Journal of Advances and Scholarly Researches in Allied Education
Vol. XV, Issue No. 2, (Special Issue) April-2018, ISSN 2230-7540

A Study on Wind and Non-Linear Dynamic Analysis of Self-Supporting Telecommunication Tower

Prof. P. K. Pasnur[1]* Shailesh S. Goral[2]

[1] Assistant Profesor, Department of Civil Engineering, JSPM's ICOER Wagholi, Pune, India

[2] PG Student, Department of Civil Engineering, JSPM's ICOER Wagholi, Pune, India

Abstract – In the contemporary time, the media transmission industry assumes an extraordinary part in human social orders and along these lines substantially more consideration is currently being paid to telecom towers than it was before. So the examination and plan of media transmission tower for wind and quake are the real issues which are assuming huge part in late decades in the outlining. Media transmission towers with various designs carry on contrastingly for horizontal loadings. Parcel of writing is accessible which proposes diverse recipes to decide seismic parameters. Likewise already, creators considered security of towers just against toppling. Amid the seismic occasion a few individuals from towers achieve its definitive quality creating disappointment. Be that as it may, execution of the diverse arrangements of media transmission tower against seismic tremor is very little examined in the literary works. So there is need of inside and out investigation of conduct of media transmission tower for various setups and its examination for tremor impact. In this examination the wind and seismic investigation of media transmission towers is done. Media transmission towers with square in plan, with various supporting frameworks are outlined and checked for gravity stacking. Similar models are displayed utilizing STAAD Pro. The towers are examined by non-straight unique technique. The outcomes acquired from non-direct unique examination are looked at on the premise of different parameters.

Keywords: Telecommunication Tower, Wind Analysis, Bracings, Non-Linear Dynamic Analysis.

- X -

1. INTRODUCTION

In this age of communication and networking telecommunication towers plays important role in human society. At times of occurrence of natural disasters, telecommunication towers have the crucial task of instant transmission of information from the affected areas to the rescue centers. In addition, performance of infrastructure such as dams, electric, gas, and fuel transmission stations, depends extensively on the information being transmitted via these telecommunication towers. Military and defence industries in addition to television, radio, and telecommunication industries are other areas of application for such towers and thus create the necessity for further research on telecommunication towers. Media transmission towers are tall structure generally intended for supporting explanatory reception apparatuses which are typically utilized for microwave transmission for correspondence, likewise utilized for sending radio, TV signs to remote spots and they are introduced at a particular stature. These towers are self-supporting structures and sorted as three-legged and four-legged space trussed structures. The self-supporting towers are regularly square or triangular in plan and are bolstered on ground or on structures. They go about as cantilever trusses and are intended to convey wind and seismic burdens. These towers despite the fact that request more steel yet cover less base range, because of which they are reasonable by and large.Besides the need of telecommunication towers in day to day life, during the events of the earthquake telecommunication and TV towers have the crucial task of instant transmission of information from the affected areas to the rescue centres so that help could reach the needed as early as possible.

Khedr and McClure (1999), studied, earthquake amplification factors for the base shear and the total vertical reaction of self-supporting latticed telecommunication towers were suggested based on modal superposition analysis performed on 10 existing towers, each being subjected to a set of strong-motion accelerograms acting in the horizontal and the vertical directions separately. Amiri and Massah (2007), studied the seismic sensitivity of 4-legged telecommunication towers is investigated based on modal superposition analysis. For this purpose ten existing 4- legged self-supporting telecommunication towers in Iran were studied under the effects of wind and earthquake loadings. To consider the earthquake effects on the models, the standard design spectrum based on the Iranian seismic code of practice and the normalized spectra of Manjil, Tabas and Naghan earthquakes have been applied. Richa Bhatt et al. (2013) have carried out study on the influence of modelling in lattice mobile towers under wind loading where in the towers are analysed for gust factor wind. Displacements, Member forces and maximum stress have been compared to find out the effect on towers. Keshav Kr. Sharma et al (2015), In this paper a comparative analysis is being carried out for different three heights of towers i.e. 25m, 35m, 45m using different bracing patterns for Wind zones I to VI and Earthquake zones II to V of India. Wind load analysis, modal analysis and response spectrum analysis are used for earthquake loading.

1.1. Configuration of telecommunication towers

Telecommunication towers are mostly square or triangular in plan, made of standard steel angles and connected together by means of bolts and nuts.

