

# Failure of Towers based on the Experiences of CPRI, Bangalore

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# Transmission line Failures

**Failure Definition :** As per IEC 60812 : 2008

*“Termination of the ability of an item to perform a required function”*

**Specific to transmission line is described as** *“ State of a structure. component or element whose purpose is terminated i.e, in which a component has failed by excessive deformation, loss of stability, overturning, collapse, rupture, buckling etc.”*

**Failure Modes :**

- a. **Electrical** : *Earthing, Lightning, Insulation & Transmission*
- b. **Structural** : *Hardware ( Conductor/Earth wire/attachments), Connections ( Bolts/Foundation interface/Welding ), Foundation, Superstructure*

# Typical Causes of Failures

**Transmission line towers :** One of the few products tested in life size ( full scale ) before being mass produced. Still the inadequacies in design and materials attributed to failures.

## **Causes of Failures :**

- **Overloading**
- **Sabotage**
- **Theft of tower members**
- **Extreme weather conditions - High intensity wind phenomenon**
- **Optimized tower design by adopting staggered pattern ( dissimilar panel arrangement for transverse and longitudinal faces )**
- **Triangulation is not complete in some areas ( body plans, cross arm elevation and plan )**
- **Members and plates are not properly detailed**
- **Improper slenderness ratio and hence error in strength calculation**



# Performance of test towers past 5 years at CPRI

Tower Type	Total Numbers	No. of Failed Towers	%age of Failed Towers
66 kV	11	01	09
132 kV	70	10	14
220 kV	40	14	35
400 kV	25	08	32
765 kV	09	03	33
<b>Total</b>	<b>155</b>	<b>36</b>	<b>23</b>

# Failure of Towers Observed During Full Scale Testing



Tower Type	Total Numbers	No. of Failed Towers	%age of Failed Towers
132 kV	12	1	08
220 kV	04	3	75
330 kV	01	1	100
400 kV	10	5	50
765 kV	01	0	Nil
<b>Total</b>	<b>28</b>	<b>10</b>	<b>36</b>

**Summary of Failed Towers during 2011-12**

Rating	HEIGHT	FAILED AT	DESCRIPTION
400kV	56.8M	90%	Security condition
220kV	42.26M	95%	Security condition
220kV	44.56M	95%	Security condition
400kV	47.51M	90%	Reliability condition
330kV	54.85M	100%	Security condition
220kV	42.26M	90%	Security condition
400kV	56.65M	100%	Security condition
400kV	66.41M	100%	Security condition
400kV	59.71M	95%	Security condition
132kV	26.20M	95%	Security condition

# Failure of Towers Observed During Full Scale Testing



Tower Type	Total Numbers	No. of Failed Towers	%age of Failed Towers
66 kV	02	0	Nil
115 kV	02	1	50
132 kV	22	6	27
220 kV	01	0	Nil
230 kV	04	1	25
330 kV	01	0	Nil
400 kV	04	1	25
765 kV	04	2	50
<b>Total</b>	<b>40</b>	<b>11</b>	<b>28</b>

## Summary of Failed Towers during 2012-13

RATING	HEIGHT	FAILED AT	DESCRIPTION
132kV	34.34M	90%	Reliability condition
132kV	38.68M	75%	Reliability condition
132kV	40.25M	90%	Security condition
132kV	41.76M	95%	Reliability condition
132kV	29.28M	100%	Dead End condition
132kV	35.65M	90%	Security condition
765kV	63.75M	95%	Security condition
132kV	37.35M	95%	Reliability condition
115kV	45.57M	95%	Safety broken condition
765kV	59.86M	75%	Safety broken condition
230kV	48.37M	90%	Security condition
400kV	58.25M	95%	Reliability condition

# Failure of Towers Observed During Full Scale Testing



Tower Type	Total Numbers	No. of Failed Towers	%age of Failed Towers
66 kV	01	0	Nil
110/115 kV	03	1	33
132 kV	10	2	20
138 kV	01	1	100
161 kV	01	0	Nil
220 kV	06	0	Nil
230 kV	01	0	Nil
330 kV	04	0	Nil
400 kV	04	0	Nil
765 kV	04	1	25
<b>Total</b>	<b>35</b>	<b>05</b>	<b>14</b>

