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"Comparative Study of Wind and Earthquake Loading on Telecommunication Tower"

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Abstract: The telecommunication industry plays a great role in human societies and thus much more attention is now being paid to telecommunication towers than it was in the past. Telecommunication towers are tall structures usually designed for supporting parabolic antennas installed at a specific height. As telecommunication towers are the only means of enhancing both the coverage area and network reliability, more and more telecommunications towers are installed nowadays. The stability of towers post-earthquake or a cyclone is of great concern. Hence in the present study, a detailed analysis has been made on the behavior of the telecommunication tower subjected to wind and seismic loads with varying the bracing system of towers. Gust factor method is used for wind load analysis. Conducted analytical study on effect of wind on telecommunication towers, for wind speed of 50m/s for four combination of bracing systems; Also studied the effect of earthquake loading on telecommunication towers using Modal analysis and Response Spectrum method, for seismic zones III, IV and V for all the four combination of bracing systems. The results of displacement at the top of the towers and stresses in the bottom leg of the towers are compared and the optimum bracing system is found.

Keywords: bracings, earthquake loading, telecommunication towers.

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1. Introduction:

India has a large population residing all over the country and the electricity supply need of this population creates a requirement of a large telecommunication and distribution system. The use of electric power has become an increasingly important part of the economy of industrial countries. The telecommunication Lines towers cost about 35 – 45 percent of the total cost of the telecommunication System. Hence utmost economy has to be exercised in their design and installation.

A telecommunication line tower is a space frame and a high order indeterminate structure. Its cost is influenced by its weight. The weight in turn Is influenced by the designer's diligence and his efficient application of the governing specifications. Given the same code in respect of material, ruling Dimension loads, unit stresses, etc., any two competent engineers could produce Designs resulting in structures which are strikingly similar in weight.

To Study Structural Behavior of Self-Supporting Telecommunication Tower under wind and seismic forces. To study and analyse the behavior of self supporting Telecommunication tower for four combination of bracing systems for Indian code practice IS 875 (part 3):1987. To analyse the effect of earthquake loading on telecommunication towers using Modal analysis and Response Spectrum method, for seismic zones III, IV and V for all the four combination of bracing systems. To compare the results of analysis of Telecommunication towers with different configurations.

2. Literature Review:

1. Shubham Kashyap (2018), The present Study interacts with the investigation of static and dynamic analysis of Electric tower structure. The analysis and modelling of tower is executed the use of FE based ANSYS software program.

2. K.N.G.N Andan (2016), transmission conductors at a sufficient and safe height from ground. In addition to their self-weight they have to withstand all forces of nature like strong wind, earthquake and snow load. Therefore transmission line towers should be designed considering both structural and electrical requirements for a safe and economical design. This paper introduces different types of transmission tower and its configuration as per Indian Standard IS-802.

3. Keshav Kr. Sharma et al (2015), comparatively analysed 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. Gust factor method is used for wind load analysis, modal analysis and response spectrum analysis are used for earthquake loading. In this paper concluded that the wind is the predominate factor in the tower modelling than the seismic forces but the seismic effect cannot be fully neglected as observed from the results and V-Bracing gives satisfactory result in wind analysis, modal analysis and response spectrum analysis for all considered wind and earthquake zones mentioned in IS code.

3. Methodology

3.1 Tower Specifications

The tower is a 4- legged square self-supporting lattice tower. The members are treated as truss members. (Only tension and compressive forces in it). The Steel Communication tower is designed for a height of 30 m. The towers are provided with 4-different types of bracings: K type, XB-type, V-type, W-type. STAAD Pro. V8i has been used for modelling, analysis of the towers. Details of towers, modelled are given in Table-1.

