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Comparative Analysis of Steel Telecommunication Tower

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Abstract: The self-supporting steel towers are widely used for telecommunication purpose. In wireless communication system these towers are plays a major role hence failure of such structure during the disaster is a major concern. In this study we considered the effect of wind load as primary force and the analysis is done using STAAD Pro software, displacement and stresses at different members are calculated on three-legged steel tower. This study has been carried out by considering a model height of 40m. Also, we made comparative analysis by replacing the angle section by a hollow circular pipe. The analysis is carried out for wind zone-2 and seismic effect is not considered. The results of displacement at the top of the tower and stresses at the bottom leg of the towers are compared.

Keywords: Three-legged Telecommunication towers, Wind Analysis, Displacement, Hollow Circular pipe, STAAD Pro.,

I. INTRODUCTION

Communication towers or lattice towers are classified into three categories they are Guyed masts, monopoles and self-supporting towers. While designing and constructing this kind of structures engineers faces the challenges to support the antenna loads, platform and steel ladder loads in open environment with high degree of safety. The major cause of failures of telecommunication tower throughout the world though still remains to be high intensity wind (HIW). The major problem faced is the difficulty in estimating the wind loads as they are based on a probabilistic in approach. The communication towers are often designed as 3D trusses. In the traditional stress calculations based on linear elastic ideal truss analysis, members are assumed to be concentrically loaded and pin-connected.

S.K.Duggle (2015) presented the analysis of steel communication tower for various wind and earthquake zones with different bracing systems. The displacement at the top of the tower is considered as main parameter. The tower height up to 35m with different bracing do not show any different in displacement. The displacement is maximum for W-bracing and minimum for V-bracing and XBX- bracing. The stress in bottom leg is maximum for K-bracing and minimum for XX-bracing.

Jithesh Rajasekharan (2014) analysed a four legged self-supporting tower subjected to wind and seismic loading. He considered three different heights of tower with different bracings for various zones. He found that joint displacement is more for the tower with Y-bracing whereas the stress in bottom leg is more for the tower with XX- bracing.

Siddesha. H (2010) presented the analysis of microwave antenna tower with static and Gust factor method and compared the towers with angle and square hollow section. The tower with different configuration have also been analysed by removing one member present in the regular tower in lower panels. Square sections were found to be most effective for legs as compared to the angle sections. Square hollow sections used in bracing along with leg members did not show any appreciable reduction of displacement.

Jesumi. A (2013) modelled five steel lattice towers with different bracing configurations such as XB, single diagonal, XX, K, and Y bracing for a given range of height. 70-72% of the height is provided for the tapered part and 28-30% of the height is provided for the straight part of the tower. The towers are analysed with STAAD Pro. V8i, to compare the maximum joint displacement. Optimized design has been carried to estimate and to compare the weight of each tower. From the results obtained, Y-bracing has been found to be the most economical bracing system up to a height of 50m.

The objective of the present work is to study the effect of wind load alone with XBX bracing system and compared the tower with angle and circular pipe section. The angle section is fully replaced circular pipe section.

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II. MODELLING OF TOWER

The steel communication tower is designed for a height of 40m. The tower is provided with XBX-type bracing for lower portion and X-bracing for upper portion. STAAD Pro. V8i has been used for modelling and analysis of tower. Also the angle section is replaced by the circular pipe section and the analysis is done. The details of towers used for modelling are given in TABLE I

TABLE I
DETAILS OF TOWER

	Angle section	Circular Pipe section
Height of the tower	40m	40m
Height of slant portion	28m	35m
Height of straight portion	12m	5m
Base width	5m	4m
Top width	2m	1m

A. Panel Details of Tower

I) *Panel Size for Angle Section Tower.*

No. of 4m panels = 7 no's
No. of 2m panels = 6 no's

The angle sections used for analysis purpose for the tower with the height of 40m is tabulated. The various angle sections were used with the consideration of the tower height of the tower. The TABLE III shows the different angle sections for different members of the tower.