## Summary of Failed Towers during 2013-14

RATING	HEIGHT	FAILED AT	DESCRIPTION
765kV	62.07M	100%	Security condition
132kV	26.76M	75%	Reliability condition
115kV	49.93M	90%	Security condition
132kV	40.26M	90%	Reliability condition
138kV	42.85M	90%	Security condition

# Failure of Towers Observed During Full Scale Testing



Tower Type	Total Numbers	No. of Failed Towers	%age of Failed Towers
33 kV	04	0	Nil
66 kV	04	0	Nil
90 kV	04	0	Nil
132 kV	10	0	Nil
220 kV	17	5	29
230 kV	02	0	Nil
400 kV	04	0	Nil
<b>Total</b>	<b>48</b>	<b>05</b>	<b>10</b>

## Summary of Failed Towers during 2015-16

RATING	HEIGHT	FAILED AT	DESCRIPTION
220kV	64.55M	90%	Reliability condition
220kV	64.55M	95%	Reliability condition
220kV	67.82M	100%	Security condition
220kV	64.32M	75%	Reliability condition
220kV	64.32M	95%	Reliability condition



# Test Towers Failed During the Year 2014-15



Tower before Test

Tower during test



230 kV D/C Suspension tower

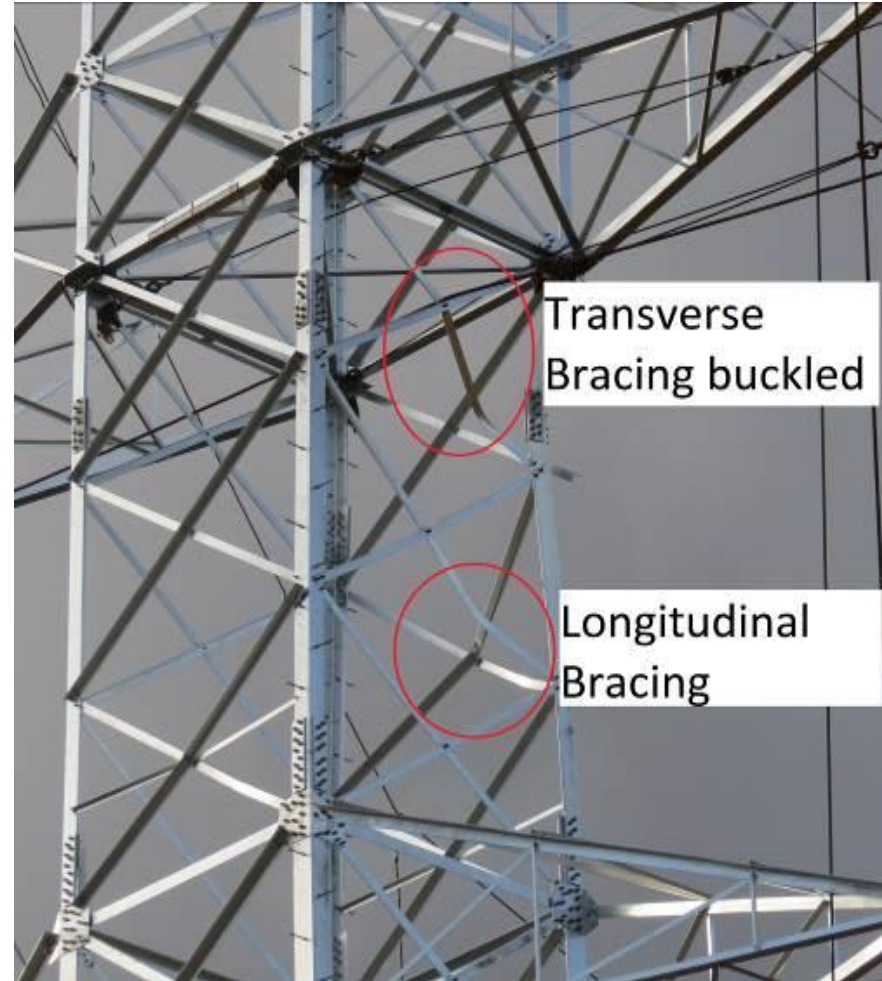
Failed at 95 % loads

## Tower before Test



**220 kV D/C Tension tower**

## Tower during test



**Failed at 95 % loads**

## Tower before Test



220 kV D/C Tension tower

## Tower during test



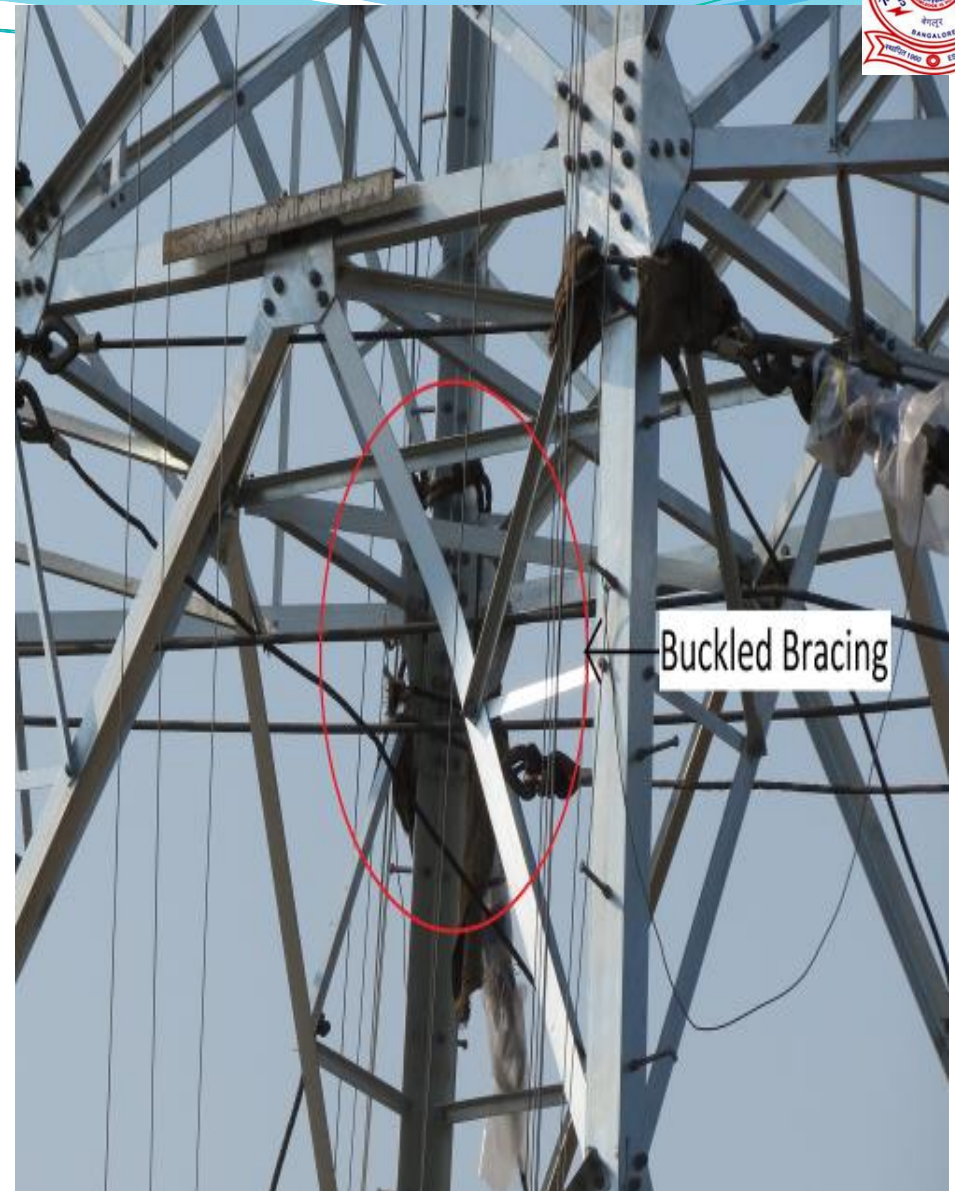
Failed during waiting period  
at 100 % loads

