अप्रैल 2014 -जुलाई 2014 के दौरान क्षतिग्रस्त टॉवरों पर विशेषज्ञों की स्थाई समिति की रिपोर्ट

REPORT OF THE STANDING COMMITTEE OF EXPERTS ON FAILURE OF TOWERS DURING APRIL 2014 - JULY 2014

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CENTRAL ELECTRICITY AUTHORITY
MINISTRY OF POWER
GOVERNMENT OF INDIA
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In fulfillment of CEA's obligation under section 73(ℓ) of Electricity Act, 2003

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EXECUTIVE SUMMARY

1.0 A Standing Committee of experts, 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.

1.1 Over the years the Indian Standards for design of transmission line tower has undergone changes. The three wind zones in the country have been modified to six wind zones and design is being revised. But unfortunately transmission lines designed according to old standards / old design philosophy are in operation in various parts of the country under different transmission utilities / transmission licensees which cannot be replaced in one go. Steps are being taken from time to time to strengthen such towers when any major failure occurs in those old lines. But all efforts are being made to design new transmission line as per latest standard and best practices.

1.2 As per the requirement of the Standing committee, all utilities / transmission licensees are supposed to report the failure of towers of 220kV and above voltage class transmission lines to CEA. In fact many state transmission utilities / transmission licensees do not report failures of towers of transmission line (s) to CEA. The objective of Standing Committee is to meet at regular intervals or as and when required to discuss the cause of failure of towers of the transmission lines in different parts of the country and recommend remedial measures to prevent repetition of such failures in future.

1.3 The meeting of Standing Committee of Experts was held in CEA on 19-06-2014 and 12-09-2014 to discuss the cause of failure of the transmission line towers failed during the period from April 2014 to July 2014. During this period, the failure of towers of various transmission lines of only three utilities [PGCIL, DTL, RRVPNL] including failure of 132kV lines of RRVPNL was reported to CEA. Accordingly the Committee discussed in detail the nature and cause of failure of towers of transmission lines of above utilities.

1.4 The pattern of failure of towers of lines of various voltage levels can be broadly classified as under:

- Towers have buckled from stub level leading to complete collapse of towers with/without damage to tower foundation.
- Towers have buckled from the top of 1st panel(normal tower) level 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 failed due to sabotage/theft of tower members.
- Towers failed due to falling of tree on the line during high intensity storm.

2.0 BRIEF DETAILS OF FAILURE OF TOWERS OF VARIOUS TRANSMISSION LINES REPORTED TO CEA

2.1 The number of towers failed & lines affected at various voltage level during the period from April, 2014 to July, 2014 is tabulated below:

Sl. No.	Names of the Transmission Lines	Date of Occurrence of failure	No. of towers failed	Name of utility
1.	765 kV S/C Meerut-Bhiwani line	30.05.2014	5	PGCIL
2.	765 kV S/C Bhiwani-Jhatikalan line	30.05.2014	1	PGCIL
3.	400 kV D/C Abdullapur-Bawana line	30.05.2014	3	PGCIL
4.	765 kV S/C Gaya-Fatehpur line	31.05.2014	15	PGCIL
5.	220 kV D/C Bamnauli-Pappankalan-1 line	30.05.2014	4	DTL
6.	220 kV D/C Bawana-Rohini-II line	30.05.2014	6	DTL
7.	220 kV D/C Mandola-Gopalpur line	30.05.2014	1	DTL
8.	132 kV S/C Tinwari-PS 8 line	17.04.2014	3	RRVPNL
9.	220 kV S/C Amarsagar-Phalodi line	17.04.2014 & 13.05.2014	18	RRVPNL
10.	220 kV S/C Tinwari-Phalodi line	11.05.2014	1	RRVPNL
11.	132 kV Chandan-Mohangarh line	17.04.2014	2	RRVPNL
12.	220 kV D/C Amarsagar-Mada line	17.04.2014	5	RRVPNL
13.	220 kV Akal-Giral line	17.04.2014	25	RRVPNL
14.	220 kV D/C Akal-Amarsagar line	17.04.2014	3	RRVPNL
15.	132 kV S/C Jaisalmer-Ramgarh line (ckt-1)	17.04.2014	3	RRVPNL
16.	132 kV S/C Pokaran- Askandra line	17.04.2014	1	RRVPNL
17.	132 kV S/C Bilara-Sojat line	15.05.2014	1	RRVPNL
18.	LILO of one circuit of 220kV D/C Tanakpur-Bareilly line at Sitarganj	23.05.2014	2	PGCIL
19.	400kV D/C Maithon- Mejia line	11.06.2014	3	PGCIL
20	400 kV D/C Kaithal-Patiala line	13.06.2014	8	PGCIL
21.	400 kV D/C Bhiwani-Jind line	29.06.2014	5	PGCIL
22.	400 kV D/C Korba-Raipur line	29.06.2014	3	PGCIL
23.	765 kV S/C Bina-Indore line	12.07.2014	1	PGCIL
24.	220 kV D/C South of Wazirabad-Kashmiri Gate line	02.07.2014	3	DTL

2.2 Some of the failure sites in respect of transmission lines listed above [i.e. at Sl. No. 5, 6, 7, 9, 13, 14, 19, 20 and 24] were visited jointly by representatives of CEA and concerned utilities and preliminary reports on the finding were submitted.

