

# COMPARITIVE STUDY OF TRANSMISSION LINE TOWER IN DIFFERENT SEISMIC ZONE WITH DIFFERENT CONFIGURATION

Yash N. Patel<sup>1</sup>, Jasmin A. Gadhiya<sup>2</sup>, Hitesh K. Dhameliya<sup>3</sup>, Kosha S. Pachchigar<sup>4</sup>

<sup>1</sup> Civil Department, Chotubhai Gopalbhai Patel Institute of Technology

<sup>2</sup> Civil Department, Chotubhai Gopalbhai Patel Institute of Technology

<sup>3</sup> Civil Department, Chotubhai Gopalbhai Patel Institute of Technology

<sup>4</sup> Civil Department, Chotubhai Gopalbhai Patel Institute of Technology

**Abstract** — There are too many literature papers available for analyzing and designing the transmission line tower. They show the comparison of different types of towers in form of applicability, economy, stability and different configuration. Transmission line tower constitute about 28 to 42 percent costs of the transmission lines. The increasing demand for electrical energy can be met more economical by developing different light weight configurations of transmission line towers by using hollow steel section instead of convectional section. In present work, the entire transmission line towers are designed with convectional section.

**Keywords-** Transmission line tower, Hollow steel section, Dynamic analysis, Staad pro v8i

## I. INTRODUCTION

In every country, the need of electric power has continuously increasing so it is necessary to transfer electricity each and every part of the society. Transmission tower lines are one of most important life-line structures to transfer electricity. Transmission towers are necessary for the purpose of supplying electricity to various regions of the nation. This has led to the increase in the building of power stations and consequent increase in power transmission lines from the generating stations to the different corners where it's needed. Transmission line should be stable and carefully designed so that they do not fail during natural disaster. It should also conform to the national and international standard. In the planning and design of a transmission line, a number of requirements have to be met from both structural and electrical point of view. From the electrical point of view, the most important requirement is insulation and safe clearances of the power Transmission tower lines are one of most important life-line structures carrying conductors from the ground. The cross-section of conductors, the spacing between conductors, and the location of ground wires with respect to the conductors will decide the design of towers and foundations.

The major components of a transmission line consist of the conductors, ground wires, insulation, towers and foundations. Most of the time transmission lines are designed for wind and ice in the transverse direction. However, seismic load is also important because the transmission line towers and the cables may be subjected to higher force and stressed during ground motion. However, the major concern of the transmission line during high earthquakes may be that the large displacements do not causes the cables to touch each other or any surrounding objects, causing power failure and accidents. Therefore, earthquake force is important in design in high earthquake zones of the country. Following are the different components of a transmission tower:

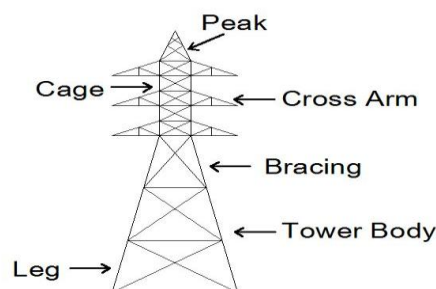


Figure 1. Components of transmission tower

## II. LITERATURE REVIEW

### A. Gopiram Addala, D.Neelima Satyam and Ramancharla Pradeep kumar “DYNAMIC ANALYSIS OF TRANSMISSION TOWERS UNDER STRONG GROUND MOTION”