## Tower before Test



220 kV D/C Tension tower

## Tower during test



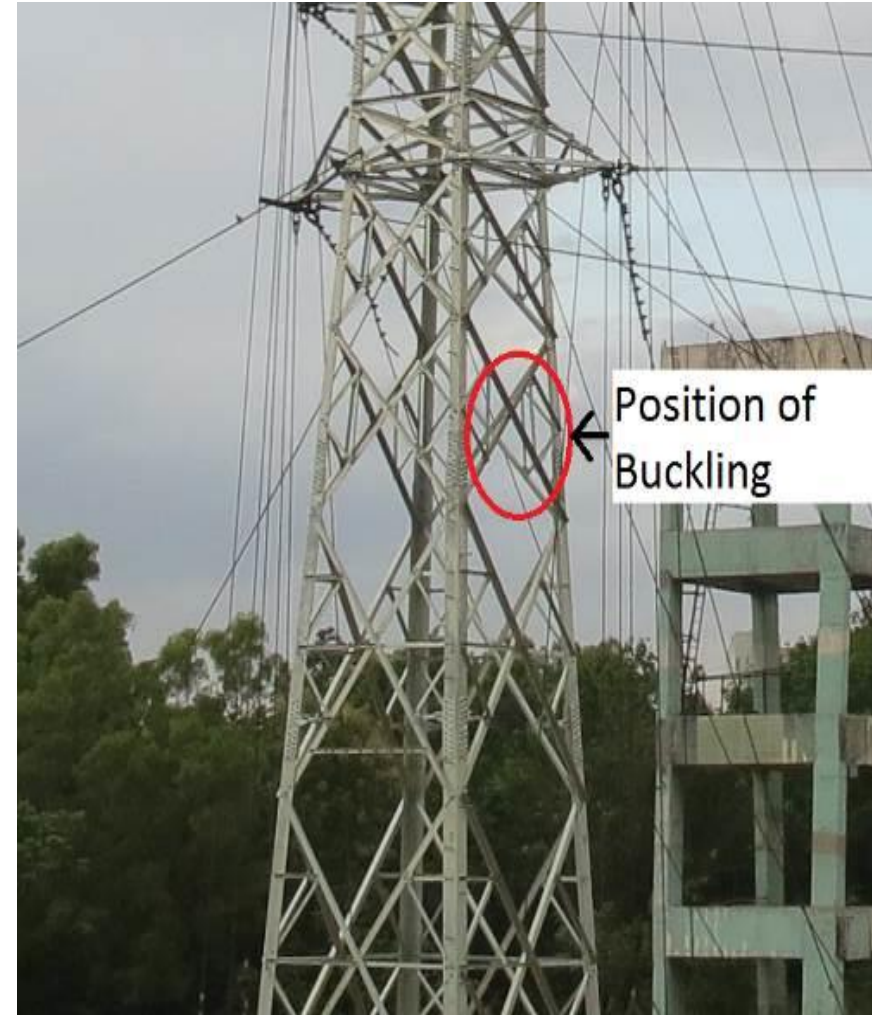
Failed during waiting period  
at 100 % loads