2.3 The number of suspension and tension towers at various voltage level, failed during above mentioned period are indicated below:

Sl. No.	Voltage Level	No. of Lines affected	No. of Towers failed		
			Suspension Towers	Tension Towers	Total
1	765 kV	4	21	1	22
2	400kV	5	15	7	22
3	220 kV	10	59	9	68
4	132kV	5	5	5	10
	Total	24	100	22	122

3.0 RECOMMENDATIONS & REMEDIAL MEASURES SUGGESTED BY THE COMMITTEE

3.1 Details of failure including minutes of meeting photographs and other information relating to each transmission lines are given in subsequent sections of the report.

3.2 The recommendations and remedial measures to be taken by the concerned utilities in respect of their lines is summarized as under:

(a) Powergrid Corporation of India Ltd.

(i) The design of towers may be reviewed for further strengthening, even though the lines were designed according to IS:802(1995), in case of more failure occurs in future in such lines.

(j) The patrolling of line needs to be increased in theft prone areas in order to avoid failure due to theft of tower members. The local people should be educated by PGCIL and involved for safety of the towers.

(ii) Coping of Chimneys, wherever required, needs to be done to avoid accumulation of water near stubs.

(b) Delhi Transco Ltd.

(i) Towers of the line were designed as per old code IS:802 (1977) and the wind zone for Delhi area has been changed as per revised code IS: 802 (1995). In view of the above, DTL may review design of towers in line with latest IS codes and strengthening of members of tower, if required, may be carried out accordingly to avoid reoccurrence of such failures in future and thereby increase the availability of the line. PGCIL/CPRI/SERC / any other organization may be consulted for review of the design.

(ii) In future, the use of tower designed as per old IS:802(1977), should be avoided as a replacement to failed towers in any existing lines or in new lines until the design review is complete.

(iii) The regular patrolling of lines should be carried out by DTL to check for missing of tower members. Regular maintenance activities such as chopping of nearby trees to maintain adequate safety clearances, considering MOE & F guidelines, removing the bushes near the foundation area, and coping of chimneys etc. should be carried out by DTL from time to time, as and when required.

(iv) For old lines, rusting in members of all the towers (due to exposure to atmosphere over a long period of time) may be checked and painting of the rusted members with Zinc rich paints may be done as remedial measures.

(v) The holes in the tower members including leg members are to be filled with bolts & nuts to increase the strength of members.

(vi) Chimneys of all the towers should be provided with coping to avoid accumulation of rain water near stub. If required, the height of the chimneys may be raised where the tower is located in agricultural field to avoid deposit of soil on the chimneys due to agricultural activities.

(vii) Quality of steel material may be ensured while replacing these missing members.

(viii) Material test of the failed tower members should be carried out from recognized NABL approved laboratories / Govt. approved laboratories to assess the quality of steel material used in the tower.

C. Rajasthan Rajya Vidyut Prasaran Nigam Ltd.

(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.

3.3 During deliberation of failure of towers of 400kV Bhiwani-Jind Transmission line, the committee felt that the towers of transmission lines in west Rajasthan, Delhi, Haryana & Punjab should be designed for terrain Category-1.

3.4 Following decisions were also taken by Committee and accordingly the BIS, PGCIL, DTL have been communicated.

(i) The Committee decided to write to BIS for the revision of IS 875 for review of wind map based on studies made by SERC in 2009 in view of frequent failure of towers in the Eastern, Northern and Western regions. CE(I/C), SETD informed that due to climatic change also, there could be changes in wind pattern.

(ii) The Committee recommended to install Anemometer in all substations of Powergrid & DTL duly computerized to get output of every one hour wind data.

(iii) It was decided to write to BIS regarding adopting design criteria of 100% Transverse wind load for normal condition and 75% Transverse wind load for broken wire condition for suspension towers.