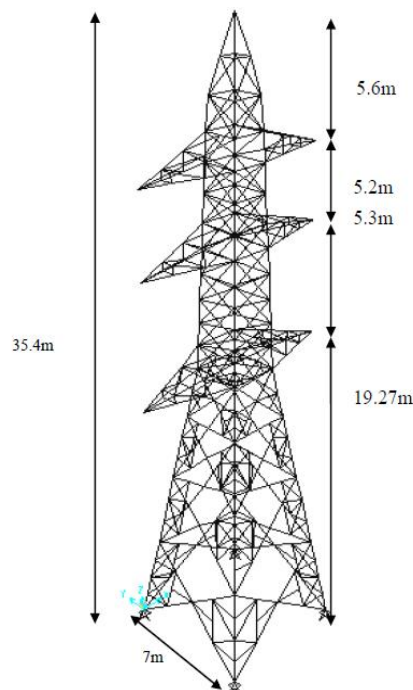
The dynamic Behavior of a single transmission tower and transmission towers that are linked by conductors has been studied by **Gopiram Addala, D.Neelima Satyam** and **Ramancharla Pradeep Kumar** in this research work. The model has been prepared in STAAD PRO and then the seismic analysis of the tower has been performed in SAP2000. The tower has been subjected to North-ridge strong ground motion (1994) and the Koyna strong ground motion (1967). Parametric study has been carried out by studying the influence of cable when the force is applied in the cable at different angles to the cross arms. It was also observed from the analysis that the forces developed when the Northridge (1994) ground motion is applied in direction of cables are more when compared to forces developed when the ground motion is applied perpendicular to the conductors. To understand the complete Behavior of transmission tower line it is necessary to model the cables. The present work can be extended in the future by modelling the cable members and performing the dynamic nonlinear analysis.

An angle tower is selected by them. When the links make an angle more than  $2^0$ . the tower was replicated in the y-direction at a distance of 350m. The transmission tower is fixed at the base. These two towers are connected by cables made of Aluminium Cantered Steel Reinforced (ACSR). The height of the tower is 35.54m and the base width of the tower is 7m. The angles used were ISA 110x110x15mm, ISA 110x110x8 mm, ISA 100x100x8mm, ISA 60x60x4mm and ISA 45x45x4mm (IS 802, 1995 and. IS 800, 1984). Properties of tower are as under.

*Table 1 Properties of tower*

Parameter	Tower	Conductor
Type	132Kv Double Circuit	20mm dia 7strands, ACSR
Weight	340kN	148kg/km
Height	35.54m	350m

A model of transmission tower is formed by importing the model to SAP2000 from STAAD pro V8i. The model formed is as under



*Figure 2 Model of transmission tower*

Time period of tower and tower system are obtained as a result

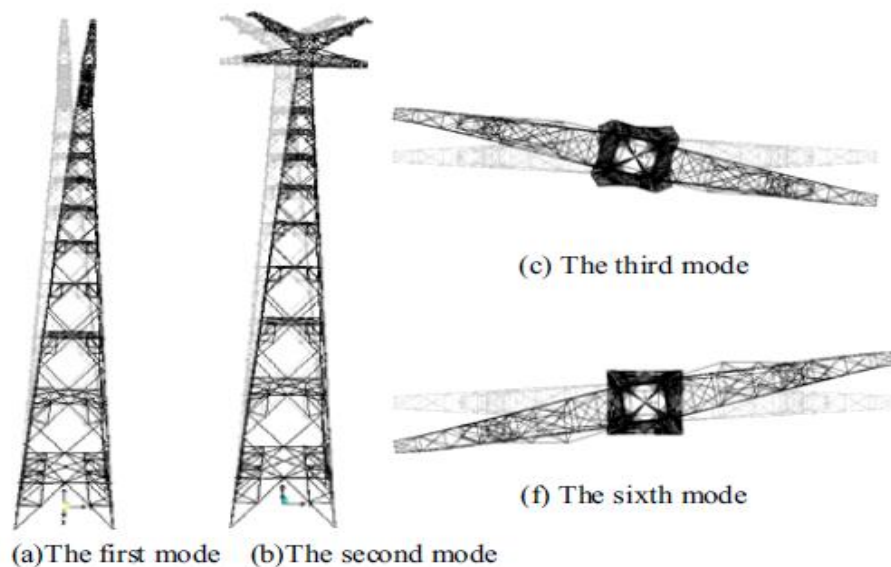
**Table 2 Time period of different modes**

