

**REPORT OF STANDING COMMITTEE OF EXPERTS TO INVESTIGATE
FAILURE OF TOWERS OF RAJASTHAN RAJYA VIDYUT PRASARAN NIGAM
LIMITED DURING APRIL & MAY, 2014**

1. BACKGROUND

Shri Alok, Chairman & Managing Director, Rajasthan Rajya Vidyut Prasaran Nigam Ltd. vide letter no.RVPN/CMD/PS/D 26 dated 7th May, 2014 had requested Chairperson, CEA to depute CEA officers for investigation of failure of towers in Jaisalmer-Jodhpur/Bundi region on 17.04.2014/19.04.2014 and Trippings of Chhabra-Hindaun-Heerapura line on 29.04.2014 and 30.04.2014.

Accordingly the team of officers from CEA [Shri P.K. Mishra, Director and Shri C.N.Devarajan, Asstt. Director] and Rajasthan Rajya Vidyut Prasaran Nigam Ltd. (RRVPNL) [Shri B.C. Meena, Chief Engineer(I/C), Shri S.K. Purohit, SE, Shri K.L. Gajraj, XEN, Shri J.S.Bhat, XEN, Shri M.K.Soni, XEN & Shri G.S. Meval, XEN] visited sites of failure of towers of the transmission lines from 29.05.2014 to 31.5.2014 and preliminary report was submitted.

As per CEA Order No.5-41/98/Secy/CEA/809, dated 30.09.1999 and subsequent amendments thereof, a Standing Committee of experts was constituted as per the Chapter II Para 3(viii) of the Electricity (Supply) Act No.54 of 1948 to investigate failure of transmission line towers of power utilities. In line with the provisions of the Electricity Act, 2003, under section 73(1), CEA is required to carry out or cause to be carried out, any investigation for the purpose of generating or transmitting or distributing electricity. A Standing Committee of Experts has been constituted in CEA to investigate failure of Transmission line towers of lines rated 220kV and above. Meeting of Standing Committee was held in CEA on 19.06.2014 to discuss the causes of failure of the transmission line towers. The Committee discussed in detail the nature and reasons of failures of towers, conductors and insulators of the transmission lines.

The brief details of failures of various lines of RRVPNL, the observations of the team who had visited the sites of failure, the analysis of failure of towers, and recommendations of the committee are given below.

2.0 BRIEF DETAILS OF FAILURE OF TOWERS OF VARIOUS LINES OF RRVPNL

The brief details of failure of towers of 220kV and 132kV Transmission Lines of RRVPNL between 17-04-2014 and 15-05-2014 are indicated below:

Sr. No.	Name of the Transmission Line	Date of Occurrence of Failure	No. of Towers failed
1	220kV S/C Amarsagar-Phalodi line (up to Gomat)	17.04.2014	10
2	220kV S/C Tinwari-Phalodi line	11.05.2014	1
3	220kV S/C Amarsagar-Phalodi line (up to Amarsagar)	17.04.2014	8
4	220kV D/C Amarsagar-Mada line	17.04.2014	5
5	220kV D/C Akal-Giral line	17.04.2014	25
6	220kV D/C Akal-Amarsagar line	17.04.2014	3
7	132kV S/C Tinwari- PS 8 line	17.04.2014	3
8	132kV Chandan-Mohangarh line-PHED line(Charged at 33kV & owner Jodhpur Discom)	17.04.2014	2
9	132kV S/C Jaisalmer-Ramgarh line (Ckt-1)	17.04.2014	3
10	132kV S/C Pokaran-Askandra line (for M/s Lanco Solar)	17.04.2014	1
11	132kV S/C Bilara-Sojat line	15.05.2014	1

3. OBSERVATIONS RELATING TO FAILED TRANSMISSION LINES

During the discussion with RRVPNL authority, it was brought to the notice that in general, most of the towers have failed on 17-04-2014 due to high velocity wind storm. The team comprising officers from CEA and RRVPNL could not visit all sites of failure of towers. Due to paucity of time, the team had visited some of the sites of failure of towers of 220 kV transmission lines and tower failure sites of 132 kV transmission lines could not be visited. However, the details of failure of all 220 kV and 132 kV lines were collected from concerned officers of RRVPNL. By the time, the team visited the site, most of the failed towers were erected and lines restored on normal towers in order to restore power supply to the affected areas.

