

Analysis and Design of an Industrial Tower

ABSTRACT—Steel Transmission Towers are often used to transmit power from one location to another using electrical conductors. Transmission line towers elevate heavy electrical transmission conductors to a safe height above the ground. Furthermore, all towers must withstand various natural disasters such as wind, earthquakes, and so on. Because towers must support the weight of above lines, they must be strong. As a result, the design engineer has a lot of responsibility, as he or she must develop not only an economical, but also a safe and trustworthy design that can withstand various loads, including its own. Transmission line towers are classified by voltage, circuit count, and kind. The most common configurations used are rectangular and square. The most prevalent type of broad-based tower is the square type. Different sorts of towers are introduced in this. Transmission towers are often built of steel or galvanized steel. Lattice structures are commonly utilized and have a sleek body made up of polygonal tubular sections with tubular cross arm management for fastening the tension or suspension clamp. The height of the tower, base width of the tower, top-hamper width, length, and depth of the cross arm are the geometric parameters of transmission line tower configuration. The leg and bracing elements are the main components of the lattice tower. They transport the tower's vertical and shear stresses to its foundation. Secondary or redundant bracing members are utilized to offer intermediate support to primary members in order to reduce unbraced length and boost load carrying capability. Rectangular and square configurations are the most common. The most frequent are square-shaped broad-based towers. STAAD PRO V8i was used to construct and analyze a standard steel latticed skyscraper of height 19 meters. On post-processing mode after load analysis The bending moment and shear forces findings were obtained, examined, and updated to meet the requirements.

Keywords— Transmission Line Tower, Tension or Suspension clamp, Lattice tower, redundant bracing members.

I. INTRODUCTION

Electric power consumption has continued to climb in every country, developed and developing, with the pace of expansion being faster in emerging countries. Electric power is becoming increasingly vital in community life and the development of numerous economic sectors. As a result, developing countries like India are prioritizing electricity development programmes. In reality, electricity is becoming a more important basic element in the economy.

A) TRANSMISSION TOWER

A tower (also known as an electricity pylon or other forms) is a tall structure that supports an overhead power line. It is usually made of steel lattice. The conductor subsystem, ground wire subsystem, and one

subsystem for each kind of support structure make up a transmission line. They're utilized to keep the Extra High Voltage alive (E.H.V). Mechanical transmission line supports account for a major amount of the line's cost and play a key role in ensuring dependable power transmission. Steel lattice towers are extensively used in the power industry to transmit power through electrical cables from the point of generation to the point of distribution. As towers are critical components of transmission lines, precise prediction of their failure is critical for transmission system dependability and safety. Transmission line towers are said to account for 28-48 percent of a transmission line's overall cost. Transmission line towers are also classed as Barrel, Corset, or Guyed towers based on their shape.

B) TOWER SPECIFICATION

The top panel is known as the cage, and the bottom panel is known as the body, with legs spreading out to provide better stability against overturning moments. The most common configurations used are rectangular and square. The most prevalent type of broad-based tower is the square type. Electric transmission towers can be anywhere from 10 to 45 meters tall, whereas flood lights in stadiums and big flyover crossings can be anywhere from 15 to 50 meters tall. Television towers can be anywhere from 100 to 300 meters tall, while radio transmission and communication towers can be anywhere from 50 to 200 meters tall. The number of circuits carried by the tower can be single, double, or multi circuit. The conductor loads will be carried by a cross-arm in the cage part. Heavy compressive forces are applied to the columns and bracing. Transmission line towers are classified by the voltage of the line they carry. In India, the most frequent voltages for power transmission are 110 kV, 220/230 kV, and 440 kV. Steel equal angle sections are commonly used for tower members.

C) TOWER CONFIGURATION

Various line configurations are available depending on the transmission system's requirements. The configuration of a transmission line tower is determined by the following factors:

- a) The insulator assembly's length.
- b) The minimum clearances between conductors and between conductor and tower that must be maintained.
- c) The ground wire or wires' position in relation to the outermost conductor.
- d) The mid-span clearance necessary due to the dynamic behaviour of conductors and the line's lightning protection.
- e) The lowest conductor's minimum clearance above ground level.