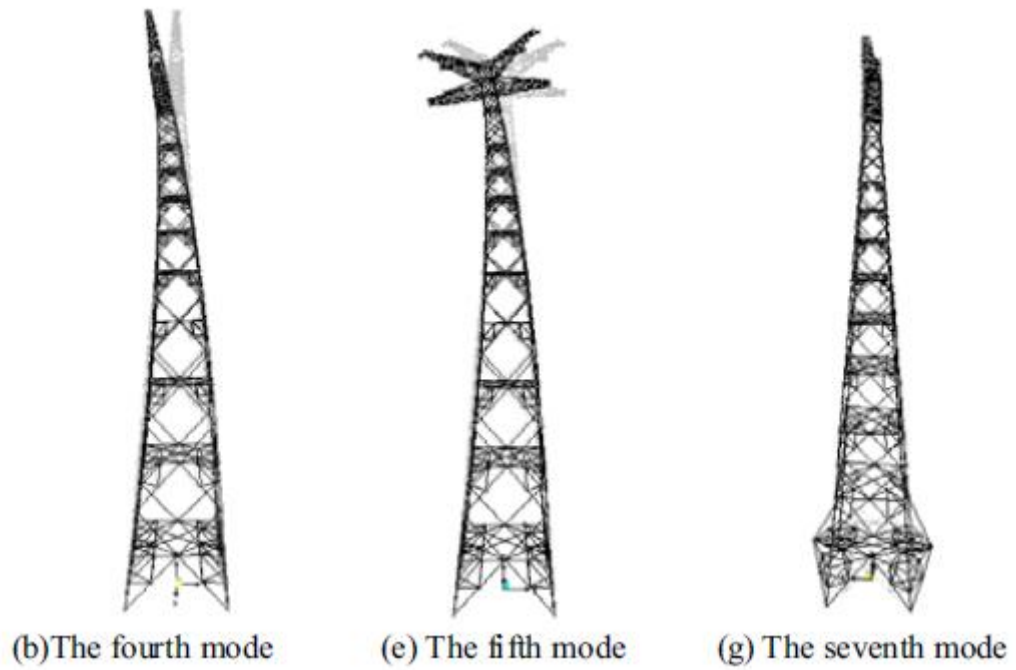
Mode Number	Time Period (Single tower) seconds	Time Period (Tower system) seconds
1	0.2920	0.2926
2	0.2890	0.2920
3	0.1183	0.2902
4	0.1180	0.2896
5	0.1106	0.1183
6	0.1065	0.1183
7	0.1065	0.1180
8	0.0933	0.1180
9	0.0884	0.1135
10	0.0857	0.1139
11	0.0791	0.1132
12	0.7868	0.1132

**B. Ph.D Sun Jianmei and Yang Fuga (2010), "SEISMIC BEHAVIOUR ANALYSIS OF LONG CROSSING TRANSMISSION TOWER AND TOWER-LINE SYSTEM"**

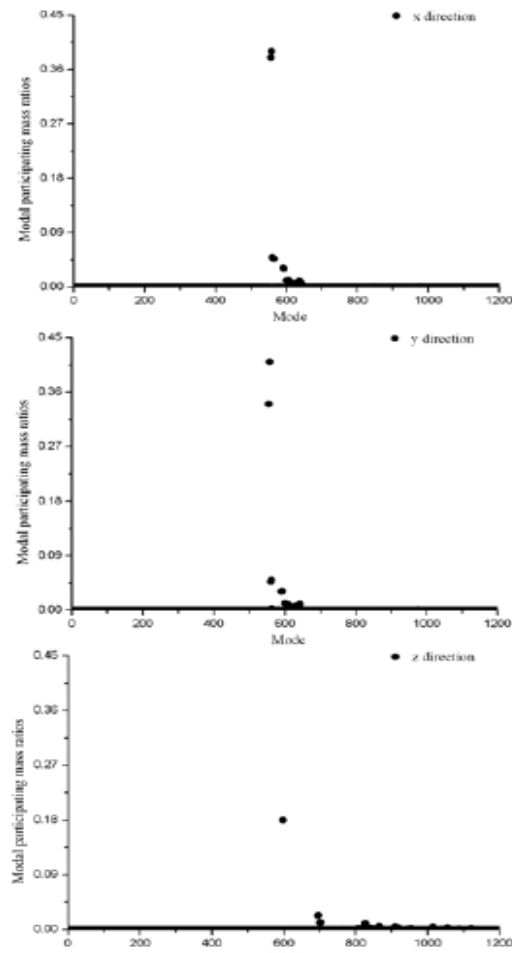
They studied the seismic response of long crossing transmission single tower and tower-line system were systematically studied by time-history analysis method. The seismic response differences of the displacement, torsion and axial force in main leg and web member of the single tower and tower-line system are studied. The torsion of tower-line system becomes much gentler than the single tower with the seismic travel time increases. Because of transmission line, the axial force of the tower-line system of the bottom of tower leg and web member at the stiffness sudden change are bigger than single tower. The maximum torsion angle of the single tower fluctuates greatly with the increasing of the peak value of seismic wave. The torsion angles of the tower-line system change slowly for the line generates the pulling force which direction is opposite to the tower. The axial forces of the web members, which at the tower legs and the places stiffness suddenly change, are influenced greatly by the line. It is necessary to consider the coupling effect of the line when the tower was analyzed under the seismic action, otherwise, the results may be conservative or imprecise.