There are mainly five types of bracing and horizontal combinations that are normally adopted in towers as follows;

1) X-Bracing without horizontals, call it XX-Bracing and it is statically determinate for each panel.

2) XB-bracing: X-bracing with horizontals is called XB bracing and it is statically indeterminate. The horizontal are the redundant members and carry only nominal forces.

3) K-bracing: K-bracing is statically determinate and gives larger head room. Therefore, it is used in the panels next to ground.

4) Y-bracing: The bracing type is statically determinate and provides better head room space and so could be used at ground or lower panels.

5) W-bracing: it is a kind of overlapping panels and statically determinate. It is suitable for small panels.

6) Arch-bracing: An arch bracing can be adopted in wide panels.

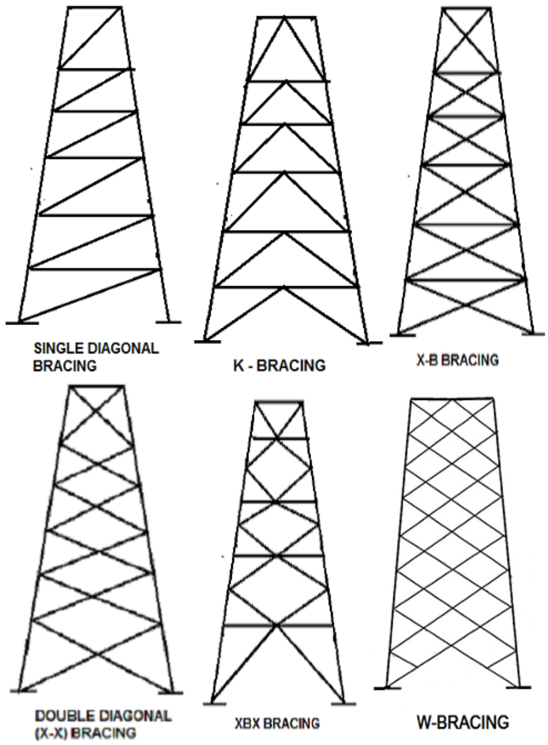

Fig. 1: Different configuration of bracing system

2. OBJECTIVES

1) To study the behaviour of self – supporting Telecommunication tower for wind and seismic forces.

2) To Study the wind analysis of telecommunication tower for different wind zones V and VI for Indian code practice IS 875 (part3):1987.

3) To Study the dynamic response of telecommunication tower for ground motion of El-centro, Koyna, Bhuj.

4) To compare the results of analysis of telecommunication towers with different configurations.

3. METHODOLOGY

The methodology includes analysis of 3D modelling of telecommunication towers of different configurations such as different bracing systems will be considered. The wind and Dynanic analysis will be carried out for the different towers to compare the effect loading on it. Based on the results obtained, best suitable configuration for telecommunication tower will be found out.

4. MODELING OF TOWER

The Steel Communication tower is designed for heights of 30 m, 60 m and 90 m. The towers are provided with 5-different types of bracings: K type, XBX-type, V-type, W-type, XX-type STAAD Pro. V8i has been used for modeling, analysis and design of towers.

- **Configuration of the tower:-**

The two towers lies in wind zones V and VI

The height of the tower is 30m.

The base width of the tower is 5 m.

The top width of the tower is 2 m.

The bracing systems used K, XBX, V, W, XX-Bracing

5. LOADS ON TOWER

A platform load of 0.82 kN/m2 is applied at 28.5 m, 58 m, and 88 m for 30 m, 60 m, and 90 m respectively. Weight of the ladder and cage assembly is assumed to be 10% of total weight.

Table 1: Antenna Loading for the Towers

Sr No.	Item	Quantity	Diameter (m)	Weight /antenna (kg)	Location from base (30m)
1.	CDMA	6	0.26 x2.5	20	27
2.	Microwave	1	1.2	77	24
3.	Microwave	1	0.6	45	24
4.	Microwave	2	0.3	25	24

5.1 Wind Load

- **Design calculations:-**

i. The basic wind speed in is 50 m/sec.

ii. The probability factor k1 is taken as 1.08.

iii. The Terrain, height and structure size factor k2 is varying at different levels of the tower and is taken from IS code as follows: k2 at 12m height = 1.00 k2 at 21m height = 1.06 k2 at 30m height = 1.10

iv. The Topography factor k3 is assumed to be 1 for plain terrain.