Report

of

Standing Committee

of

Experts

REPORT OF STANDING COMMITTEE OF EXPERTS TO INVESTIGATE FAILURE OF TOWERS DURING THE PERIOD APRIL 2014 to JULY 2014

1.0 As per CEA Order No. 5-41/98/Secy/CEA/809, dated 30.9.1999 and subsequent amendments thereof, a Standing Committee of experts was constituted as per Chapter II Para 3 (viii) of the Electricity (Supply) Act No.54 of 1948 to investigate failure of transmission line towers of power utilities. As per the Electricity Act, 2003, CEA continues to be authorized under Section 73 (l) to carry out or cause to be carried out, any investigation for the purpose of generating or transmitting or distributing electricity. The scope and terms of reference of the Committee are as follows:

- To investigate the causes of failure of towers
- To avert recurrence of such failures in future

The meeting of Standing Committee of Experts was held in CEA on 19-06-2014 and 12-09-2014 to discuss the cause of failure of the transmission line towers failed during the period from April 2014 to July 2014. During this period, the failure of towers of various transmission lines of only three utilities [PGCIL, DTL, RRVPNL] including failure of 132kV lines of RRVPNL was reported to CEA. Accordingly the Committee discussed in detail the nature and cause of failure of towers of transmission lines of above utilities.

The Committee normally investigates failure of towers of transmission lines of 220kV and above voltage class as per scope & terms of reference of the Committee. However, at the request of RRVPNL, the failure of towers of 132kV lines was also investigated.

As requested by DTL and RRVPNL, the detailed report on failure of towers in respect of various lines of Delhi Transco Ltd., failed on 30.05.2014 due to heavy storm, has already been sent to DTL & MoP. Similarly the detailed report on failure of towers in respect of various lines of RRVPNL (220kV and 132kV lines), failed during April & May, 2014] has already been sent to RRVPNL separately.

2.0 OBSERVATIONS, RECOMMENDATIONS & REMEDIAL MEASURES SUGGESTED BY THE COMMITTEE ON FAILURE OF TOWERS OF VARIOUS UTILITIES

2.1 FAILURE OF TOWERS OF VARIOUS TRANSMISSION LINES OF POWERGRID

2.1.1 The towers of following 765kV, 400kV and 220kV Transmission Lines of POWERGRID had failed during above mentioned period.

Sl.No.	Name of the Transmission Lines	Date of Occurrence of failure	No. of towers failed
1.	765 kV S/C Meerut-Bhiwani line	30.05.2014	5
2.	765 kV S/C Bhiwani-Jhatikalan line	30.05.2014	1
3.	400 kV D/C Abdullapur-Bawana line	30.05.2014	3
4.	765 kV S/C Gaya-Fatehpur line	31.05.2014	15
5.	LILO of one circuit of 220kV D/C Tanakpur-Bareilly line at Sitarganj	23.05.2014	2
6.	400kV D/C Maithon- Mejia line	11.06.2014	3
7	400 kV D/C Kaithal-Patiala line	13.06.2014	8
8	400 kV D/C Bhiwani-Jind line	29.06.2014	5
9.	400 kV D/C Korba-Raipur line	29.06.2014	3
10.	765 kV S/C Bina-Indore line	12.07.2014	1
		Total	**46**

2.1.2 <u>Observation of Committee & recommendations</u>

(i) <u>765kV S/C Meerut – Bhiwani line</u> [Location Nos. 208(B+0), 209(A+0), 210(A+0), 211(A+0) & 212(A+0)]

This line was constructed by M/s Aster and commissioned on 30/01/2014. This line was designed for wind Zone-IV and narrow front wind effects. The towers at location Nos. 208(B+0), 209(A+0), 210(A+0), 211(A+0) & 212(A+0) had failed on 30.05.14 due to localized cyclone/whirl wind resulting in excessive wind load on towers. As reported during the meeting, few members of the towers were also found missing and they have been replaced. The top part of towers were damaged. The line was restored on normal towers on 15.06.2014.

The committee recommended to identify the theft prone areas and to increase the patrolling.

(ii) <u>765kV S/C Bhiwani-Jhatikalan line</u> [Location no. 174(A+0)]

This line was constructed by M/s EMCO and commercialized on 01.10.2012. The line was designed considering loads for wind Zone-IV and narrow front wind effects. The tower at location no. 174(A+0) failed due to localized cyclone/whirl wind on 30.05.2014 resulting in excessive wind load on tower. The stubs & foundations were not damaged. This is the first failure in this line. The line was restored on normal towers on 08.06.2014.

PGCIL suggested for wait & watch till any further failure occurs in the line. The Committee agreed with the views of Powergrid.