Table- 1: Details of the tower

Details of the tower	Dimension in m
Height of Tower	30 m
Height of Slant portion	21 m
Height of Straight portion at the top of a tower	9 m
Base width	5 m
Top width	2 m

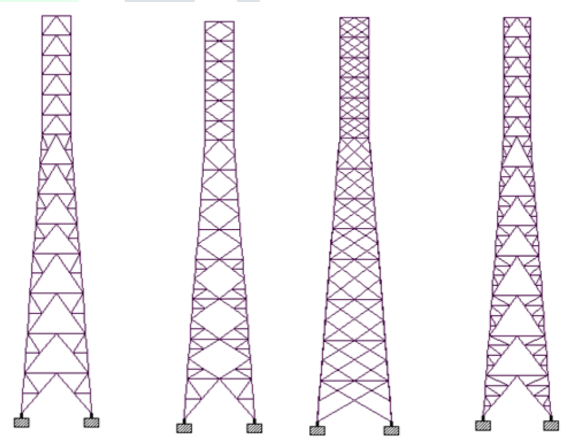

Fig 1:-bracing pattern (K, XB, W, V - Type)

In this present study, we have analyzed the stability of the 30m lattice tower in Zone III, Zone IV, Zone V. Load is defined using Response Spectrum method in STAAD Pro.

Table - 2: STAAD inputs for Seismic Analysis

Parameters	Zone III	Zone IV	Zone V
Zone Factor	0.16	0.24	0.36
Importance factor	1.5	1.5	1.5
Response Reduction Factor	4	1	1
X`x`Soil Type	Medium		
Damping Ratio	0.02	0.02	0.02

The structure is considered as a space truss and the wind load cases and seismic loading are considered separately. The design has been done using the limit state method. In case of seismic analysis, the behavior of the structure is studied in seismic zone III, zone IV and zone V. In total four numbers of towers are analyzed for each zone and the results are tabulated in Table V. The Frequency and time period for various bracings under study for all the seismic zones are tabulated in Table VI

Table- 3: Seismic effect on Tower

Parameter	Zone	Bracing			
		K	XB	W	V
Displ (mm)	III	44.6	49.5	72.2	56.0
	IV	49.1	79.0	109.4	93.0
	V	87.4	96.4	131.7	115.2
Base Shear (kN)	III	4.29	4.49	6.99	5.62
	IV	25.7	26.9	41.9	33.7
	V	38.5	40.3	62.9	50.5
Comp Force (kN)	III	168.3	229.1	251.3	210
	IV	230.3	234.9	338.0	294.1
	V	267.5	267.0	390.0	344.5
Tens Force (kN)	III	121.4	118.7	193.2	148.5
	IV	121.4	118.7	193.2	148.5
	V	121.4	118.7	193.2	148.5
Comp Stress (N/mm2)	III	103.9	109.7	125.2	142.0
	IV	121.5	152.6	154.3	197.2
	V	140.9	178.3	177.3	230.3
Tens Stress (N/mm2)	III	74.2	80.4	103.5	102.9
	IV	74.2	80.4	103.5	102.9
	V	74.2	80.4	103.5	102.9

In case of wind analysis, the stability of the various towers subjected to 50 m/s basic wind speed is analysed and the results are tabulated in Table 4.

Table- 4: Wind load effect on Tower

Bracings	K	XB	W	V
Displacement (mm)	32.7	36.3	53.8	40.5
Tensile stress(N/mm2)	64.1	80.4	103	148
Compressive Stress(N/mm2)	89.0	109	125	142
Tensile Force(kN)	121	118	193	136
Compressive Force(kN)	168	165	251	210

4 Result & Discussion

4.1 Displacement at Top of the Tower - Seismic

Fig.2. shows the comparative displacement values of all the bracings at various seismic zones are presented.