(i) 220kV S/C Phalodi -Amarsagar line(upto Gomat)

The 220 kV Amarsagar – Phalodi S/c Transmission Line was constructed by M/s Krishna Construction, Pali during 2003-04 and was commissioned on 30.05.2004. The towers of this line were designed for wind zone-IV as per IS: 802-1995 as informed by RRVPNL officers.

Ten (10) towers [at location Nos. 69(Type-A), 70(Type-A), 71(Type-A), 133(Type-A), 135(Type-A), 137(Type-A), 138(Type-B), 139(Type-A), 141(Type-A), and 142(Type-A)] of the above line had failed. Due to paucity of time, the team could visit only five (5) out of ten (10) locations of failure of towers on 29.05.2014 [i.e location Nos. 69, 70, 71, 138, 142]. It was observed that the earthwire peak of tower at location No. 69 was bent. The towers at location Nos. 70 and 71 had collapsed from stub level. The foundations of these towers were intact, but new towers were erected adjacent to old locations by laying new foundations. The tower at location No. 138 was twisted and fell and hence new tower has been erected. New tower was erected on the existing foundation at location No. 142. Before the site visit all ten (10) numbers of failed towers were erected after rectifications of damages in order to restore power supply. Mostly ‘A’ type towers in one section of the line have fallen on the ground from stub level. During the visit to site, RRVPNL authorities were advised to carry back filling around the chimney in the foundation pit of tower at location No.142 and to carry out coping on chimney of the foundations at tower location No.138. The line was restored on normal tower on 27.05.2014.

(ii) 220kV S/C Phalodi -Amarsagar line(upto Amarsagar)

The 220 kV Phalodi-Amarsagar S/c Transmission Line (upto Amarsagar) was constructed by M/s. Sona Engineering and was commissioned on 30-05-2014. The towers of this line were designed for wind zone-IV as per IS:802-1995 as informed by RRVPNL officers.

Eight (8) towers [at location Nos. 159(Type-C), 160(Type-A), 233(Type-A), 264(Type-A), 269(Type-A), 272(Type-B), 274(Type-A) and 278(Type-A)] of above line had

failed. Due to paucity of time, the team could visit only two (2) out of eight (8) locations of failure of towers [i.e location Nos. 159 and 160]. At location No. 160, (A+0) Type tower has been replaced by (B+3) Type. The peak of tower at location No. 159 was damaged. The same has been rectified. Before the site visit, all failed towers were erected after rectifications of damages in order to restore power supply. During the visit to the site, crack in the foundation (at location No. 160) was observed. The earthing of tower was not done. RRVPN authorities were advised to rectify the same.

(iii) 220 kV D/C Akal-Giral line

The 220 kV Akal – Giral D/c Transmission Line was constructed by M/s. Hitech Foundations and was commissioned on 11-08-2010. The towers of this line were designed for wind zone-IV as per IS: 802-1995 as informed by RRVPNL officer.

Twenty five (25) towers [at location Nos. 21(Type-A), 22(Type-A+6), 23(Type-A), 24 (Type-A), 25 (Type-A), 41(Type-A), 42(Type-A), 43 (Type-A), 44(Type-A), 45(Type-A+3), 48(Type-A+6), 50(Type-A+3), 52(Type-A),54(Type-A),62(Type-A), 63(Type-A),64(Type-A), 72(Type-A), 73(Type-A), 74(Type-A), 82(Type-A), 83(Type-A), 84(Type-A), 86(Type-A+3), and 98(Type-A+6)] of above line had failed. Due to paucity of time the team could visit only sixteen (16) [i.e. location Nos. 21, 41, 42, 45, 48, 50, 62, 63, 72, 73, 74, 82, 83, 84, 86, and 98] out of twenty five (25) locations of failure of towers of above line. It was reported that theft of tower members are common in these areas and missing of members in some towers of the line [at location Nos. 21, 62 & 73] were observed. It was observed that the tower at 10 locations [i.e. location Nos. 21, 42, 62, 63, 72, 73, 83, 84, 86 and 98] had collapsed from stub level. The foundations of most of these towers were damaged (except tower at location No. 21) and in some cases new foundation have been laid adjacent to old locations. Damage of towers at cross arm level was observed at location Nos. 41, 48, 50 and 82, but foundations of these towers were intact. During the site visit it was informed that stub setting was required at 10 locations (i.e. Location Nos. 25, 62, 63, 72, 73, 74, 83, 84, 86 & 98). Erection of towers was required at 11 locations (i.e Location Nos. 21, 22, 23, 24, 41, 42, 44, 45, 48, 50 & 82) without stub setting and stringing of conductor was required at 7 sections (i.e. Section Nos. 20 to 28, 36 to 46, 46 to 55, 60 to 68, 68 to 77, 77 to 88 & 88 to 100).