TABLE II
DETAILS OF CIRCULAR TOWER

Height of the tower (m)	Panel Size
0-10	2.5 m
10-20	2.0 m
20-30	1.5m
30-35	1.0m
35-40	1.0m

TABLE IV
MEMBER DETAILS OF CIRCULAR TOWER

Height(m)	Main leg	Bracing
0-10	PIP1339H	PIP761H
10-20	PIP1270H	PIP603H
20-30	PIP1143H	PIP603H
30-35	PIP889H	PIP424H
35-40	PIP761H	PIP424H

The above TABLE II shows the various panel sizes and the circular pipe sections for the tower of 40m height. The other details of the tower using the circular pipes are shown in the TABLE I. All the external load parameters are same for the both the tower.

TABLE III
SECTIONAL DETAILS OF TOWER

Height	Main Leg	Horizontal Member	Primary Bracing	Secondary Bracing
0-8	200 x 200 x16	80 x 80 x 10	110 x 110 x 16	70 x 70 x 6
8-16	150 x 150 x 18	80 x 80 x 10	100 x 100 x 12	70 x 70 x 6
16-24	110 x 110 x 16	80 x 80 x 10	100 x 100 x 12	60 x 60 x 10
24-28	110 x 110 x 16	80 x 80 x 10	60 x 60 x 10	45 x 45 x 6
28-38	100 x 100 x 12	60 x 60 x 10	70 x 70 x 6	Nil
38-40	90 x 90 x 6	60 x 60 x 10	70 x 70 x 6	Nil

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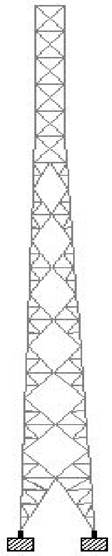

Fig. 1. 40m tower with XBX bracing

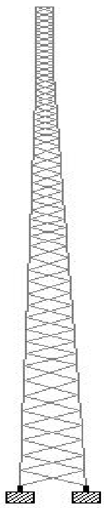

Fig. 2. 40m tower with zigzag bracing

III. LOADING ON THE TOWER

A. *Loads Acting on the Tower*

The loads acting on the both the towers are considered as the same. Only the wind load and the other accessories like ladder, platform for repairing and maintaining the structure. The platform load of 0.82 KN/m^2 is applied at a height of 35m from the base. The self –weight of the ladder and the cage is assumed 10% of the total weight of the structure. The antenna loads are properly distributed at their respective nodes. The details of the loads due to antennas are shown in TABLE V.

TABLE V
ANTENNA LOADS ON THE TOWERS

Item	Quantity	Diameter (m)	Weight (kg)	Height from base(m)
CDMA	6	0.26 x 2.5	20	38
Microwave	1	1.2	77	35
Microwave	1	0.6	45	35
Microwave	2	0.3	25	35

B. *Wind Load the Acting on the Tower*

The wind load acting on the tower structure is calculated as per the Indian standards. The IS 875(part 3) : 1987 and the IS 802(part 1: Sec I) -1995 are used for the wind load calculation. The design wind speed is expressed as

$$V_z = V_b \times K_1 \times K_2 \times K_3$$

For the calculation wind speed and other parameters considered are follows:

Wind zone II, basic wind speed is 39m/s, the risk coefficient factor K_1=0.92 (considering design life of 25 years), topography factor K_3 = 1.0 (flat terrain), the values of terrain and height factor K_2 is calculated for category II and class-c.

The design wind pressure is expressed as

$$P_z = 0.6 \times V_z^2$$

Where

P_z = design wind pressure in N/m^2.

TABLE VI shows the wind pressure at various heights.

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TABLE VI
WIND LOAD ACTING ON THE TOWER

Height (m)	K_2	V_z (KN)	P_z (N/m^2)
8	0.91	32.65	639.629
12	0.946	33.942	691.230
16	0.976	35.019	735.798
20	1.0	35.88	772.420
24	1.016	36.454	797.34
28	1.032	37.028	822.643
32	1.043	37.423	840.286
34	1.058	37.96	864.577
36	1.07	38.392	884.395
40	1.082	38.822	904.382

IV. RESULT AND DISCUSSION

A. *Wind Load Analysis Result*

Wind load analysis is carried out only for zone of basic wind speed 39m/s. The combination of dead load, antenna load and wind load are taken for the analysis of models. The displacement at the top node is compared in the TABLE VII and the maximum stress at the bottom leg of the structure is compared in TABLE VIII. Also Fig. 3(a) shows the variation in the displacement at the respective nodes and Fig. 3(b) shows the variation of the stress at the bottom leg.