(iii) <u>400 kV D/C Abdullapur-Bawana line</u> [Location no. 417(DB+0), 418(DA+18) and 419(DB+6)]

This line was constructed under Naptha Jhakri evacuation project in the year 2000 and designed as per IS 802:1995. The tower at Location no. 418(DA+18) had failed on 30.05.2014 along with towers at Location no. 417(DB+0) & 419 (DB+6). Earlier one (DA+18m) tower failed in June, 2000. Then strengthening of extension to DA type towers w.r.t. narrow front wind condition was carried out and no incident of tower collapse observed after strengthening of the tower. This is the second failure of the line. The tower at location no. 418 (DA+18) collapsed from about 9m above ground level with bending of 2 stubs. Earthwire peaks of location no. 417 (DB+0) and 419 (DB+6) got damaged. The towers failed due to massive dust storm. The line was restored on normal towers on 11.06.2014.

The committee recommended to review the design for further strengthening of towers in case more failure occurs in future as these towers are being used for power line crossings.

(iv) <u>765 kV S/C Gaya-Fatehpur line</u> [Location Nos. 320 to 330,305,306, 311& 315]

This line was constructed by M/s KPTL and commissioned on 31/03/2012. The towers at Location Nos. 320 to 330, 305, 306, 311 and 315 had failed on 31.05.2014. Earlier one tower at location no. 314 failed on 11/12th April, 2012. This is the second failure. Nine (9) towers have failed from bottom cross arm level (near diamond section) while six (6) towers have fallen completely on ground. All the failed towers were of 'A' type and located in plain stretch of cultivation field and the stretch might have experienced high wind speed during the storm. The foundations were intact. Powergrid officials informed that theft of tower members was also noticed in this line and informed that patrolling of lines will be intensified to avoid thefts.

The committee recommended to increase the patrolling of lines to avoid such type of failure in future.

(v) <u>LILO of one circuit of 220kV D/C Tanakpur-Bareilly Transmission Line at Sitarganj</u> [Location Nos. 65(DD+18) & 64(DD+0)]

The LILO of one circuit of 220kV D/C Tanakpur-Bareilly Transmission Line at Sitarganj was constructed by M/s Utkal Ltd. and commissioned on 01.03.2009. The towers were designed for wind zone-4 and according to IS 802:1995 and tested before putting into use.

The towers at location Nos. 65(DD+18) & 64(DD+0) had failed on 23.05.2014.The tower at location no. 65 (DD+18) had collapsed and fallen on the ground from the stub level and earthwire peak of adjacent tower at location no. 64(DD+0) which is situated in a plain stretch of cultivated land, had got damaged due to high intensity localized storm followed by rain on 23/05/2014. There is a river named 'Kailash' flowing between the tower locations 65 & 66 which are located in cultivated land with few trees near by. Some uprooted trees and broken

branches were seen in the vicinity of the site. There was no theft of any member from the towers. In view of the abrupt severe changes in the land course involving the 'Kailash' river bed channel, it is likely that critical wind loading during the severe storm occurred on tower 65.

Powergrid officers suggested that the towers with leg extension are proposed for strengthening and Committee agreed with the view of Powergrid.

(vi) <u>400kV D/C Maithon-Mejia Transmission Line</u>[Location no. 92, 93 & 94]

This line was constructed by M/s Jyoti Structures Ltd. and was commissioned on 01.12.2011. The tower at location Nos. 92, 93 & 94) had failed on 11-06-2014. The towers of this line were designed for wind speed of 47m/sec corresponding to wind zone-4 of IS:802-1995. The line was under satisfactory operation since commissioning except the tower at location No. 93 which had collapsed during construction stage due to local storm. The line is crossing 132kV D/C J.K.Nagar-Kalipahari line between location no. 93 and 94.

The tower at location no. 93(DA+18) had collapsed from first panel in transverse direction. Due to this impact the top and middle cross arms and earthwire peak of tower at location no. 92 (DD+0) and middle cross arm and earthwire peak of tower at location no. 94 (DD+3) got damaged. These towers were damaged due to severe localized cyclone. Many distribution lines of DVC and WBSEDCL in the vicinity also got damaged. No missing members were found. Few unfilled holes were found in the members at tower location No. 93. Some bolts and nuts were also found near tower no. 93. This may be due to breaking of bolts during failure. All the foundations were intact but the stubs were damaged. Conductors and earthwire were damaged & had fallen on 132kV line passing beneath it.

Based on the discussion with site officials & examination of photographs of the failed towers, it is inferred that the failure of the towers could be due to severe localized cyclone. On examination of chimneys it is found that coping has not been done. The line was restored on 17.06.2014 on ERS.

Committee recommended for coping of all the chimneys of the towers of the line in order to avoid accumulation of water near stubs. Powergrid officers informed that the tower at location No. 93 is proposed to be strengthened upto bottom cross arm level by providing one additional angle so as to form star angles with stitching of the new section with the existing section by suitable plates and the Committee agreed with the view of Powergrid.