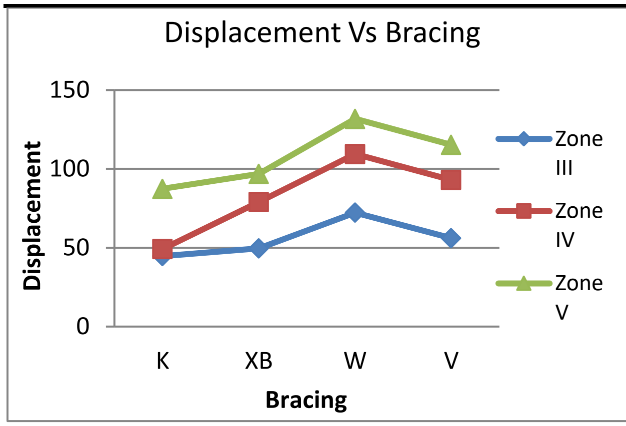

Fig.2: Displacement vs bracing

4.2. Base shear - Seismic

The base shear obtained from the Response Spectrum Analysis for various bracing system at different seismic zone is given in Fig.3.

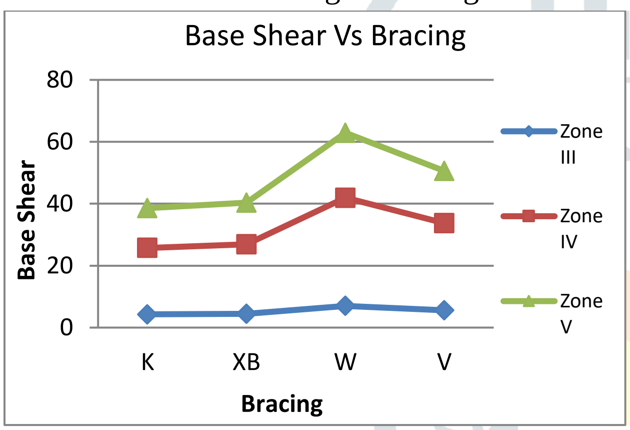

Fig.3: Base shear vs bracing

4.3. Member forces - Seismic

The comparative maximum compressive force and maximum tensile force developed in the tower for various bracings and at different zones are presented in Fig.4. and Fig.5. Respectively

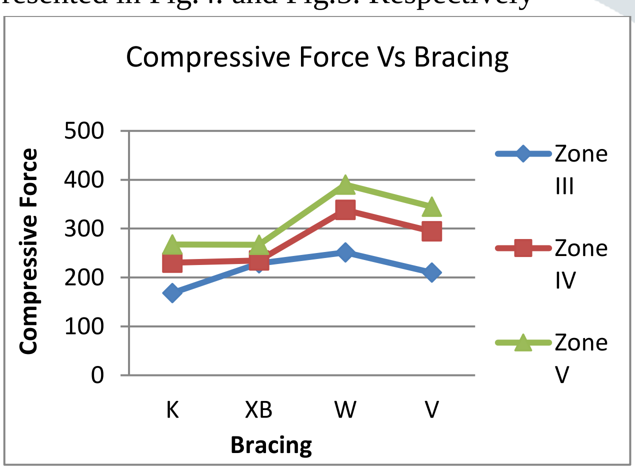

Fig.4: Compressive force vs bracing

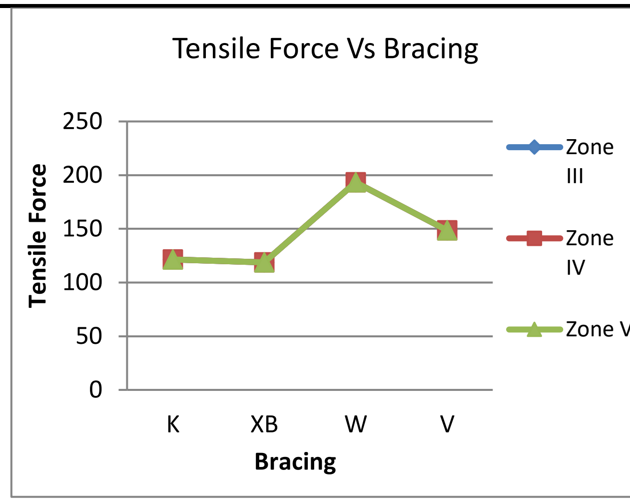

Fig.5: Tensile force vs bracing

4.4. Axial stresses - Seismic

The comparative maximum compressive stress and maximum tensile stress developed in the tower for various bracings and at different zones are presented in Fig.6. and Fig.7 respectively.