Dynamic analysis of a single tower is carried out. When the modal participating mass ratio of the structure has reached 98% the first 200 mode shapes for single tower were extracted the first 200 mode shapes for single tower were extracted. The first seven vibration modes are shown in Fig 4.





**Figure 4. Different modes of the building of tower**



**Figure 5. Modal participating mass ratios of tower-line system**

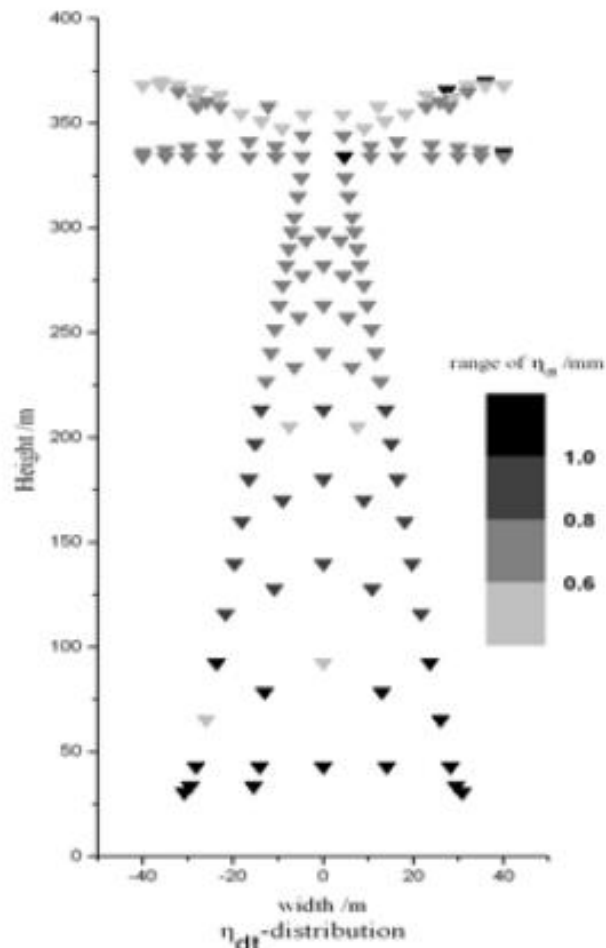


Figure 6. Maximum displacements of single tower and tower line system

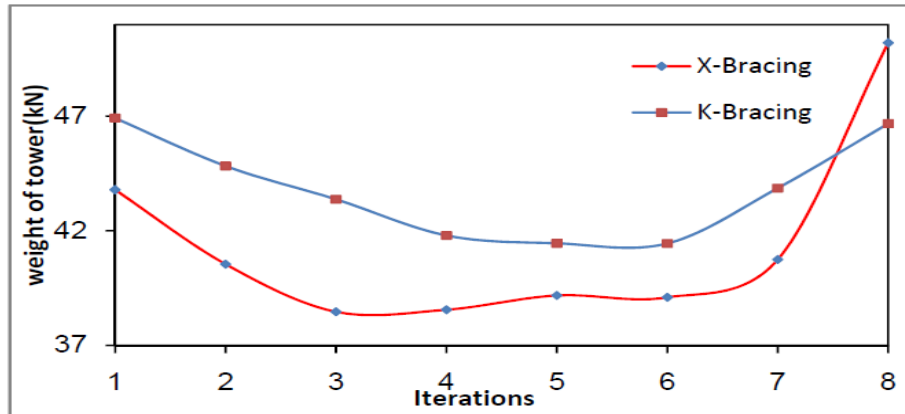
Thus from this result it can be concluded that Because of the mass of line, the fundamental period of the tower-line system is longer than the single tower. Compared to the single tower, the main modes of the tower-line system are almost same. Compared to the single tower, the existing of line on the tower-line system causes the maximum displacement of tower top increased and the maximum displacement of tower base reduced. The maximum torsion angle of the single tower fluctuates greatly with the increasing of the peak value of seismic wave.