(iv) **220 kV D/C Akal-Amarsagar line**

The 220 kV Akal - Amarsagar D/c Transmission Line was constructed by M/s. Hitech / Hundai and was commissioned on 22-05-2011. The towers of this line were designed for wind zone-IV as per IS: 802-1995 as informed by RRVPNL officer.

Three (3) towers [at location Nos. 41(Type-A), 43(Type-B), and 50(Type-A+3)] of above line had failed. The team had visited all locations of failure of towers of above line. Before the site visit all failed towers were erected after rectifications of damages in order to restore power supply. All three towers were damaged from bottom cross arm level and foundations were intact. The line was restored on normal tower on 02.05.2014. It was observed that some of the members of the tower were missing and unfilled holes were found in members.

(v) **220kV S/C Tinwari-Phalodi line**

The line was constructed by M/s KMCC Ltd., Jodhpur. The line was commissioned on 06-04-2005. The bracings and main leg members of tower at location No. 153 were twisted. RRVPN official informed that the tower was erected and supply was restored on 15/05/2014.

(vi) **220 kV D/C Amarsagar-Mada line**

The line was constructed by M/s C&T Ltd and commissioned on 14/4/2005. One 'C' type tower & four 'A' type towers have failed. RRVPNL officer informed that the failed towers were erected and line was restored on 18/05/2014.

(vii) **132kV S/C Tinwari-PS 8 line**

The line was constructed by M/s Ridhi Sidhi, Jaisalmer. Three towers (2 numbers 'A' type & one 'B' type) have failed. This is the third failure of the line. RRVPN official informed that these towers were reinstated and supply was restored on 09.05.2014.

(viii) **132kV Chandan-Mohangarh line**

The line was constructed by M/s A to Z and commissioned on 31/05/2011. Two towers were twisted from stub level. RRVPN officers informed that the towers were erected and the line was charged on 15/05/2014.

(ix) **132kV S/C Jaisalmer-Ramgarh transmission line (Ckt-I)**

This line was constructed by Rajasthan State Electricity Board and was commissioned on 03/07/1996. Three towers viz. 56(B+0), 63(A+0) and 64(B+0) have failed. It was informed that theft of tower members was prominent in this line. RRVPNL officers informed that these towers were erected and line was restored on 29/05/2014.

(x) **132kV S/C Pokaran-Askandra line**

This line was constructed by M/s A2Z Engineers and was commissioned on 17/02/2012. The tower at location No. 34 (Type-B) has failed from stub level. RRVPNL officers have informed that Meteorological Department recorded a wind speed of 168.5 km/hr. in this area. They informed that the failed tower was erected and the line was restored on 20/04/2014.

(xi) **132kV S/C Bilara-Sojat transmission line**

The line was constructed by Rajasthan State Electricity Board departmentally and was commissioned on 19/01/1983. The tower failed on 15/05/2014. It was reported that the tower stubs at location No. 99A were rusted and corroded. The tower became weak due to rusting of stubs and failed due to the heavy wind. RRVPNL officer informed that the failed tower was erected and line was charged on 27/05/2014.

4. ANALYSIS OF FAILURES

In the span of about one month (between 17-04-2014 to 15-05-2014), Sixty two (62) number of towers of 220kV and 132kV transmission lines of RRVPNL had failed, out of which 60 Nos. of towers had failed on 17-04-2014 and most of them are towers of 220kV

lines. Out of 62 Nos. of towers, 52 Nos. of towers belongs to six (6) numbers of 220kV transmission lines and 10 Nos. of towers belongs to five (5) numbers of 132kV transmission lines. Due to failure of so many transmission lines, the power supply to western part of Rajasthan was severely affected. More than 90% of the failed towers were suspension towers (A- type). But tension towers [Type-B, Type-C] have also failed in some of the locations. In some locations of the tower earthing was not done properly. In general the type of failure of towers of 220kV /132kV transmission lines can be broadly classified as follows:

- Towers have buckled from stub level leading to complete collapse of towers with / without damage to tower foundation.
- Towers have buckled from bottom cross arm level or top Cross arm or peak broken without any damage to lower portion of the tower and foundation. .
- Tower members were found missing.