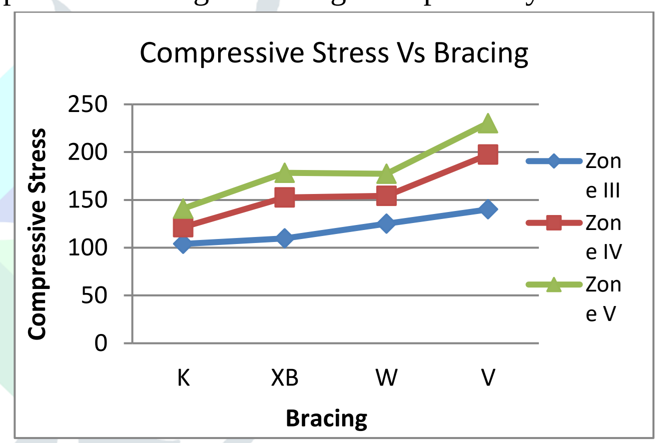

Fig.6: Compressive stress vs bracing

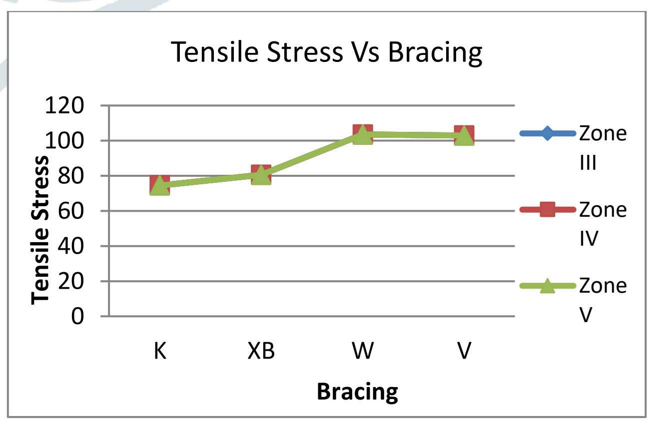

Fig.7: Tensile stress vs bracing

For Wind load analysis, displacement at top of towers, stresses and member forcevalues obtained for various bracing are plotted in form of the graph.

4.5. Displacement at Top of Tower –Wind load

The displacement obtained from the wind load analysis is shown in the Fig.8.

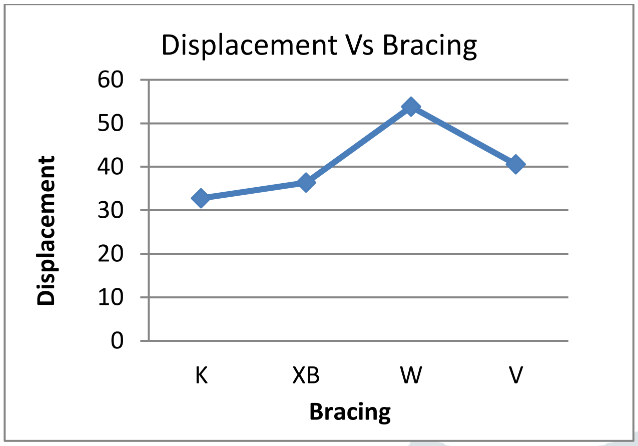

Fig.8: Displacement vs bracing

4.6. Axial stresses – Wind load

The variation of tensile and compressive stresses for the various bracing systems considered is presented in Fig.9. and Fig.10 respectively.