(vii) <u>400kV D/C Kaithal-Patiala Transmission line</u> [Location Nos. 447 to 454]

Towers of this line were designed and constructed by M/s KEC International Limited. The towers at Location Nos. 447 to 454 (8 towers), which are (DA+0) type, had failed on 13.06.2014. The original Nalagarh-Hissar Transmission Line was in operation from 01.01.2000. Subsequently, LILO of one circuit was done at Kaithal and LILO of second circuit was done at Patiala. Further, LILO was done for the two lines in September 2011 at Patiala and Kaithal. The failure

occurred in the original Nalagarh-Hissar portion of the line. The suspension towers of this line were designed for wind zone IV as per IS: 802-1995. This is the first instance of failure in the line. Towers at location no. 447, 448, 451, 452 and 453 have fallen from second panel level in transverse directions. Tower at location no. 454 failed from bottom cross arm level. Tower at location no. 449 & 450 fell from stub level. No theft of tower parts/ members was observed at any of the location.

The site of failure was surrounded by agricultural fields. These were open land and very few trees and huts were found in the vicinity. It was reported that a high intensity storm followed by rainfall was experienced which caused widespread damage in the area. Some trees were uprooted nearby.

Based on the investigation, it was concluded that the high speed wind caused the failure of tower at location no. 450. The impact load of this sudden failure caused secondary failure at location no. 447-449 and 451-454. Restoration work was started immediately.

Powergrid officials informed that hip bracings have already been provided in these towers and suggested for no further strengthening till further failure in the line. The Committee agreed with view of powergrid.

(viii) <u>400kV D/C Bhiwani-Jind Transmission Line</u>[Location Nos. 31 to 35]

This line was designed by Powergrid and constructed by M/s Aravali Infrastructure Limited, New Delhi. The line was commissioned on 31.03.2013. The towers at location Nos. 31 to 35 had failed on 29.06.2014. The suspension towers were designed for wind zone IV (47m/sec) as per IS: 802-1995.

This was the second failure of the line. In March 2014, five (5) towers at location No. 193 to 197 had collapsed due to high wind.

The site was surrounded by agricultural fields with a few trees & huts in the vicinity of the line. 400kV D/C Moga-Bhiwani line is crossing the line between location No. 34 and 35.

Tower at location no. 31(DA+0) had top left'X' arm bent. Tower at location no. 32 (DA+0) failed from middle 'X' arm level. Tower at location no. 33 (DA+9) had fallen from normal tower level. Tower at location No. 34 (DD+25) which had 3m raised chimney had fallen from stub level. Tower at location No. 35 (DD+ 25) which had 3m raised chimney suffered secondary failure and all the three left cross arms damaged due to the impact of collapse of tower at location No. 34. No theft of tower parts was observed during the investigation. It was reported that a high intensity storm followed by rainfall was experienced in the area which caused widespread damage in the area. Some trees were uprooted nearby.

The high speed wind might have caused the failure to tower at location No. 33. The impact loads due the sudden failure, caused secondary failure of towers at

location no. 31, 32, 34 and 35. Since the terrain was open from all directions and adjacent to a canal, high speed wind fronts could have formed to cause the unprecedented wind loads on towers.

During discussion, the Committee felt that towers in West Rajasthan, Delhi, Haryana & Punjab area should be designed for Terrain Category-I due to nature of terrain.

(ix) 400kV D/C Korba-Raipur Transmission Line
[Location Nos. 266 (DA+0), 267 (DA+0) & 268(DD+6)]

This line was designed by Powergrid and constructed by M/s Kalpataru Power Transmission Limited, Gandhinagar, and was commissioned on 21.06.2011. The towers at location no. 266 (DA+0), 267 (DA+0) & 268(DD+6) had failed on 29.06.2014. The suspension towers of this line were designed for wind zone-II (Speed 39m/s) as per IS: 802-1995. This is the first instance of tower failure in this line. The tower at location no. 268 (DD+6) had fallen to the ground completely. The towers at location Nos. 266 (DA+0) & 267(DA+0) had collapsed / fallen from stub level subsequently due to fall of tower at location No. 268. It was observed that some miscreants had cut the main bracings of the tower which resulted in the failure of the tower. The matter was reported to Police and FIR was lodged. Powergrid informed that patrolling has been intensified in the area to prevent such occurrence in future.

The Committee suggested that local people should be educated by Powergrid and should be engaged for the safety of the towers.

(x) 765kV S/C Bina-Indore Transmission line [Location no. 556]

The towers of this line were designed by Powergrid and constructed by M/s Jyoti Structures Limited, Mumbai, and the line was commissioned on 01.07.2013. The tower at location No. 556 had failed on 12.07.2014.The suspension towers of this line were designed for wind zone:II (39 m/sec) and reliability level-2 as per IS: 802-1995. This is the first instance of tower failure in this line.