Three criteria primarily dictate the tower configuration:

- i. The tower's height.
- ii. Base-width.

iii. Maximum hamper width

II. LITERATURE REVIEW

A lot of research work has been done in the field of Transmission Tower before. Design and detailed analysis were done on braced panels, compression members, stiffness etc.

a) (V.G. RAO, OPTIMUM DESIGN FOR TRANSMISSION LINE TOWERS, COMPUTERS AND STRUCTURES, VOL .57, 1992 81-92.) [1]: - The transmission line towers support electrical power conductors and ground-wires at suitable height above ground to satisfy certain functional requirements. It is reported that transmission line towers contribute to about 28-48% of the total cost of a transmission line.

b) (GUPTA A, ANALYSIS AND ECONOMICAL DESIGN OF TRANSMISSION LINE TOWERS OF DIFFERENT CONFIGURATION 2005) [2]:- Transmission line is an integrated system consisting of conductor subsystem, ground wire subsystem and one subsystem for each category of support structure.

c) (Y.M. GHUGAL, U.S. SALUNKE, 2011 - ANALYSIS AND DESIGN OF THREE AND FOUR LEGGED 400KV STEEL TRANSMISSION LINE TOWERS) [3]: - The four-legged lattice towers are most commonly used as transmission line towers. Three legged towers only used as telecommunication, microwaves, radio. In this study constant loading parameters including wind forces as per IS: 802 (1995) are taken into account.

d) (V. LAKSHMI AND M.V.R SATYANARAYANA, STUDY ON PERFORMANCE OF 220KV M/C MA TOWER DUE TO WIND VOL. 3 ISSUE 3, MARCH 2011) [4]: - Transmission line towers are used for supporting the high current or Extra High Voltage electric transmission lines. This is simultaneously given rise to the need for relatively large supporting structures.

e) (N. Prasad Rao, G.M. Samuel Knight, S.J. Mohan, Lakshmanan, Studies on failure of transmission line towers in testing, 2010 [5]: - The towers are vital components of the transmission lines and hence, accurate prediction of their failure is very important for the reliability and safety of the transmission system. When failure occurs, direct and indirect losses are high, leaving aside other costs associated with power disruption and litigation. The tower members are modeled as beam column and plate elements.

f) (KAUSHIK YOGESH, AJIT, BHARDWAJ LAL HEERA, ANALYSIS AND DESIGN OF FOUR LEG STEEL TRASMISSION TOWER USING STAAD.PRO, 2015) [6]: - A tower is a freely standing self-supporting structure fixed to the base or foundation. In developed countries the environmental impact of the traditional transmission towers is no longer accepted. Currently available design solutions with acceptable appearance are not employed in the developing countries mainly for cost reasons. In the developing countries the use of the traditional lattice transmission towers will continue

employing steel angles.

III. MODEL ANALYSIS

A four-legged transmission tower of height 19 m was designed and analyzed. The tower designed carries both 220 kV and 440 kV power capacity. For section analysis SP 16 was followed and for analysis of transmission tower body IS 802: 1995 (Part 1) was followed. A load of 3.5 kN on 220 kV and 5 kN on 440 kV. The whole structure was designed and analyzed on STAAD-PRO V8i software. The tower was subjected to different loading i.e. Dead Load, Live Load and Wind Load complying with Indian Standard Codes like (IS: 875 part 1 ,1987 - Dead Load, IS: 875 part 2, 1987 - Live Load and IS: 875 part 3 ,1987 - Wind Load) Using this software we have checked the bending moment shear force, deflection of different members