## Tower before Test

## Tower during test



66 kV M/C Tension tower



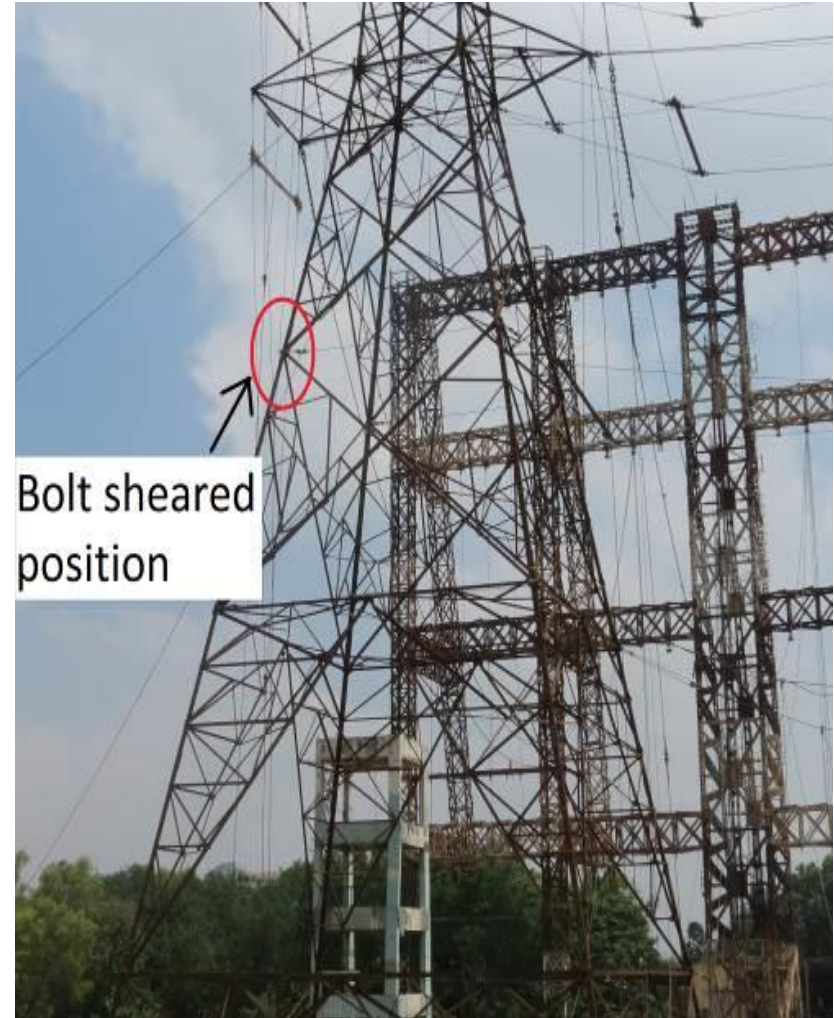
Failed during waiting period  
at 100 % loads

