Analysis And Design of Telecommunication Tower Using Tubular Section

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Abstract- *Due to vast urbanization as well as to ensure wireless communication with several remote places it is vital to study the behavior of telecommunication towers. These structures are most probably vulnerable to earthquake as well as wind forces, hence failure of such structures is a major cause of concern. This paper aims to find out the optimum sections as well as its ability to resist the lateral forces generated due to wind and earthquake. For this purpose, a comparative study is carried out by using different sections with different bracing systems.*

Keywords- Wind Analysis; Static method; Response spectrum analysis

I. INTRODUCTION

This Telecommunication towers are typically tall structures designed to support antennas for telecommunications and broadcasting, including television. There are three main types: guyed mast, monopole tower, and self-supporting structure. They are among the tallest human-made structures. In today's world, telecommunication has become the basic needs for businesses, governments and families to seamlessly connect and share information. telecommunication is one of the most crucial infrastructures for protection. From natural disaster alerts to military purpose, there are number of institutions that depend on telecommunication to provide safety. A failure of a telecommunication tower especially during a disaster is a major concern in two ways. Failure of telecommunication systems due to collapse of a tower in a disaster situation causes a major setback for rescue and other essential operations. Also, a failure of tower will itself cause a considerable economic loss as well as possible damages to human lives. Hence, analysis of telecommunication towers considering all possible extreme conditions is of utmost importance. These towers are made up steel frames and the structural behavior is depending on various parameters like height, base width, bracing system, loading conditions etc.

II. LITERATURE REVIEW

Keshav Kr. Sharma et al. [1] (2015) In this paper a comparative analysis was carried out for different heights of towers using different bracing patterns for Wind zones I to VI and Earthquake zones II to V of India. Gust factor method was used for wind load analysis, modal analysis and response spectrum analysis were used for earthquake loading. The results of displacement at the top of the towers and stresses in the bottom leg of the towers are compared.

Jithesh Rajasekharan et al. [2](2014) Designed the lattice tower for three heights of 30m, 40m and 50m with different types of bracings to study the effect of wind load on 4- legged lattice tower for wind zone V and VI using gust factor method. They also studied the seismic effect on the tower structures by carrying out the modal analysis and response spectrum analysis for zone II to zone V and concluded that the member stresses in bottom leg of XX braced tower are higher as compared to other tower models. The frequency of the tower with Y bracing displayed the least natural frequency since its stiffness was found to be higher due to more weight of the structure as compared to other models. It was observed that from 30m to 40m tower height, the increase in displacement is nearly linear but as the height increases from 40m to 50m there is a steep increase in the displacement in all the zones.

A. Jesumi et al. [3] (2013)modeled five steel lattice towers with different bracing configurations such as the X-B, single diagonal, X-X, K and Y bracings for a given range of height. The heights of the towers were 40m and 50m with a base width of 2m and 5m respectively. The tower of height 40m has 13 panels and the tower of height 50m has 16 panels. 70-72% of the height was provided for the tapered part and 28-30% of the height was provided for the straight part of the tower. The towers have been analyzed for wind loads with STAAD Pro. V8i, to compare the maximum joint displacement of each tower. Optimized design has been carried out 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.

Nitin Bhosale et al. [4] (2012)have carried out the seismic response of 4-legged telecommunication towers under the effect of design spectrum from the Indian code of practice for zone IV. The axial forces of the tower member were considered, comparison was made between roof top tower and ground tower.

Siddesha.H [5] (2010) Presented the analysis of microwave antenna tower with Static and Gust Factor Method (GFM) and compared the towers with angle and square hollow sections. The displacement at the top of the tower was considered as the main parameter. The analysis was also done for different configuration by removing one member as present in the regular tower at 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 the leg members did not show any appreciable reduction of displacement. X-type and M-type bracings in square hollow sections for legs and bracings in the lower first panel of towers showed maximum reduction in displacement as compared to the regular towers with angle sections.

Prasad Rao et. al (2004) [6]derived a relationship between the ratio of the test to theoretical deflection and a non-dimensional parameter to serve as an index for monitoring the structural displacement during testing. The towers are analyzed using SAP/NASTRAN programs. The natural frequencies obtained from the analysis program were higher than the experimental ones. The proposed equation to predict natural frequency was derived based on the test and analytical deflections as well as geometrical parameters.

J.Vinortha Jenifer et. al (2017) [7]This paper represents the efficiency of a particular cross section which can be adopted for communication work. For this purpose, the towers are modelled and modal analysis has been carried out for various member cross sections of telecommunication towers for four different heights using FEA package ANSYS workbench.