The tower at location no. 556(A+0) had failed from two panels above bottom level. The tower legs were twisted. However, the stubs were intact. The tower was located in cultivated land. Committee was of the view that the tower might have failed due to high speed whirlwind along with gale storm.

Powergrid officers suggested to wait & watch till any more failure occurs in future and the Committee agreed with view of PGCIL.

2.2 THE FAILURE OF TOWER OF VARIOUS LINES OF DELHI TRANSCO LTD.

2.2.1 The towers of following 220kV transmission lines of DTL had failed during above mentioned period.

Sl. No.	Names of the Transmission Lines	Date of Occurrence of failure	No. of towers failed
1.	220 kV D/C Bamnauli-Pappankalan-1 line	30.05.2014	4
2.	220 kV D/C Bawana-Rohini-II line	30.05.2014	6
3.	220 kV D/C Mandola-Gopalpur line	30.05.2014	1
4.	220 kV D/C South of Wazirabad-Kashmiri Gate line	02.07.2014	3
	Total		**14**

2.2.2 OBSERVATIONS OF THE COMMITTEE AND RECOMMENDATIONS

(i) 220 kV D/C Bamnauli-Pappankalan-I Transmission Line [Location no. 9(A+3), 10(A+3), 11(A+3) & 12(A+3)]

The 220 kV D/C Bamnauli-Pappankalan-I Transmission Line was constructed by M/s Pioneer Construction Company and was commissioned in 2000. The towers of this line were designed for medium wind zone as per old IS 802 as informed by DTL officer.

General Observations:

(a) Location No. 9 (A+3): The tower bent and fell in transverse direction from 1st panel (normal tower) level. Leg member has been broken at this level. The foundation was intact. Anti Climbing Device was missing. There were holes left in the leg members. Being old line, some of the members have rusted.

(b) Location No. 10 (A+3): The tower bent and fell in transverse direction from 1st panel (Normal tower) level. Two stubs were also bent. The foundation was intact. Some bolts were missing at the leg joints. Extra holes were left in the leg members. Some of the members have rusted.

(c) Location No. 11 (A+3): The tower bent and fell from 1st panel (Normal tower) level. The foundation was intact. Extra holes were left in leg members. Some of the members have rusted.

(d) Location No. 12 (A+3): The tower bent and fell from 1st panel (Normal tower) level. The foundation was intact. Extra holes were left in leg members. Some of the members have rusted.

It was observed that a compound wall was running parallel to the line. The high velocity localized whirl wind, obstructed by the raised compound wall near the failed towers, might have increased the wind pressure further near the tower locations leading to damage of the towers at normal tower level. Most likely, the

towers, which were subjected to such whirl wind, have suffered damages whereas the other adjoining towers in the line are found to be intact. All the four towers (A-Type) in one section of the line had fallen towards the wall in transverse direction. The foundations were intact. Other transmission line i.e. 220kV Bamnauli-Najafgarh D/c line with towers having broad base, which is passing parallel and close to this line was also intact and no damage was reported.

The line was restored on normal tower on 16-06-2014 (Ckt-I) and 23-06-2014 (Ckt-II).

(ii) <u>220 kV D/C Bawana-Rohini-II Transmission line</u>[Location no.29(B+0), 30(A+3), 31(A+3), 32(A+3), 36(A+3) & 37(C+3)]

This line was constructed in 1995 by M/s Aquarian Enterprises and commissioned in 2005. Design criteria adopted was as per old IS 802.

<u>General observations</u> :

a) **Location No. 29(B+0):** The tower was damaged from top cross arm level. The foundations were intact. Coping of chimneys was not done.

b) **Location No. 30(A+3):** The tower was bent from top of the 1st panel of normal tower and took a 'U' shape, top pointing towards ground. The foundations were intact. Coping of chimneys was not done. Some holes were left in the tower members.

c) **Location No. 31(A+3):** The tower was bent from top of the 1st panel. Foundations were intact. Coping of chimneys was not done. Some holes were left in the tower members. Stubs were bent. These needs repair/ replacement.

d) **Location No. 32 (A+3):** The tower was bent from top of the 1st panel. Foundations were intact. Coping of chimneys were not done. Some holes were left in the tower members. Stubs were bent. These needs repair/ replacement. Bushes were grown around the foundation. These are to be removed.

e) **Location No. 36 (A+3):** The tower was bent from top of the 1st panel. Foundations were intact. Stubs were bent and need repair/ replacement.

f) **Location No. 37 (C+3):** The tower fell from the stub level. Stubs were damaged. Stubs are to be repaired/replaced.