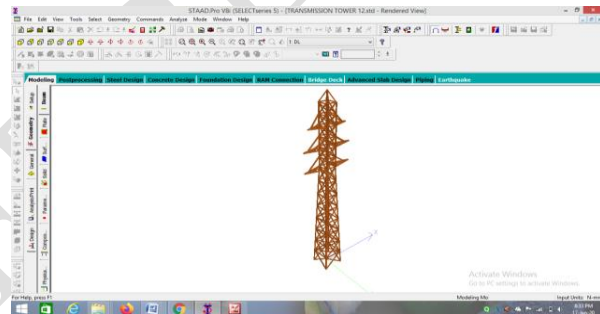


Fig.1 3D Rendering view

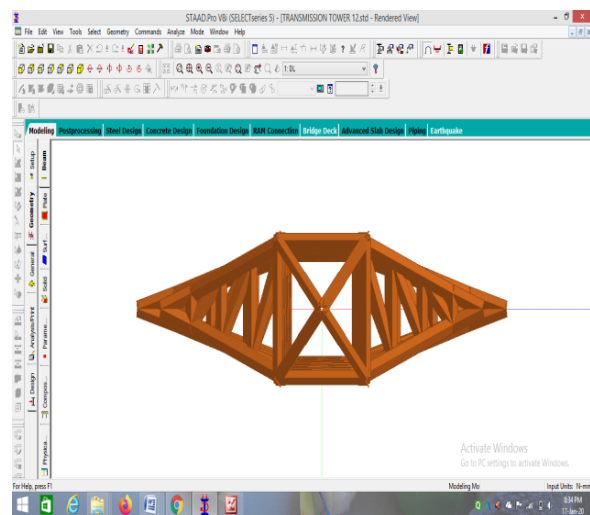


Fig. 2 Top View

A) Section Analysis:

Members	Section	Material
Column	ISA	Steel

	100x100x10	
Wings	ISA 100x100x8	Steel
Bracings	ISA 75x75x8	Steel

Table 1: Section Database

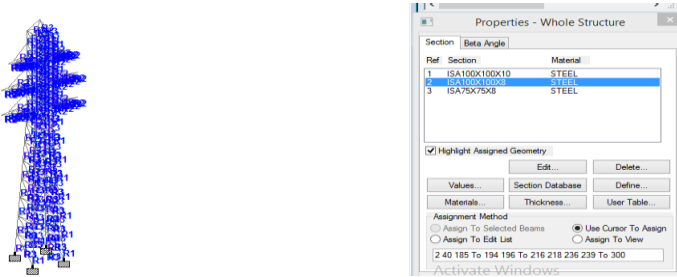


Fig. 3 Assigning different section properties

Sl no	Intensity	Height
1	9.47E-05	0
2	9.47E-05	4572
3	0.000101	5681.85
4	0.000106	6791.69
5	0.000111	7901.54
6	0.000115	9011.38
7	0.000119	10121.2
8	0.000122	11231.1
9	0.000126	12340.9
10	0.000129	13450.8
11	0.000132	14560.6
12	0.000135	15670.5
13	0.000137	16780.3
14	0.00014	17890.2
15	0.000142	19000

Table 3 Wind Intensities

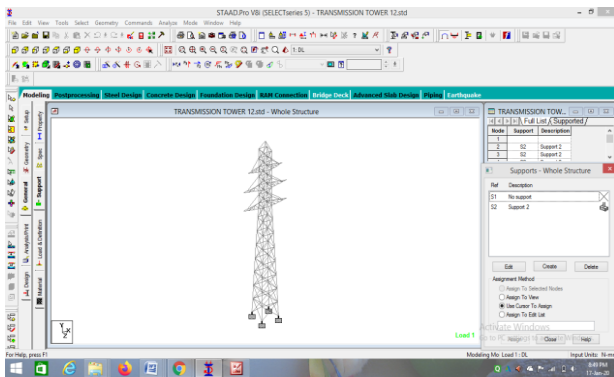


Fig. 4. Assigning fixed support

B) LOAD ANALYSIS IN DETAIL ON TRANSMISSION TOWER:

1. Load Definition:

i) Wind load definition:

Sl No.	Title	values
1	Building category	II
2	Basic wind speed	50 kmph
3	Exposure category	B
4	Structure Type	Trussed Type
5	Height	19 m
6	Width	5 m

Table 2. Wind Definition values

ii) Intensity:

iii) Exposure Factor - 0.5

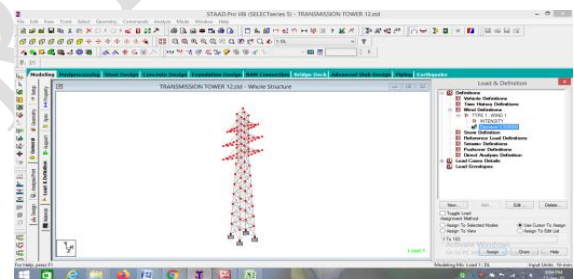


Fig. 5. Assigning of exposure factor

2. Dead Load Analysis:

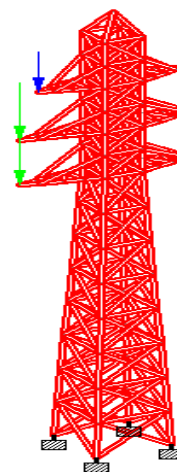


Fig.6. Assigned Dead Load

Self-Load Factor	KN
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220kV wing	KN
440kV wing	KN