#### C. Alaa C. Galeb and Ahmed Mohammed Khayoon,"OPTIMUM DESIGN OF TRANSMISSION TOWERS SUBJECTED TO WIND AND EARTHQUAKE LOADING"

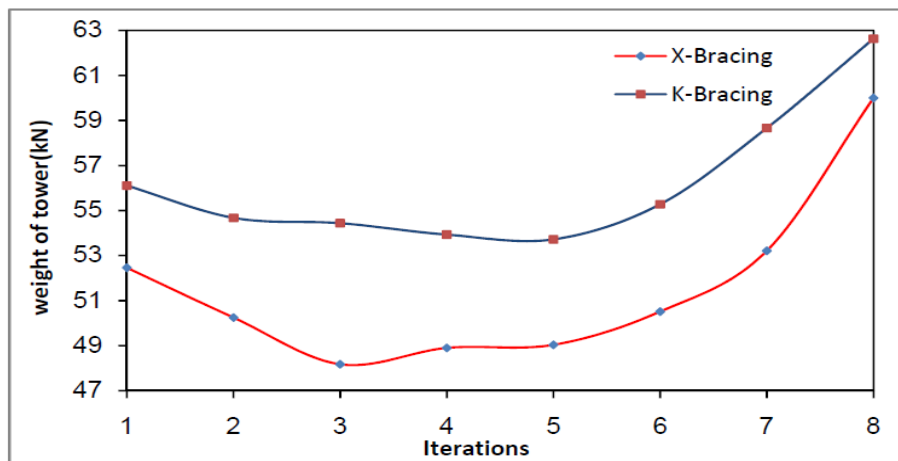
They have used different type of angles, methods and towers and then analysed the results. 1s1 and 1s2 type of towers were used. While changing the coordinate variables, using Hooke and Jeeves method, the member areas are treated as dependent design variables. The sections used are: angle and pipe sections which represent the commonly used sections in lattice transmission towers, in addition to tube sections. two different type of bracing i.e, K bracing and X bracing are used.

It is found that the 1S2 tower with angle section and X-bracing, under anti-cascade loading condition, has a reduction in weight of about 14% of the weight before optimization, while the reduction for 2S2 was 24% for the same conditions. For seismic loading conditions, the reductions were about 24% for 1S2 tower and 22% for 2S2 tower with angle section and X-bracing. The results showed that the 1S2 tower with pipe section has a weight of 85% of that with angle section, under the same loading condition, while for 2S2 tower, the weight with pipe section was about 88% of that with angle section.

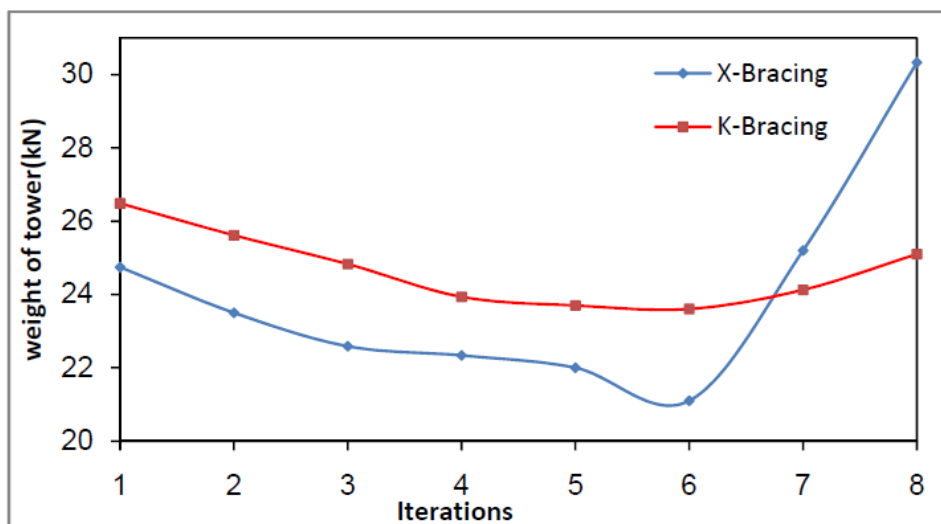
Comparison of K bracing tower and X bracing tower is shown here. Comparison shown here are of different types of tower with different section and different loading conditions. Only some of the results are shown below.