During discussion with RRVPNL officers, it was informed that the above mentioned lines were designed by Private Firms using BIS: 802(1995) and initially towers were tested. Same design & type of towers have been used in all new lines. Rajasthan falls under wind zone IV. All lines mentioned above traverse in western part of Rajasthan, which is very much prone to high wind and storm during April and May, being desert area. It was also reported that very high velocity localized whirl winds have caused damaged to number of 33/11 kV lines in the locality near the failed tower locations. The intensity of storm was so high that around 450 Poles of 33kV & 11kV lines were damaged in Pokharan area, trees were uprooted & houses were damaged near the 220kV Amarsagar-Phalodi line. Velocity of wind storm as informed by RRVPNL was about 168.84 km/hr in nearby area. Wind speed recorded by wind turbines SCADA of some wind mills at Mokala site, Akal site, Khuri site was 34m/sec, 36m/sec & 43.3m/sec respectively. Hoarding, the towers of wind mills and associated 33kV lines were also damaged, lines constructed by private companies like 220kV D/C Akal-Dansari(Inox) Pvt. Line & 3 towers of 132 kV D/C Suzlon line were also affected due to storm. Hydra Crane had fallen down on the ground due to impact of very high velocity whirl wind. In absence of meteorological data, it is difficult to assess the exact wind speed at locations where the towers have failed. However, data provided by RRVPNL officials show that on that particular day, the wind velocity was about 168.84 km/hr in some locations, which is nearly equal to wind speed corresponding to wind Zone-4(i.e. 47 meter/second).

The basic wind speed data provided in IS:875 based on which the wind zone have been classified, takes into account the recorded cyclones to some extent but do not account for other localized high intensity wind condition having narrow front viz. tornadoes, hurricanes, localized thunder storm, dust storm etc. These are short lived and cover small area but devastation caused by such high intensity winds is very severe though restricted to a smaller area only.

The intensity / speed of wind has exceeded the limit for which towers was designed and hence number of towers of 220kV and 132kV lines have collapsed either from stub level or cross arm level. Moreover, the towers/lines are not generally designed for very high intensity wind condition because of high cost involved and the probability of occurrences of such incidences is very low.

In some locations, missing of tower members / unfilled holes in members were observed. The unfilled holes in members of the tower reduce the strength of members. Missing of members reduces the structural strength of towers. Such towers with such deficiencies are more prone to failure during very high velocity wind / storm.

5. RECOMMENDATIONS OF THE STANDING COMMITTEE

- (i) As more than 90% of the failed towers are suspension towers (A- type), therefore it is felt that design of A- Type towers needs to be reviewed. However, Tension towers [Type-B, Type-C] have also failed in some of the locations. Such failures may be due to cascading effect. As per information provided by RRVPNL, the 220kV transmission lines were constructed between 2004 and 2011. The design of failed towers of 220kV / 132kV lines needs to be checked and ensured that design has been done in line with revised code (IS:802-1995) corresponding to wind Zone – 4 as western part of Rajasthan comes under wind Zone -4 (i.e. wind velocity of 47m/sec. = 169.2 km./hr.). The suspension towers may be

strengthened by providing hip bracings, if not provided, upto bottom cross arm level.

- (ii) Some of the towers have buckled either from top cross arm level or from bottom cross arm level or peak broken and foundations of towers are reported to be intact. Hence strengthening of tower members above bottom cross arm level may be required.
- (iii) Some of the towers of 220kV / 132kV lines have completely collapsed from stub level. However, in some cases foundations are intact and in some cases foundation has been severely damaged. Hence foundation design of towers may also be reviewed.
- (iv) The regular patrolling of lines should be carried out by RRVPNL to check for missing tower members/nuts & bolts. Regular maintenance activities such as replacement of missing members, missing nuts & bolts and trimming / chopping of nearby trees to maintain adequate safety clearances etc. should be carried out by RRVPNL from time to time.
- (v) For old lines, rusting in members of all the towers may be checked and painting of the rusted members with zinc rich paints may be done as a remedial measure.
- (vi) The holes left in the tower members including leg members are to be filled with bolts & nuts to increase the strength of members.
- (vii) Chimneys of all the towers should be provided with coping to avoid accumulation of rain water near stub. Back filling of foundation pits may be done wherever necessary to avoid water logging.

- (viii) Proper earthing of tower may be ensured.
- (ix) Quality of steel material may be ensured while replacing missing members of towers.
- (x) Material test of failed tower members should be carried out from recognized NABL approved laboratories / Govt. approved laboratories in order to assess the quality of steel material used in the tower.
- (xi) In future, while planning routing of transmission line, high velocity / storm prone areas may be avoided.

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