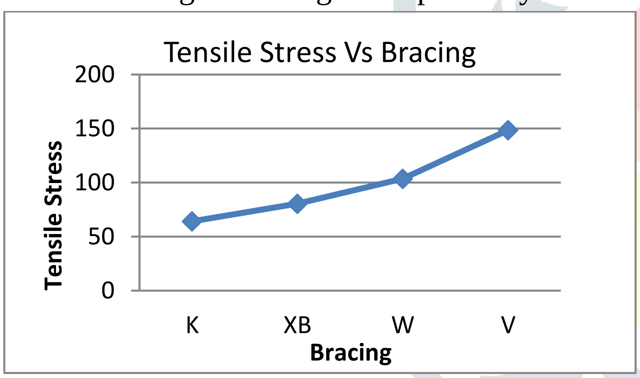

Fig.9: Tensile stress vs bracing

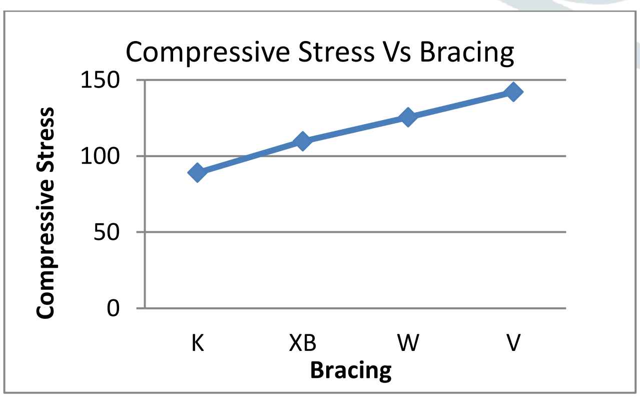

Fig.10: Compressive stress vs bracing

4.7. Member forces – Wind load

The magnitude of force in members both tensile and compressive in nature are same. From the Fig. 11.and Fig.12.

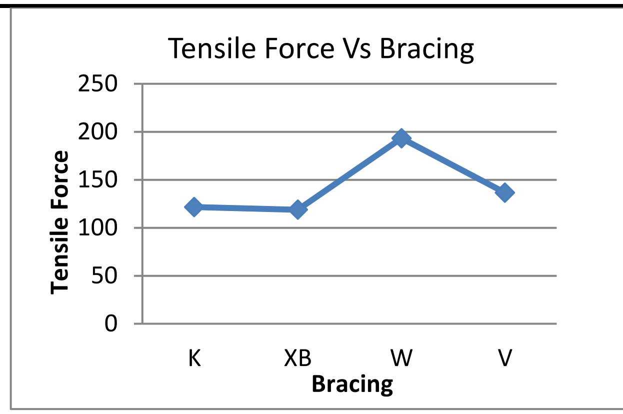

Fig.11: Tensile force vs bracing

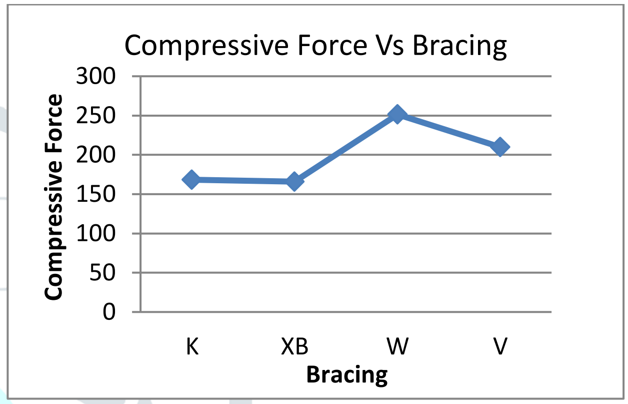

Fig.12: Compressive force vs bracing

4.8. Cost Analysis

To compare cost in all 4 different bracing system we need to optimize structure. And after optimization following results are obtained:-