- **Calculation of wind load:-**

The design wind speed is calculated as:

Vz= Vb×k1×k2×k3

Vz at 12m = 50 × 1.08 × 1.00 × 1 = 54.00 m/sec

Vz at 21m = 50 × 1.08 × 1.06 × 1 = 57.24 m/sec

Vz at 30m = 50 × 1.08 × 1.10 × 1 = 59.40 m/sec

- **Calculation of Design Wind Pressure:-**

pz= 0.6 Vz^2

pz at 12 m = 0.6 × $(54.00)^2$ x 10^{-3} = 1.7496 kN/m^2

pz at 21 m = 0.6 × $(57.24)^2$ x 10^{-3} = 1.9658 kN/m^2

pz at 30 m = 0.6 × $(59.40)^2$ x 10^{-3} = 2.1170 kN/m^2

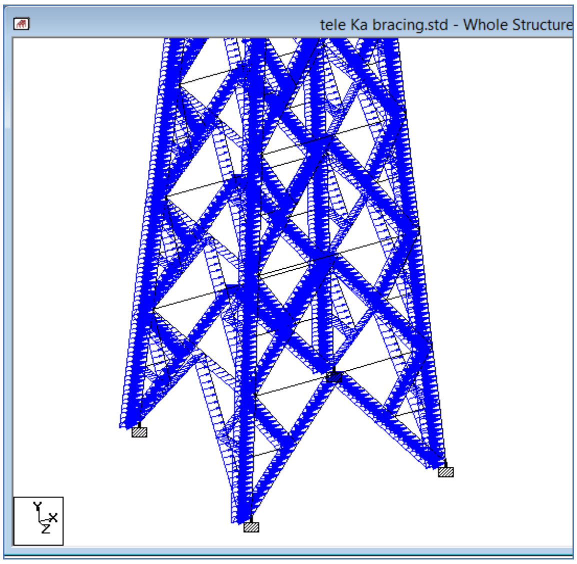

Fig. 2: Wind load applied on tower of K-bracing system

5.2 Dynamic Load

In addition to wind analysis of the towers the dynamic analysis of the tower considering time history method is also carried out. For time history method, the data of El-Centro earthquake occurred in Imperial valley, Southern California on 18 May 1940 is used and it is applied on the tower. The non-linear time history analysis of the tower has been carried out. The details of El-Centro earthquake are as under. Fig. 4 shows the acceleration time history of El-centro earthquake.

1) Name of time history : El Centro

2) Magnitude : 7.1

4) Peak ground acceleration : 0.214g

5) Time for PGA : 11.44 second

7) Total no of acceleration records : 1560

8) Time step :0.02 second

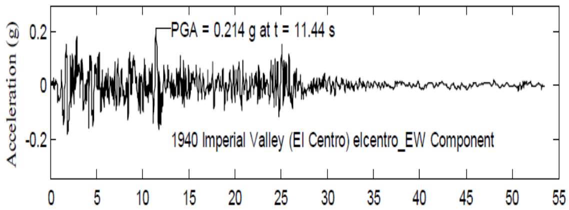

Fig. 3: Ground motion acceleration versus time with PGA value of 1940 Imperial Valley (El Centro) elcentro.

6. RESULT AND DISCUSSION

6.1 For Wind Load

Joint displacement at the top of the tower and the stresses in the bottom leg of tower were obtained for towers of height 30 m, 60 m, and 90 m with different bracing arrangements for wind zones V and VI are tabulated in Table VIII and Table IX, respectively.

Table 2: Joint Displacement (mm) at top of tower

Tower height (m)	Wind zone (m/s)	Displacement (mm)				
		K-bracing	V-bracing	W-bracing	XBX-bracing	XX-bracing
30	Zone-V (50m/s)	32.46	40.27	53.52	36.39	44.81
60		157.11	165.57	178.24	163.25	171.68
90		185.67	196.81	210.43	189.65	207.59
30	Zone-VI (55m/s)	35.41	43.53	57.85	39.38	48.43
60		164.65	172.22	188.24	168.95	179.93
90		212.45	228.70	245.58	219.73	235.65

Table 3: Member stresses (N/mm2) in bottom leg with different bracing

Tower height (m)	Wind zone (m/s)	Stress (N/mm^2)				
		K-bracing	V-bracing	W-bracing	XBX-bracing	XX-bracing
30	Zone-V (50m/s)	67.68	61.70	63.92	55.85	56.84
60		138.59	125.97	128.09	130.62	122.52
90		173.80	167.48	169.80	159.53	157.24
30	Zone-VI (55m/s)	76.25	65.24	90.78	69.42	64.075
60		146.06	135.21	142.03	137.41	132.28
90		189.06	177.88	184.54	174.65	173.79