## Tower before Test



**220 kV D/C Tension tower**

## Tower during test



**Failed during 75 % to 90 %**

## Tower before Test



**230 kV D/C Tension tower**

## Tower during test



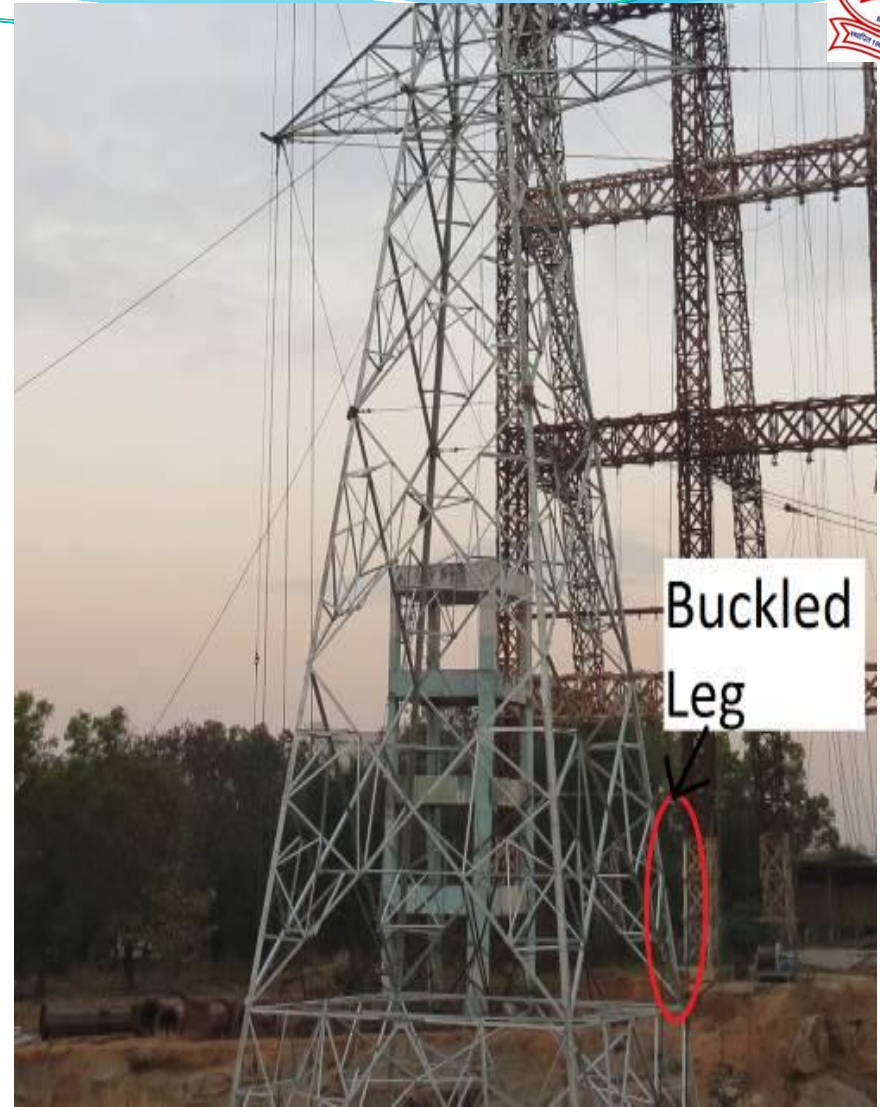
**Failed during 95 % to 100 %**

## Tower before Test



**330 kV D/C Tension tower**

## Tower during test



**Failed at 95 % loads**



## Tower before Test



400 kV D/C Tension tower

## Tower during test



Failed at 95 % loads



## Whole Tower Collapsed during Test



# Failure of Towers Observed During Full Scale Testing



Tower Type	Total Numbers	No. of Failed Towers	%age of Failed Towers
33 kV	03	0	Nil
66 kV	04	1	25
115 kV	02	0	Nil
132 kV	16	1	06
161 kV	03	0	Nil
220 kV	12	4	33
230 kV	09	2	22
330 kV	03	1	33
400 kV	03	2	67
<b>Total</b>	<b>60</b>	<b>11</b>	<b>18</b>

## Summary of Failed Towers during 2014-15

S. No.	Rating	Total Height (m)	Nature of Failure	Loading Condition	%age of Load
1	230 kV	63.09	Whole Tower Collapsed	Normal Condition (RC)	90%
2	220 kV	50.57	Bracing Buckled	Anti-Cascading Condition	75%
3	220 kV	51.07	Whole Tower Collapsed	Normal Condition(RC)	100%
4	220 kV	39.60	Bracing Buckled	Broken Wire Condition (SC)	100%
5	66 kV	32.05	Redundant Buckled	Broken Wire Condition (SC)	100%
6	220 kV	55.54	Bolt Sheared	Broken Wire Condition (SC)	75%
7	230 kV	67.30	Whole Tower Collapsed	Normal Condition(RC)	95%
8	330 kV	44.03	Leg Buckled	Broken Wire Condition (SC)	100%
9	400 kV	58.73	Bolt Sheared	Normal Condition(RC)	95%
10	132 kV	25.15	Bolt Sheared	Normal Condition(RC)	95%
11	400 kV	45.45	Bolt Sheared	Broken Wire Condition (SC)	100%

# Conclusions of Failed Towers during 2014-15

- Maximum percentage of failed towers are 400 kV : 67 %
- Failure rate increases when voltage rating increases.
- Out of 11 failed towers, 5 towers failed in **Reliability condition**  
5 towers failed in **Security condition**, 1 tower failed in **Anti – cascading condition**
- Out of 11 failed towers 3 towers collapsed under **Reliability condition**, the failures under security condition is not major
- Maximum towers failed after reaching 90 % loads.
- Many times bolts were responsible for tower failures.