Table- 8: Cost Analysis

Sr No	Type of bracing	Tonnage (kg)
1	K	7206.6
4	XB	7825.1
7	W	9918.6
10	V	9284.1

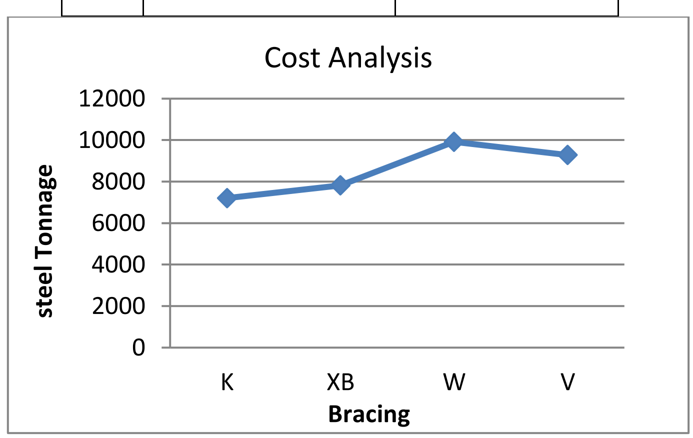

Fig.13: Cost Comparison

5. Conclusion

The effect of Wind and Earthquake on Telecommunication tower with four different types of bracings are studied. The following conclusions can be drawn based on the analysis of results.

1) From the wind analysis, it can be observed that the increase in joint displacement of K bracing and XB bracing are almost same and it is 63.03% and 22.84% less compared to W bracing and V bracing respectively.
2) The member force in KB bracing is found to be minimum and the force increase by 1.45%, 51.51%, and 26.58% for K, W, and V bracing respectively compared to K bracing.
3) The stress in towers with K bracing is found to be less by 23.28%, 40.65%, and 59.55% for KB, W and V bracing respectively.
4) In the response spectrum analysis, the joint displacement at tower located in seismic zone III is found to be less for tower with K bracing. The deflection at the top is 10.87%, 61.68% and 25.47% more for XB bracings, W bracings and V bracing respectively compared to K bracing. Also taking member forces and stress into account, K bracing proves to be optimum compared to other bracing system.
5) In seismic zone IV and zone V, the joint displacement of K bracing is less compared to XB,W and V respectively. Also stresses developed in towers with K bracing are less compared to towers with other bracing systems.
6) Based on cost comparison we can conclude that K bracing system is optimized bracing system compared to other bracing system.

From the analysis it is clearly seen that the wind effects are critical for tower design and it is suggested to adopt K bracing system.

REFERENCES

1. JitheshRajasekharan," Analysis of Telecommunication Tower Subjected To Seismic And Wind Loading" published on international journal of advancement in engineering technology, management and applied science,2 July 2014.
2. NitinBhosale et al, "Influence of Host Structure Characterstics On Response Of Rooftop Telecommunication Tower" published on international journal of civil and structural engineering, volume 2,no 3,2012.
3. Ghodrati Amiri et al,"Seismic Behaviour of 4-Legged Self Supporting Telecommunication Tower" published on 13th world conference on earthquake engineering, August 2004.
4. A.Jesumi et al, "Optimal Bracing System For Steel Towers" published on international journal of engineering research and applications, March-April 2013.
5. 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.
6. Venkateswarlu, B., Harikrishna, P., Rajan, S. and Kumar, M., "Stochastic gust response of microwave lattice towers", Computers and Structures, Vol. 52, No. 5, (1994), 1031-1041.
7. McClure G., Georgi L., Assi R, 2004, "Seismic considerations for Telecommunication towers mounted on building rooftop", 13th World Conference on Earthquake Engineering, Vancouver, Canada, Paper No. 1988.
8. Da Silva, J.G.S., Da S. Vellasco, P.C.G., De Andrade, S.A.L. & De Oliveir, M.I.R. (2005). Structural assessment of current steel design models for telecommunication and Telecommunication towers. Journal of Constructional Steel Research.