III. MODELLING

The Steel Communication tower is designed for heightof 30m. The towers areprovided with 3-different types of bracings: K type, X-type, XX-type. STAAD Pro. Advanced Connect has been used formodeling, analysis and design of towers. Details of towers used for modelling are given in Table-1for various base width. Fig. 1 shows 30m high towers with different types of bracings considered inthe study. Table II to Table IV show the member properties assigned to towers.

Table 1 Details of 30m tower

Height of tower	30 m		
H/B ratio	6.67	7.5	8.33
Base width	4.5 m	4 m	3.6 m
Height of slant portion	23 m	23 m	23 m
Height of vertical at top of tower	7 m	7 m	7 m
Top width	2 m	2 m	2m
No of panels	15	15	15

Table 2Member details of 30m tower with Angle Section

Height (30m)	0-14	14-23	23-30
	ANGLE SECTION		
Main Leg	ISA150x150x 15	ISA120x120x12	ISA100x100x10
Horizontal bracing	ISA100x100x 10	ISA100x100x8	ISA90x90x10
Cross bracing	ISA100x100x 10	ISA100x100x8	ISA90x90x10

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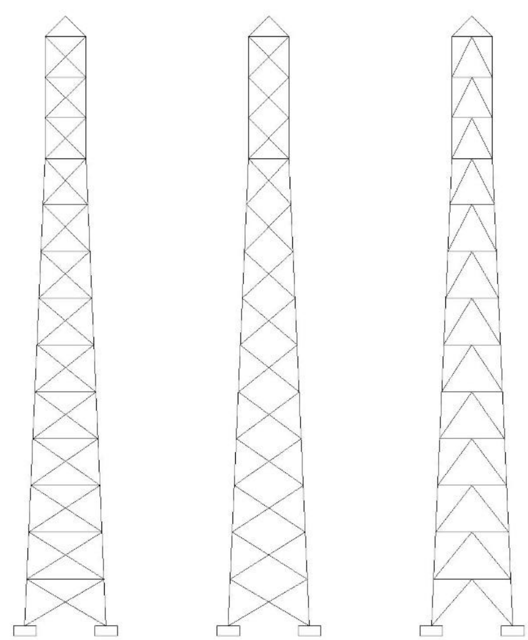

Figure 1 30m tower using different bracing system

Table 3Member details of 30m tower with Circular Hollow Section

Height (30m)	0-14	14-23	23-30
	CIRCULAR HOLLOW SECTION		
Main Leg	PIP 1270H	PIP1143H	PIP889M
Horizontal bracing	PIP761H	PIP603H	PIP483H
Cross bracing	PIP761H	PIP603H	PIP483H

Table 4 Member details of 30m tower with Square Hollow Section

Height (30m)	0-14	14-23	23-30
	SQUARE HOLLOW SECTION		
Main Leg	TUB1251254.5	TUB1101104.5	TUB75754.9
Horizontal bracing	TUB75754.9	TUB63633.6	TUB45453.6
Cross bracing	TUBE75754	TUB63633.6	TUB45453.6

IV. LOADS ON TOWER

A platform load of 0.82 kN/m2 is applied at 22m, 30m respectively. Weight of the ladder and cage assembly is assumed to be 10% of total weight.

Table 5 Antenna Load Details

Sr. No.	Item	Quantity	Weight of antenna (kg)
1	GSM 1	3	20
2	GSM 2	6	77
3	M/W circular	4	45

4.1 WIND LOAD

IS 875(part 3):2015 and IS 802 (Part1:Sec 1)-1995 are referred to estimate wind loads on the towers. Design wind speed (V_z) is expressed as:

Table 6 Joint displacement at top of the tower

Tower height	Base width	Section	Displacement		
			X bracing	XX bracing	K bracing
30m	4.5	ANGLE	36.693	35.743	32.054
	4		42.743	41.75	40
	3.5		48.942	48.491	43.702
	4.5	CHS	36.155	34.135	36.197
	4		42.743	41.75	40
	3.5		48.92	47.175	43.801
	4.5	SHS	53.734	51.341	51.257
	4		62.92	64.604	61.09
	3.5		72.388	70.605	84.788

$$V_z=V_b k_1 k_2 k_3$$

Where, V_b=basic wind speed in m/s at height z, k_1=probability factor(risk coefficient ,k_2=terrain, height and structure size factor,k_3=topography factor and design wind pressure is expressed as:$p_z=0.6V_z^2$where,p_z=design wind pressure in N/m2 at height z.

Wind loads are calculated for base wind speed 44m/s respectively.