**Fig 7 Comparison between X and K-Bracing for 1S2 Tower with Angle Section under Anti-Cascade Loading Condition**



**Fig 8 Comparison between x and k-bracing for 2s2 tower with angle section under anti-cascade loading condition**



**Fig 9 comparison between x and k-bracing for 1s2 tower with pipe section under seismic loading conditions**

From the above results it can be concluded that The tower with angle section and X-bracing has the greater reduction in weight after reaching 21%. The tower with pipe section and X-bracing has an optimum weight smaller than the other section shapes about 78% of that of angle section. Tube section is not economic to use in this type of transmission tower.



The transmission tower with X-bracing is lighter than that with K-bracing with angle, pipe and tube sections under wind and seismic load conditions

#### **D. Gopi Sudam Punse,” ANALYSIS AND DESIGN OF TRANSMISSION TOWER”**

He analysed and design a narrow based Transmission Tower (using Multi Voltage Multi Circuit). The objective is to optimize the 220kv and 110kv narrow based lattice tower in geometry aspect. The loads considered in analysis and design are wind load, conductors, ground wire and insulator strings in transverse and longitudinal direction and vertical loads due to weight of tower .Geometry of the tower used in this paper is a s follow.

##### **GEOMETRY OF TOWER**

1. Vertical spacing between conductors of 220KV = 5.5 m
2. Vertical spacing between top conductor and ground wire = 7.45 m
3. Vertical spacing between conductors of 110KV = 4.5m
4. Clearance between BC and TC1(including insulator string = 2.34m) = 7m
5. Ground clearance = 7.015m
6. Extra height at ground level = 3.665m
7. Max. sag = 7m
8. Height of Insulator string = 1.82 m

Total height of tower = 1+2+3+4+5+6+7+8+9 = **53.95 m**

Cross arm length 220KV = 4.6m

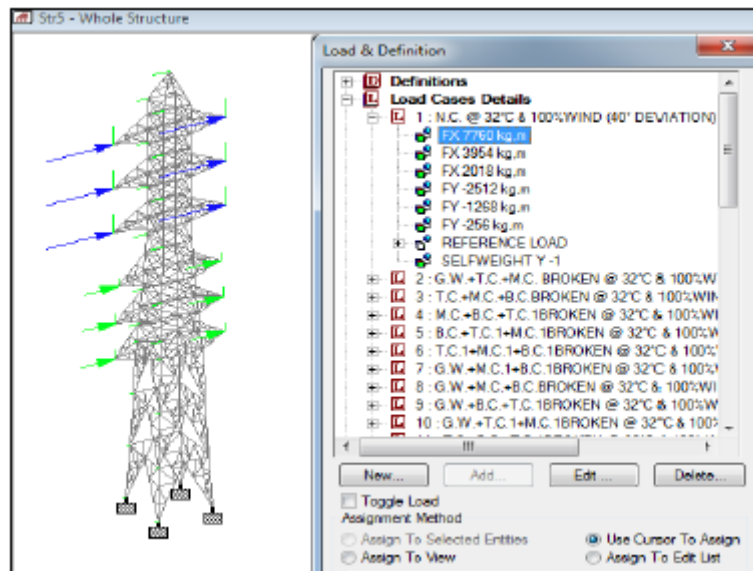
Cross arm length 110KV = 3.8m

Base width  $1/8 \times 53.95 = 6.774$  say 6m

Width at waist level =  $1/2 \times 6 = 3$ m

Inclination at base = 2.419 0

Load case of this tower are shown below



**Figure 10. Loads acting on transmission tower under normal condition**

This Paper concluded that The Narrow based steel lattice transmission tower can safely withstand the design wind load and actual load acting on tower. The axial forces are taken by the bottom tier members. The horizontal and diagonal members are less prominent in taking the loads of the tower as compared to vertical members. The tower with angle section and X-bracing has the greater reduction in weight after optimization. Tube section is not economic to use in this type of transmission tower.