# SPECIAL TOWERS/POLES TESTED



**765 kV S/C Power Grid**



**154 kV D/C Steel pole  
Korea**



**220/132 kV M/C Steel pole,  
MPPTCL Jabalpur  
First time in India**

# SPECIAL TOWERS/POLES TESTED

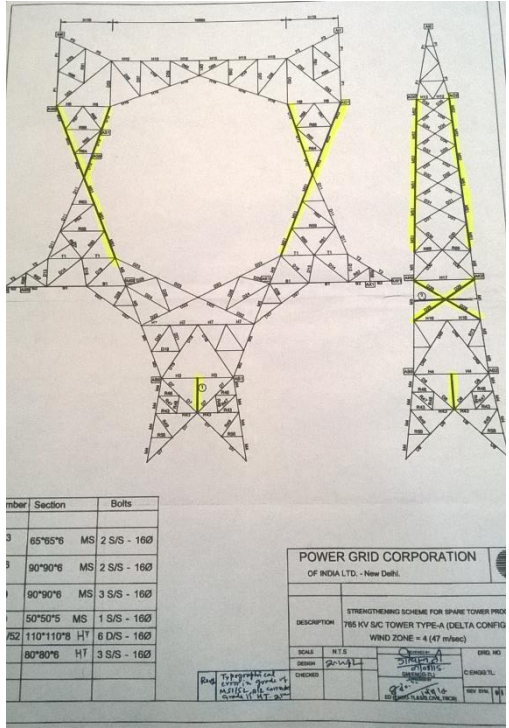
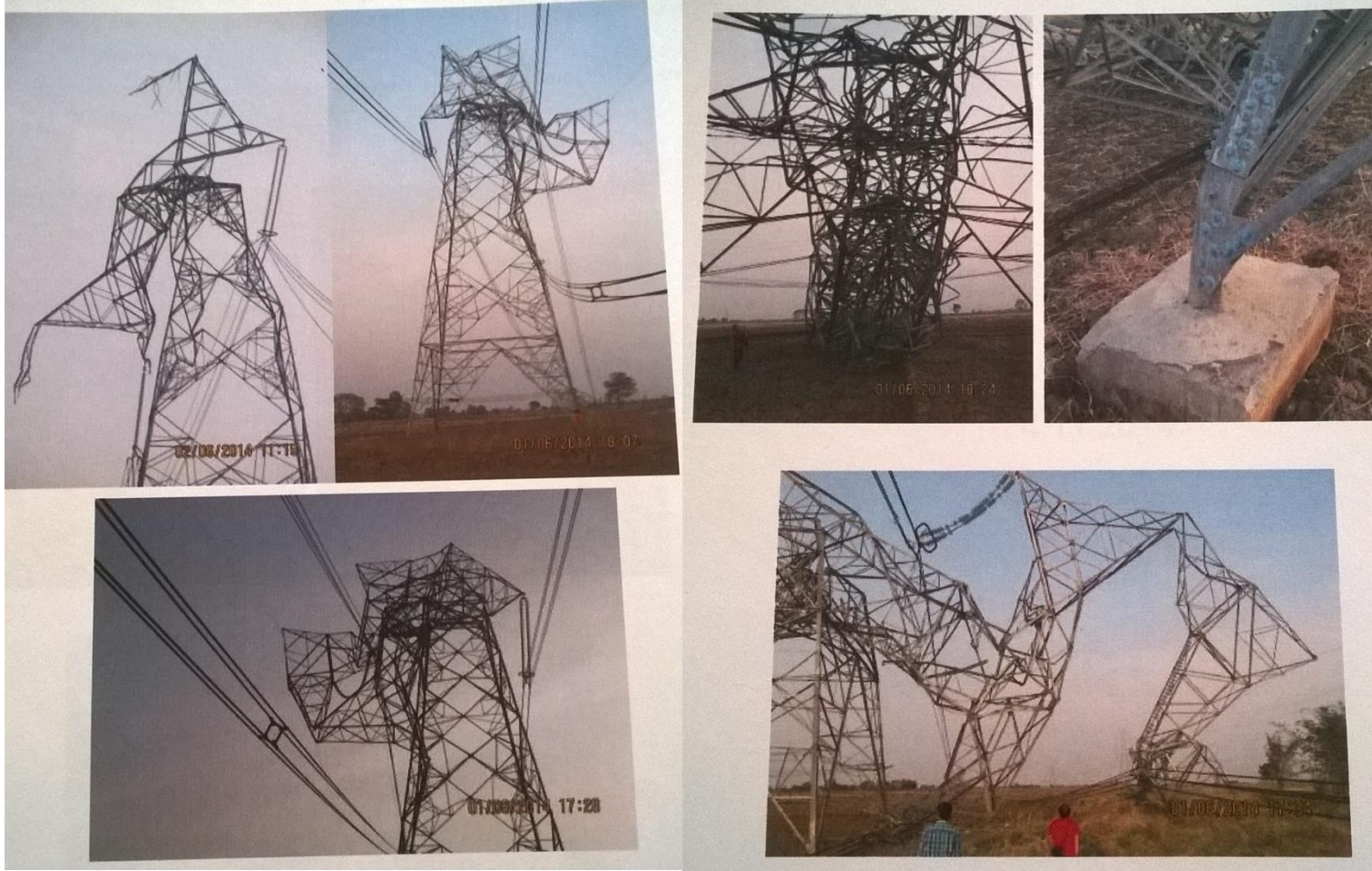


**275/132 kV M/C Pole**



**220 kV D/C Pole**

# Failure Investigation / Analysis of 765 kV S/C Gaya- Fathepur Transmission line ( Horizontal Delta Wind Zone - 4 )



**Failure Analysis of 765 kV S/C “A” tower ( Strengthening measures suggested )**







23/09/2015 11:10