It was observed that a canal was running parallel to the line at a higher elevation. The high velocity localized whirl wind, obstructed by the canal near the failed towers, might have increased wind pressure further near the tower locations leading to damage of the towers at normal tower level. Most likely, the towers, which were subjected to such whirl wind, have suffered damages whereas the other adjoining towers in the line are found to be intact. The towers have fallen towards the canal.

The line was restored on normal tower on 20-06-2014.

(iii) 220 kV D/C Mandola-Gopalpur Transmission line[Location no.25(A+6)]

This line was energized in year 1975. As informed by DTL, design criteria adopted was as per old IS 802. One tower at location no. 25 (A+6) had failed on 30.05.2014.

General observations

The tower failed due to falling of a tree on the line during the high intensity storm. New tower has been erected and the line was restored on normal tower on 16-06-2014 (Ckt-I) and 17-06-2014 (Ckt-II).

(iv) 220kV D/C South of Wazirabad-Kashmiri Gate line
[Location nos. 14 (A+3), 15(A+3) & 16(B+6)]

This line was designed by M/s Scentee India Pvt. Ltd. and constructed by M/s Hythro Power Corporation during the year 1994 to 2002. The towers at (Location Nos. 14 (A+3), 15(A+3) & 16(B+6) had failed on 02.07.2014). The towers of this line were designed as per IS: 802-1977 and IS: 2062-1975. The location of the failed towers was near 2nd Pusta, Usmanpur behind Shastri Park Metro Station.

General observations

It was reported that there was heavy wind storm accompanied by rainfall in the afternoon of 02.07.2014.

Two legs of the tower at location No. 14 (A+3) were bent from base of normal tower level, and two legs were bent from stub level. The chimneys of the tower were about 10 feet high. This tower fell on the conductors of 220kV D/C Geeta Colony-Wazirabad transmission line running parallel to this line. No missing tower members were observed. Tower at location No. 15(A+3) was bent from stub level whose chimneys are also about 10 feet high. The middle & top cross arms of the tower at location No. 16(B+6) were damaged due to falling of tower at location No. 15. The towers are located on the bank of river Yamuna and the ground profile between location no. 14 & 15 is not plain. The towers of this line are narrow based. There was no damage to the broad based towers of 220kV D/C Geeta Colony-Wazirabad Transmission line running parallel to this line.

2.2.3 Analysis of failures:

From the preliminary investigation and discussion with DTL officers, it was brought to the notice that all towers of above three lines were designed with narrow base. It was also reported that high velocity localized whirl wind have caused damage to number of trees in the locality near the failed tower locations. A part of nearby wall in agricultural field was also damaged due to the effect of wind and relevant photographs are enclosed.

All the four towers (A-Type) in one section of the **220 kV D/C Bamnauli-Pappankalan-I Transmission Line** had fallen towards the wall in transverse

direction. The foundations were intact. The other transmission line i.e. 220kV Bamnauli-Najafgarh D/c line with towers having broad base, which is passing parallel and close to this line was also intact and no damage was reported. Hence it is presumed that the high velocity localized whirl wind, obstructed by the raised compound wall running parallel to above line (near the location of failed towers), might have increased wind pressure further near the tower locations leading to damage of the towers at normal tower level. Most likely, the towers, which were subjected to such whirl wind, have suffered damages whereas the other adjoining towers in the line are found to be intact.

Similarly five towers of **220 kV D/C Bawana-Rohini-II Transmission line** have fallen towards the canal in transverse direction and one tower damaged from top cross arm level. The foundations were intact. Hence it is presumed that the high velocity localized whirl wind, obstructed by the canal near the failed towers, might have developed further wind pressure near the tower locations leading to damage of the towers at normal tower level. Most likely, the towers, which were subjected to such whirl wind, have suffered damages whereas the other adjoining towers in the line are found to be intact.

DTL officers have informed that the towers were designed long back by a private firm using old codes probably as per IS 802: 1977 and these towers are being used in most of their lines. No relevant design documents are available with them. It is pertinent to mention that earlier the entire country was divided into only three wind pressure zones as per IS 802:1977. Subsequently the IS 802 was revised in year 1995 and the country was divided into six wind zones based on wind velocity pattern. As per new code (IS 802:1995), Delhi comes under wind zone-IV with a higher wind speed as compared to old code (IS 802:1977) for which towers of DTL were designed. In absence of meteorological data it is difficult to assess the wind speed on 30-05-2014 at the failed tower locations. However, paper clippings provided by DTL shows that on that particular day, the wind velocity was in the range of 114 to 130 km/hr in some parts of Delhi. DTL officials were requested to collect relevant information from the Meteorological department.

The basic wind speed data provided in IS: 875 based on which the wind zones 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 storms/ dust-storms etc. These are short lived and cover small area but devastation caused for such high intensity winds is very severe though restricted to a smaller area only.