Following stipulations have been made. Terrain category – 2 (Open terrain with well scattered obstruction height having 1.5 to 10m), Risk coefficient k1=1.08 (Mean probable design life of structure= 100 years) and Topographic factor k3=1 (Up-wind slope less than 30)

V. DYNAMIC LOAD

IS 1893: part 1,2016 has been used to access the dynamic load. Analysis has been carried out for Seismic zone II, III, IV and V. Following stipulations have been made Importance factor (I)=1.5, Response reduction factor (R)= 4 (steel frame with concentric braces), Soil condition as Medium and Damping Ratio – 2%. (For steel Structure).

V. RESULT AND DISCUSSION

5.1 FOR WIND LOAD

Joint displacement at top of tower is obtained for 30m tower height with different bracing arrangements for wind speed 44 m/s are tabulated in table 6

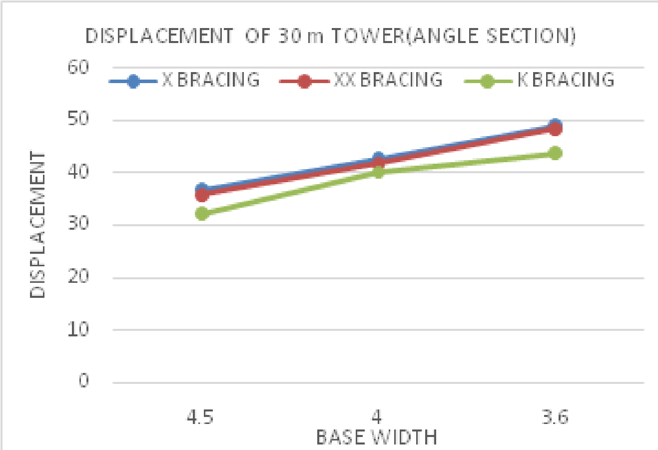

Figure 2 Comparison of different types bracing for 30m tower using Angle section

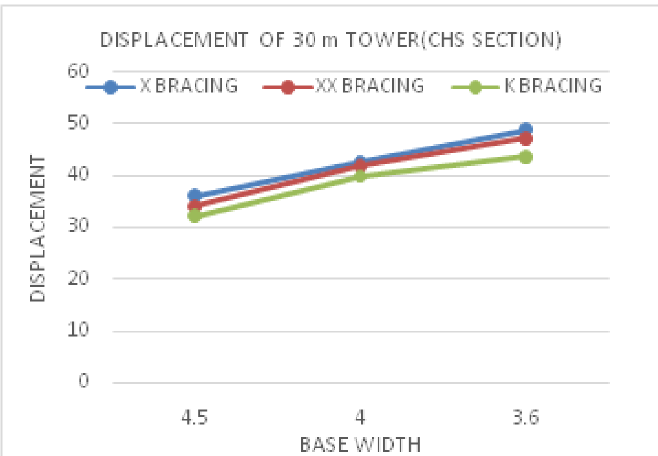

Figure 3 Comparison of different types of bracing for 30m tower using CHS

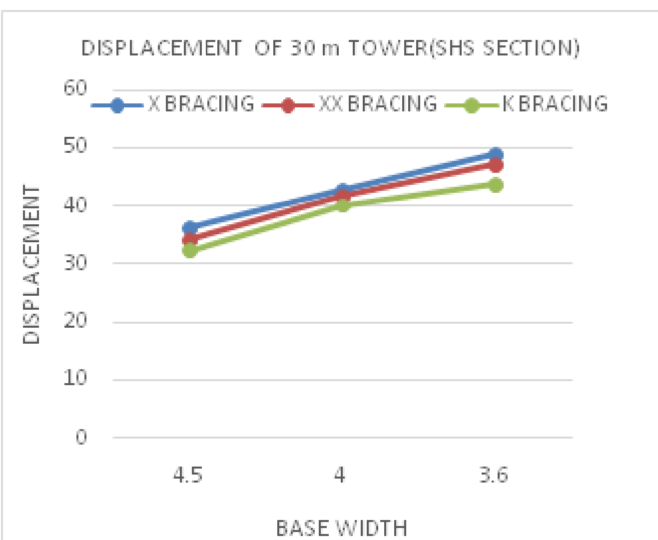

Figure 4 Comparison of different types of bracing for 30m tower using SHS

VI. CONCLUSION

1. As base width of tower decreases displacement increases.
2. The K bracing has less displacement as compare to other two bracings.
3. The displacement of X bracing with SHS is more as compare to angle section and circular hollow section
4. The displacement of 30m tower using ANGLE section and CHS is almost same.
5. K bracing is the most effective bracing for all height of towers.

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