B	0.173	0.216	1.38	0.057	0.025	0.006	0.017	0.012	0.011
2	MEDMISC1950183(2) Mark No. B 33 SA 456	0.293	0.229	0.956	0.047	0.026	—	0.008	0.006	0.002
3	MEDMISC1950183(3) Mark No. B 33 SA 35	0.197	0.143	0.945	0.048	0.036		0.005	0.006	0.001
4	MEDMISC1950183(4) Mark No. B 33 SA 869	0.187	0.216	0.713	0.050	0.032	—	0.011	0.005	0.001
5	MEDMISC1950183(5) Mark No. B 33 SA 382	0.162	0.231	0.729	0.040	0.029		0.014	0.012	0.001
6	MEDMISC1950183(6) Mark No. B 32 SA 73	0.208	0.219	0.734	0.051	0.035	-	0.009	0.006	0.002
7	MEDMISC1950183(7) Mark No. B 33 SA 338B	0.168	0.232	1.26	0.050	0.028	-	0.005	0.008	0.032
8	MEDMISC1950183(8) Mark No. B 32 SA 261B	0.191	0.282	1.25	0.057	0.071	[illegible]	0.008	0.010	0.037
9	MEDMISC1950183(9) Mark No. B 33 SA 380B	0.177	0.227	1.26	0.043	0.045	0.030	0.009	0.095	0.030
10	MEDMISC1950183(10) Mark No. B 32 SA 25	0.210	0.253	0.699	0.065	0.061	0.097	0.112	0.144	0.004
11	MEDMISC1950183(11) Mark No. B 32 SA 432	0.230	0.237	0.580	0.068	0.059	0.098	0.097	0.190	0.004

Dr. K R. Kandiy

Test Engineer

"Sheet 1 of 1"

Meteorological data: -

As per requirement of CEA/SRPC and RSTCPL to know the Meteorological data for particular tower collapse area we approach many agency but since tower collapse area is very interior no one has meteorological data for that area. Even Govt. Meteorological department close their office at 17:30. For this after long search we come to know that RE-Connect Energy is doing this Meteorological analysis in their office lab by creating some models. This method is time taking to analysis actual condition there are four stages. For RSTCPL case they gone to all level 1 to 4 of analysis.

Trucon Associates RSTCPL Tower Designer Report:-

- Trucon Associates had design the all tower for RSTCPL Raichur-Sholapur Line II. Trucon Associates also check the all parameters of design and found that there is no issue on tower design. The Tower may collapse because of up and down thrust movement of wind on that day & time as mentions by Reconnect energy report. RSTCPL noted the same that the tower collapsed may be because of up thrust twister movement on tower. Local villagers also witnessed the same on that day.

Tower Collapse Pictures

Thank You…..