In view of above reason, the whirl wind could be one of the causes of failure of towers as other adjoining towers of the line as well as other nearby lines are intact. Moreover, the towers / lines are not generally designed for such condition because of high cost involved and the probability of occurrences of such incidences are very low. The holes in some of the tower members including leg members are found to be left unfilled with bolts & nuts, which results in decrease in strength of members.

The Material test reports of samples taken from the failed towers, conducted at M/s Microtech Testing & Research Laboratory, Delhi (Building & road materials)

has been examined by CEA and found to be in order. But DTL may ensure that the test laboratory in which such tests have been carried out is recognized NABL approved laboratories / Govt./ Govt. approved laboratory.

2.2.4 Recommendations of the Standing Committee

(i) Towers of the line were designed as per old code IS:802 (1977) and the wind zone for Delhi area has been changed as per revised code IS: 802 (1995). In view of the above, DTL may review design of towers in line with latest IS codes and strengthening of members of tower, if required, may be carried out accordingly to avoid reoccurrence of such failures in future and thereby increase the availability of the line. PGCIL/CPRI/SERC / any other organization may be consulted for review of the design.

(ii) In future, the use of tower designed as per old IS:802(1977), should be avoided as a replacement to failed towers in any existing lines or in new lines until the design review is complete.

(iii) The regular patrolling of lines should be carried out by DTL to check for missing of tower members. Regular maintenance activities such as chopping of nearby trees to maintain adequate safety clearances, considering MOE & F guidelines, removing the bushes near the foundation area, and coping of chimneys etc. should be carried out by DTL from time to time, as and when required.

(iv) For old lines, rusting in members of all the towers (due to exposure to atmosphere over a long period of time) may be checked and painting of the rusted members with Zinc rich paints may be done as remedial measures.

(v) The holes in the tower members including leg members are to be filled with bolts & nuts to increase the strength of members.

(vi) Chimneys of all the towers should be provided with coping to avoid accumulation of rain water near stub. If required, the height of the chimneys may be raised where the tower is located in agricultural field to avoid deposit of soil on the chimneys due to agricultural activities.

(vii) Quality of steel material may be ensured while replacing these missing members.

(viii) Material test of the failed tower members should be carried out from recognized NABL approved laboratories / Govt. approved laboratories to assess the quality of steel material used in the tower.

2.3 FAILURE OF TOWERS OF VARIOUS TRANSMISSION LINES OF RRVPNL

2.3.1 The towers of following 220kV and 132kV Transmission Lines of RRVPNL had failed during above mentioned period.

Sr. No.	Name of the Transmission Line	Date of Occurrence	No. of tower failed
1	220kV S/C Amarsagar-Phalodi line	17.04.2014 & 13.05.2014	18
2	220kV S/C Tinwari-Phalodi line	11.05.2014	1
3	220kV D/C Amarsagar-Mada line	17.04.2014	5
4	220kV D/C Akal-Giral line	17.04.2014	25
5	220kV D/C Akal-Amarsagar line	17.04.2014	3
6	132kV S/C Tinwari- PS 8 line	17.04.2014	3
7	132kV Chandan-Mohangarh line-PHED line (Charged at 33kV & owner Jodhpur Discom)	17.04.2014	2
8	132kV S/C Jaisalmer-Ramgarh line (Ckt-1)	17.04.2014	3
9	132kV S/C Pokaran-Askandra line (for M/s Lanco Solar)	17.04.2014	1
10	132kV S/C Bilara-Sojat line	15.05.2014	1
	Total		**62**

2.3.2 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. 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) <u>220kV S/C Phalodi -Amarsagar line(upto Amarsagar)</u>

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) <u>220 kV D/C Akal-Giral line</u>

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) <u>220 kV D/C Akal-Amarsagar line</u>

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) <u>220kV S/C Tinwari-Phalodi line</u>

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) <u>220 kV D/C Amarsagar-Mada line</u>

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) <u>132kV S/C Tinwari-PS 8 line</u>

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) <u>132kV Chandan-Mohangarh line</u>

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.

2.3.3 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.

2.3.4 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.

MINUTES OF MEETING, PRELIMINARY INVESTIGATION REPORT AND PHOTOGRAPHS OF FAILED TOWER

The Minutes of meetings of the Standing Committee are enclosed at **Annexure-A**. The photographs of failed towers along with Preliminary Investigation Report on failure of tower(s) at different locations for the above lines are enclosed at **Annexure – B.**

(S.K.Ray Mohapatra)
Director (Transmission)
SETD Division
And
Member Secretary,
Standing Committee of
Experts to investigate
failure of towers

(K. K.Arya)
Chief Engineer (SE&TD)
And
Chairman,
Standing Committee of
Experts to investigate
failure of towers

New Delhi

Date :