Table 4 Dead Load Values

3. Live load analysis:

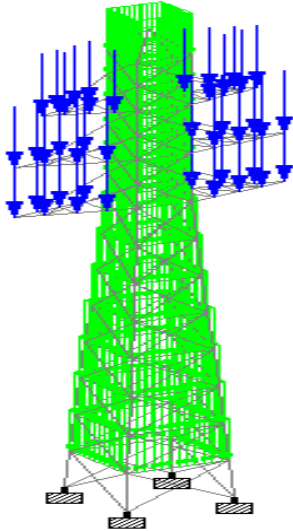


Fig.7. Assigned Live Load

Loads on Wings	1.5KN
Uniform force on other members	0.75KN/m

Table 5 Live Load Values

4. Effect of wind:

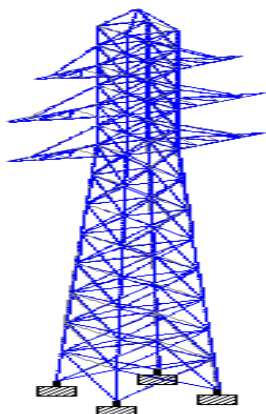


Fig. 8. Assigning Wind load at X+ direction

IV. STEEL DESIGN

CODE: - IS 802: 1995 PART I

FYLD (yield strength of steel) – 250 N/mm²

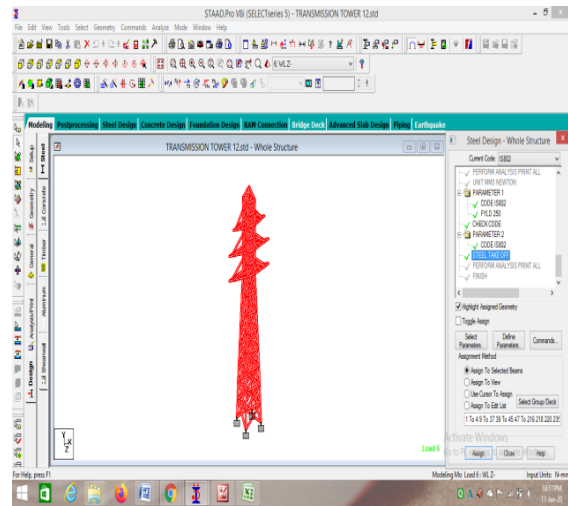


Fig.9. Assigning steel Take off

V. FINAL ANALYSIS & RESULTS

A. Shear Force & Bending Moment analysis for beam no 140:

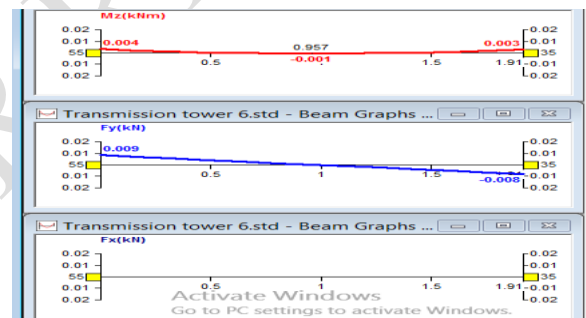


Fig10: Graph of load and moment variation

B. Stress variation:

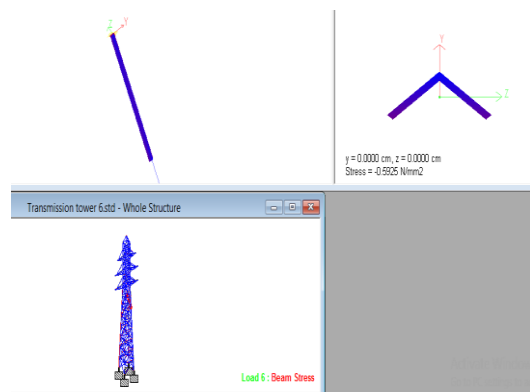


Fig:11 Stress Diagram

C. Brief details of few accepted members:

1 ST ISA75X75X8	(INDIAN SECTIONS)
PASS TENSION	0.006 13

1657.90 T	0.00	0.00	0.00
2 ST ISA100X100X8 (INDIAN SECTIONS)			
PASS COMPRESSION	0.012	7	
4525.23 C	0.00	0.00	0.00
3 ST ISA75X75X8 (INDIAN SECTIONS)			
PASS TENSION	0.006	12	
1756.79 T	0.00	0.00	0.00
4 ST ISA75X75X8 (INDIAN SECTIONS)			
PASS TENSION	0.019	7	
5454.03 T	0.00	0.00	0.00
9 ST ISA100X100X10 (INDIAN SECTIONS)			
PASS COMPRESSION	0.042	7	
18588.51 C	0.00	0.00	0.00
10 ST ISA100X100X10 (INDIAN SECTIONS)			
PASS COMPRESSION	0.043	7	
18916.62 C	0.00	0.00	0.00
11 ST ISA100X100X10 (INDIAN SECTIONS)			
PASS COMPRESSION	0.023	7	
10258.14 C	0.00	0.00	0.00
12 ST ISA100X100X10 (INDIAN SECTIONS)			
PASS COMPRESSION	0.043	7	
18749.50 C	0.00	0.00	0.00
17 ST ISA100X100X10 (INDIAN SECTIONS)			
PASS COMPRESSION	0.033	7	
14412.75 C	0.00	0.00	0.00
18 ST ISA100X100X10 (INDIAN SECTIONS)			
PASS COMPRESSION	0.033	7	

Table 6: List of passing members
D. Calculation of quantity of steel:

STEEL TAKE-OFF		
PROFILE	LENGTH	WEIGHT(NEWT)
ST ISA75X75X8	278231.06	24365.866
ST ISA100X100X8	67907.80	8033.627
ST ISA100X100X10	74083.25	10869.885

TOTAL =	43269.379	

Table 7: Steel Take-off

E. Total reactive load-case details:

TOTAL REACTION LOAD (KN-m) SUMMARY (LOADING 5)						
SUMMATION FORCE-X =	0.00					
SUMMATION FORCE-Y =	0.00					
SUMMATION FORCE-Z =	-4.14					
SUMMATION OF MOMENTS AROUND THE ORIGIN-						
MX=	-43.07	MY=	-0.01	MZ=	0.00	
MAXIMUM DISPLACEMENTS (Cm /RADIANS) (LOADING 5)						
MAXIMUMS AT NODE						
X = -1.28088E-03	1					
Y = 1.34028E-02	31					
Z = 3.52137E-01	1					
RX= 0.00000E+00	0					
RY= 0.00000E+00	0					
RZ= 0.00000E+00	0					
EXTERNAL AND INTERNAL JOINT LOAD SUMMARY KN/m						
JT	EXT FX/	EXT FY/	EXT FZ/	EXT MX/	EXT MY/	EXT MZ/
	INT FX	INT FY	INT FZ	INT MX	INT MY	INT MZ
SUPPORT=1						
2	0.00	0.00	0.03	0.00	0.00	0.00
1.59	-10.71	1.00	0.00	0.00	0.00	111111
3	0.00	0.00	0.03	0.00	0.00	0.00
-1.59	10.71	1.00	0.00	0.00	0.00	111111
4	0.00	0.00	0.03	0.00	0.00	0.00
1.59	10.83	1.01	0.00	0.00	0.00	111111
5	0.00	0.00	0.03	0.00	0.00	0.00
-1.59	-10.83	1.01	0.00	0.00	0.00	111111

Table 8- Summary of reactive loads

F. Applied load case details:

TOTAL APPLIED LOAD (kN -m) SUMMARY (LOADING 6)			
SUMMATION FORCE-X =	0.00		
SUMMATION FORCE-Y =	0.00		
SUMMATION FORCE-Z =	-4.14		
SUMMATION OF MOMENTS AROUND THE			

ORIGIN-			
MX=	-43.07	MY=	-0.01
		MZ=	0.00

Table 9- Summary of applied loads

VI. CONCLUSION

Based on the design and analysis done on the tower we have concluded as follows: -

- 1) Configuration of the structure of the tower plays a vital role in its performance especially while considering eccentric loading condition.
- 2) The vertical members are more prominent in taking the loads of the tower than the horizontal and diagonal members. The members supporting the cables at higher elevation are likely to have larger influence on the behavior of the tower structure.
- 3) From the result shown by the software all the given members with their given sections have passed tension and compression. Therefore, we can conclude that members are all safely designed.

VII. REFERENCES

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