6.2 For Dynamic Load

For dynamic load El-centro data is applied to the current structural systems and following results were obtained

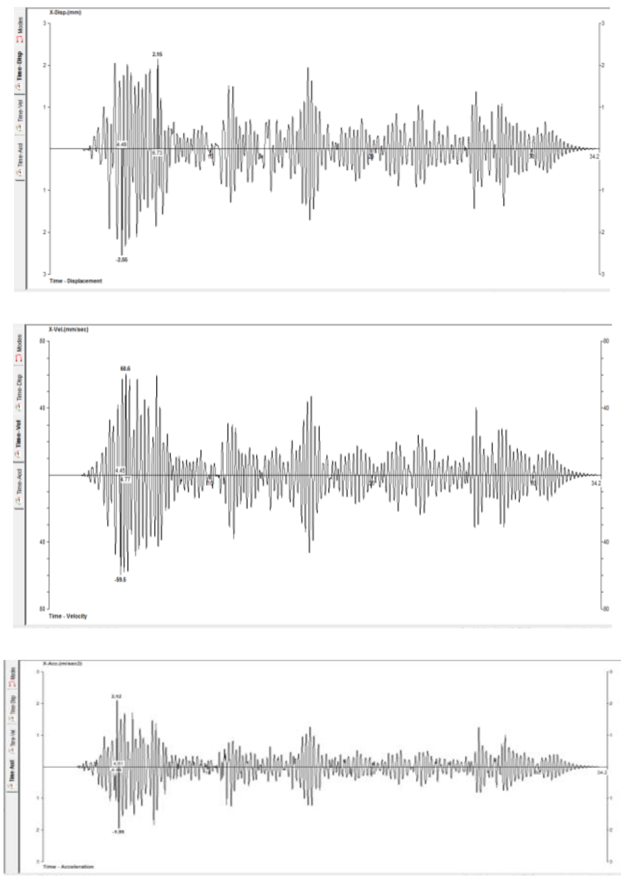

Fig. 4: Top node displacement, velocity, and acceleration of 30m for k-bracing tower due to

1940 Imperial Valley (El Centro) ground motion in x-direction

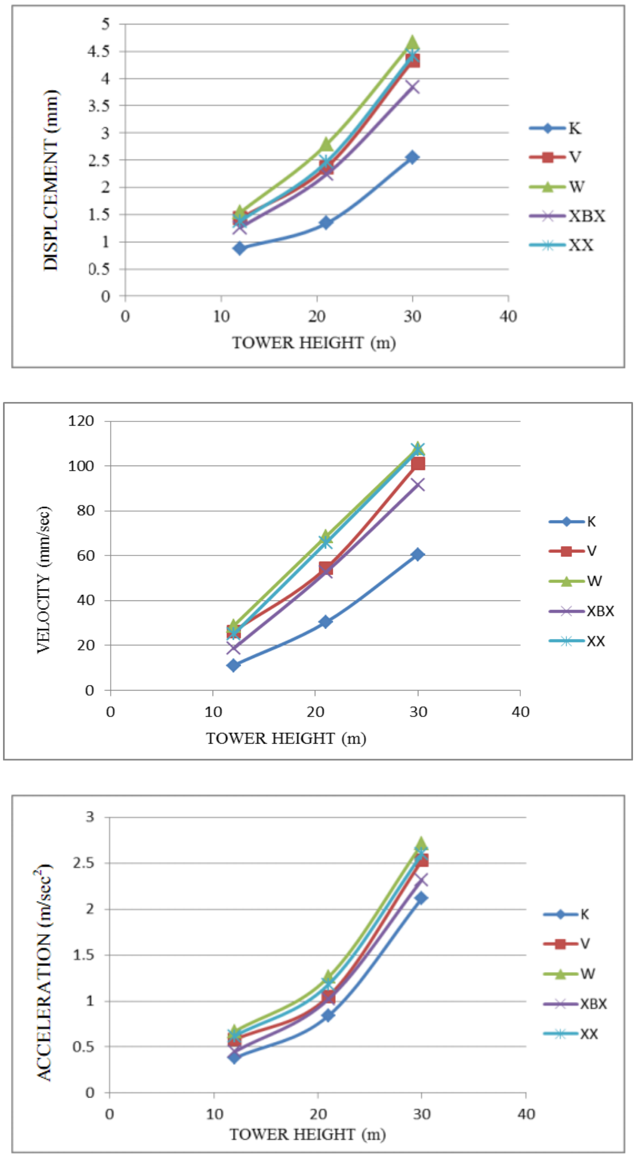

Fig. 5: Nodes displacement, velocity, and acceleration of 30m tower at level of 12, 21 and 30m due to ground motion in x-direction.