TABLE VII
COMPARISON OF DISPLACEMENT AT TOP

Height (m)	Bracing	
	XBX	Zigzag
40	176.43 mm	368mm

From the above table it is shown that the displacement of the towers with the same height. The resultant displacement at the top is doubled in the tower with circular pipes with zigzag bracing. Also the Fig. 3(a) shows the comparison of the displacement of both the towers.

TABLE VIII
COMPARISON OF STRESS AT BOTTOM LEG

Height (m)	Bracing	
	XBX	Zigzag
40	74.08 N/mm^2	120.16N/mm^2

The TABLE VIII shows the stresses at the bottom leg of the both the towers. It is clear that the stress in the tower with XBX bracing is only half of the stress produced by the tower with the circular pipes in zigzag bracing system.

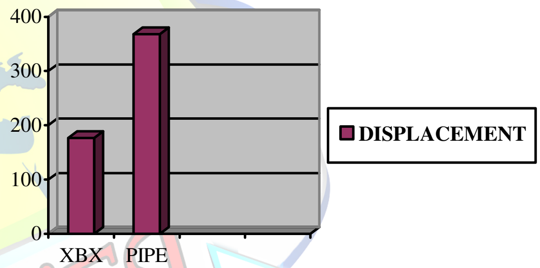

Fig. 3 (a) Displacement at top in mm

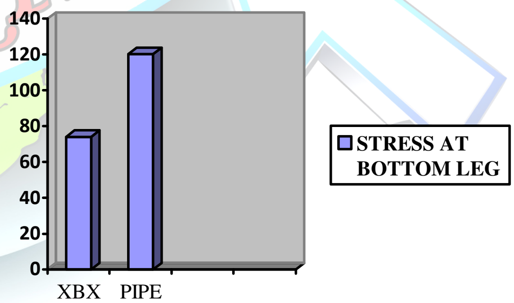

Fig. 3(b) Stress at the bottom leg in N/mm^2

B. *Quantity of Materials*

The total amount of steel required to fully complete the structure is worked out by suing the software STAAD Pro. V8i. The amount of steel used is represented in the Fig. 4.

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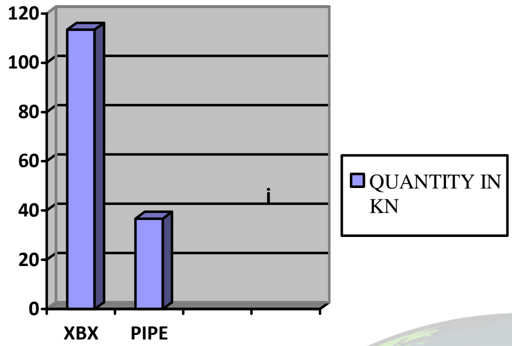

Fig. 4 Comparison of material Requsired

V. CONCLUSION

The objective of this work was to study the response of two towers of same height with different bracing system and different shape of material for the wind zone-2.

The followings are the main conclusion from the study:

- From the wind analysis result it is observed the displacement at the top of tower is nearly doubled in the tower with circular pipe instead of angle sections.
- The stress at the bottom leg of the towers in the same wind zone is increased about 100%.
- The total quantity of material used in the both of the towers is computed using the software and it shows the material used in the tower with XBX bracing is 67.62% more than the tower with the zigzag bracing system in circular pipes
- Also the dead load by the structure is so reduced by the considerable amount and this will help in the selection of the foundation.
- The space required for the construction is reduced and the other equipment can be placed in less area.
- This zigzag bracing system reduce the complication in the construction of lattice towers because of the easy steel design.

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