#### **E. C. Preeti, K. Jagan Mohan,” ANALYSIS OF TRANSMISSION TOWERS WITH DIFFERENT CONFIGURATIONS”**

In this report, they have attempted to optimize the transmission line by changing the geometry and Behavior of transmission line structure. A 220 kV single circuit transmission line carrying self-supporting square base towers is

considered. To optimize the existing geometry, a square base tower is replaced by a triangular base self-supporting tower and a guyed mast. Using STAAD, analysis of each of these three towers has been carried out as a three-dimensional structure. The three towers are shown as below.

**TABLE 2. WIND LOADING ON DIFFERENT TYPES OF TOWER**

Height (m) / Wind (kg) (from G.L.)	Square Tower	Triangular Tower	Guyed Mast
0	292	306	129
8.91	-	-	279
10.5	475	-	-
12.14	-	461	-
18.9	243	210	195
20.2	118	111	101
24.1	127	119	108
25.4	107	101	89
29.1	122	118	103
<b>Total</b>	<b>5571</b>	<b>5353</b>	<b>3708</b>
<b>No. of exposed members</b>	<b>180</b>	<b>195</b>	<b>174</b>

Results obtained as a result of weight of all the three towers are shown below. As all the towers are designed with enough factor of safety; the self-weight of different towers obtained is as follows:

- Square Tower 2775 kg
- Triangular Tower 2519 kg
- Guyed Mast 1666 kg.

The final conclusion of this report is that the configuration of towers has concluded that all the three towers are having the same height but different base widths. Thus, using triangular base self-supporting tower will bring a saving of 9.23% in the weight of tower, and using square base guyed mast will lead to a saving of 39.96% in the tower (excluding guy ropes), which is directly the cost saving in each tower optimization of the transmission line.

### III. DISCUSSION

For Based on various literature reviews, it is observed that presently increasing in population provision of transmission line tower is necessary for supplying electricity. The cost of transmission tower is 28 to 42 percent of transmission line. So for economical design of transmission line tower is based on its width. Generally convectional sections used in transmission line tower. Using of hollow steel section in leg member and convectional section in bracing is economical.

### IV. CONCLUSION

Based on various literature review it could be conclude that:

- 1) The cost of transmission tower is 28 to 42 percent so economical design is necessary.
- 2) The design and consumption of steel is depended on the base width if the tower.
- 3) The load carrying capacity of hollow steel section is more than convectional section and it is also economical.
- 4) In all shaped of tower triangular shaped tower is more economical than others.

### REFERENCES

- [1] Gopiram Addala, D.Neelima Satyam and Ramancharla Pradeep Kumar (2010) "Dynamic Analysis Of Transmission Towers Under Strong Ground Motion" 3rd International Earthquake Symposium, Bangladesh, Dhaka, March.5-6 2010
- [2] Ph.D Sun Jianmei and Yang Fuga (2010) "Seismic Behaviour Analysis of Long Crossing Transmission Tower and Tower-line System" International Conference on Intelligent System Design and Engineering Application
- [3] Alaa C. Galeb and Ahmed Mohammed Khayoon (2013) "Optimum Design of Transmission Towers Subjected to Wind and Earthquake Loading" Jordan Journal of Civil Engineering, Volume 7, No. 1
- [4] Gopi sudam punse (2014) "Analysis and design of transmission tower" International Journal Of Modern Engineering Research
- [5] C. Preeti, K. Jagan Mohan "Analysis of Transmission Towers with Different Configurations"



- [6] Indian Standards, "Use of structural steel in overhead transmission line tower", IS 802 (part 1) : 1967, Bureau of Indian Standards , New Delhi.
- [7] Indian Standards, "General construction in steel" IS 800:2007, Bureau of Indian Standards , New Delhi
- [8] Indian Standards, "Aluminium conductors for overhead transmission purposes", IS 398(part II):1976, Bureau of Indian Standards , New Delhi.