7. CONCLUSIONS

Basic purpose of the study to know the performance of the telecommunication tower under wind and dynamic load from above results and discussion, conclusion made as follows.

1) For wind zone V and VI tower height of 30m 60m 90m having W-Bracing gives maximum value of displacement and K-Bracing or XBX - Bracing gives minimum value of displacement.

2) Stresses in the bottom leg members of tower with tower height for a particular bracing pattern in V and VI wind zones It was concluded from table that stress increases with variation of wind zone from V to VI and found to be maximum for K-bracing and minimum for XX-bracing.

3) In dynamic analysis the story displacement is maximum for W-bracing and minimum for K-bracing due to ground motion. The story velocity as well as story acceleration is maximum for W-bracing and minimum for K-bracing.

4) From the above analysis it can be concluded that the wind is the predominate load factor in the tower modeling than the seismic forces but the seismic effect cannot be fully neglected as observed from the results.

5) From the above analysis it can be concluded that K-bracing and XBX-bracing gives satisfactory result in wind analysis and time history analysis for considered wind load and ground motion.

ACKNOWLEDGMENT

I express my deepest gratitude to my project guide Prof. Barelikar S. M. whose encouragement, guidance and support me to develop an understanding of the subject.

Dr. A.W. Dhawale Head of the Civil Engineering Department, JSPM, ICOER for providing their invaluable advice and giving opportunities to do this project successfully.

Finally, I take this opportunity to extend my deep appreciation to my family and friends, for all that they meant to me during the crucial times of my project.

REFERENCES

G. Ghodrati Amiri and S. R. Massah (2007). “Seismic Response of 4-Legged Self-Supporting Telecommunication Towers”, International Journal of Engineering, Volume 20, No. 2, August 2007.

G. Ghodrati Amiri and S. R. Massah (2007). “Seismic Response of 4-Legged Self-Supporting Telecommunication Towers”, International Journal of Engineering, Volume 20, No. 2, August 2007.

Hemal J shah & Dr. Atul K Desai (2014). “Seismic Analysis of Tall TV Tower Considering

Different Bracing Systems", International Journal of Engineering, Business and Enterprise and Applications (IJEBEA) ISSN: 2279-0020, February 2014.

IS: 1893 (part 1): (2002), Indian Standard Criteria for Earthquake Resistant Design of Structures, Part 1: General Provisions and Buildings. Bureau of Indian Standards, New Delhi.

IS: 875 (part 3)☹1987), Indian Code of Practice for Design Loads (other than Earthquake) for Buildings and Structures, Part 3: Wind Loads. Bureau of Indian Standards, New Delhi.

Jesumi A., and M.G. Rajendran (2013). "Optimal Bracing System for Steel Towers", International Journal of Engineering Research and Applications, Volume 3, Issue 2, ISSN: 2248-9622.

Kehdr M.A. and McClure G. (1999). Earthquake Amplification Factors for Self-Supporting Telecommunciation Towers. Canadian Journal of Civil Engineering 1999; 26(2): pp. 208-215.

Keshav Kr. Sharma, S.K. Duggal, Deepak Kumar Singh and A. K. Sachan (2015). "Comparative Analysis Of Steel Telecommunication Tower Subjected To Seismic & Wind Loading", Civil Engineering and Urban Planning: An International Journal (CiVEJ) Vol.2,No.3,

Punmia B.C. and Jain, (2006). "Design of steel structure", Laxmi publication.

Siddesha H. (2010). "Wind Analysis of Microwave Antenna Towers", International Journal of Applied Engineering Research, Dindigul, Volume 1, No 3, 2010, ISSN 0976-4259.

Corresponding Author

Prof. P. K. Pasnur*

Assistant Profesor, Department of Civil Engineering, JSPM's ICOER Wagholi, Pune, India

E-Mail – pallavi.vangari1@gmail.com