Parametric Study on Behavior of Microwave Tower with Different Bracing Patterns under Lateral Loads

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Abstract – *The expansion of telecommunications and broadcasting systems, a large number of lattice towers are used to support the microwave antennas. The main feature of the tower is its height; it is usually several times larger than the corresponding horizontal dimension. The primary objective of work is to understand the effect of wind on microwave towers. This study deals with the behavior of microwave towers under lateral loads, varying base width, different height and different bracing systems are adopted and analyzed to study lateral displacement, axial force, utilization ratio etc. The failure of tower can rapidly propagate along leg and brace members and result in severe damage that cost can affected.*

***Key Words*: Microwave Tower, Location, STAAD PRO, Dynamic analysis, Wind Analysis, Bracings, Lateral Displacements**

1. INTRODUCTION

In every country, the development of telecasting and broadcasting networks has continued to rise. The rate of growth is greater in developing countries on account of the comparatively low base of telecasting and broadcasting networks. This in turn, has led to the increase in the construction of steel towers of various configurations and heights as shown in Fig 1.1. These towers are predominately used for-

- Microwave transmission for communication
- Radio transmission
- Television transmission
- Satellite reception
- Air traffic controls
- Power transmission lines
- Meteorological measurements
- Derrick and Crawler Cranes
- Oil drilling masts
- Overhead water tanks

❖ The effective dimension of a tower is its height. It is usually several times larger than the horizontal dimensions. Frequently the area, which may be occupied at ground level, is very limited and thus, rather slender structures are commonly used.

According to the size and type of loading, this depends on the purpose of the tower; towers are group under two heads.

❖ According to the type of loading

1. Towers having Large Vertical loads
2. Towers having mainly horizontal wind loads

❖ According to the size of tower

1. Lightweight tower
2. Heavy weight tower

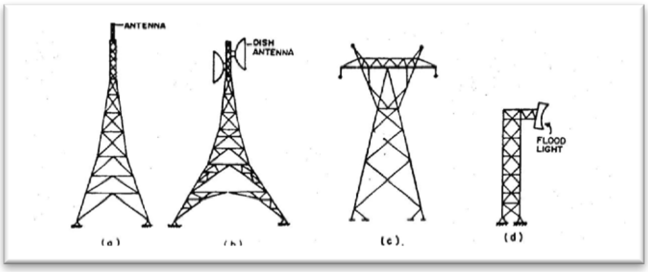

Fig:1.1 Various types of towers

2. OBJECTIVES

(i) Selecting of various alternatives on the basis of weight and deflection of tower by taking different base width, vertical profile of the tower and different bracing systems and select the most optimum alternative.
(ii) The aim of my work is “Parametric Study on Behavior of Microwave Tower with different Bracing Patterns under Lateral Load”
(iii) Analyze the axial force, bending moment, lateral displacement, frequency, wind force, weight of the structure and utilization ratio using gust response method.

3. LITREATURE VIEW

Prof. S. M. Barelikar Shailesh S. Goral (2017) investigated the analysis and design of telecommunication tower for wind and earthquake are the major issues which are playing significant role in recent decades in the designing. Telecommunication towers with different configurations behave differently for lateral loadings. In this research the wind and seismic analysis of telecommunication towers is carried out. Telecommunication towers with square in plan, with different bracing systems are designed and checked for gravity loading. The same models are modelled using STAAD Pro. The towers are analyzed by non-linear dynamic method. The results obtained from non-linear dynamic analysis are compared on the basis of various parameters.

Jithesh Rajasekharan, S Vijaya (2014) investigated the Comparative Analysis Of Steel Telecommunication Tower Subjected To Seismic and Wind Loading. This research paper consists of effects of earthquake force and wind force on tubular tower Structure with different bracing system such as invert ‗V' bracing and ‗X'. The Indian standard code of practice IS-1893 (Part I: 2002), IS-875:1987 (PartIII), IS-800-2007 guidelines and methodology are used to analyze the tower structure. The behavior of tower was examined and compared on the basis of displacement and base shear.The lateral displacement goes on increasing as the height of tower increases. The base shear goes on increasing as the height of tower increases. The inverted V bracing has less displacement as compare to X bracing. The lateral displacement goes on increasing as the height of tower increases.

Jobil Varghese Riya Joseph (2015) **Analysis of Monopole Communication Tower with bracing** The project work deals with the analysis of monopole mobile towers. behavior of monopoles when used as a communication tower. Efficiency of monopole tower is evaluated based on the finite element results. Since pole structures have smaller dimension and require

lesser space for installation, they can be used as a suitable alternate for lattice towers. Displacement was higher than other models for model one for both static and dynamic analysis.

Abdulaqder M. Tah, Kamiran M. Alsilevanai, Mustafa Ozakca (2016) investigated Comparison of various Bracing System for Self-Supporting Steel Lattice Structure Towers. This paper aims to identifying the economical bracing system for 40, 50 and 60 m height of the tower and deals with effectiveness of various bracing systems used in lattice tower. In this study seven types of bracings (K, KD, Y, YD, D, XB and X) used in 4-legged square based self supporting telecommunication tower and four types of bracings (K, D, XB, X) used in 3-leg triangular based self supporting telecommunication towers are analyzed. In tower models, the main member legs use beam elements while the bracing system utilized truss elements. In this paper telecommunication tower have been analyze under critical loads such as wind and earthquake load.

P. Markandeya Raju M. Pavan Kumar D. Vishalakshi K. Manoharini (2017) investigated the PARAMETRIC COMPARISON OF COMMUNICATION TOWERS WITH DIFFERENT BRACINGS In this study, the towers are analysed for 6 different basic wind speeds that are considered according to IS 875: 2015 (PART 3). This project is aimed at comparing a four legged communication towers with different bracing systems for different wind zones in India. Towers are designed as per IS: 800-2007 using STAAD.Pro and the wind forces are calculated as per IS: 875 Part-III. From this study, it can be concluded that for a 24m height four legged tele-communication tower, angular cross section with Kbracing pattern is found to be most effective and economical among all considered basic wind speeds (i.e. 33 m/sec, 39 m/sec, 44 m/sec, 47 m/sec, 50 m/sec and 55 m/sec).

4. METHODOLOGY

4.1 MODELLING OF TOWER

In the present work, an attempt has been made to carry out a parametric study for microwave steel tower under the effect of lateral loading. The dynamic wind load is applied on a tower using gust factor method.

4.2 PRELIMINERY DATA

Consider 80m high microwave tower with x and horizontal bracing for the present work. Preparing worksheet for calculating dynamic wind loads on structure. Analyze the structure with effect of dynamic wind loads.

Tower	
Geometry	Square
Height of tower	80.0m
Base width	10.0m
Top width	5.0m

Table -1: Modeling methodology

Number of panels	15
Panel height	Top two 5.0 m and rest ten are 5.39148 m each
Type of bracings	X and Horizontal
Material properties	
Structural steel grade	Fe : 250
Wind data	
Location	Bangalore
Basic wind speed	33m/s
Life of structure	100 years
Topography	Flat
Terrain category	1.0
Risk Coefficient k1	1.05
Importance Factor k4	1.3
Wind factor Kd	0.9
Combination factor Kc	0.9
Damping Coefficient β	0.020 for bolted steel structure
Force Coefficient Cf	Depending on solidity ratio Ø as per IS 875 (part-3) : 2015
Permissible Limit of displacements : Height / 300 as per IS 800 : 2007	

Table -2: Material Properties and wind data

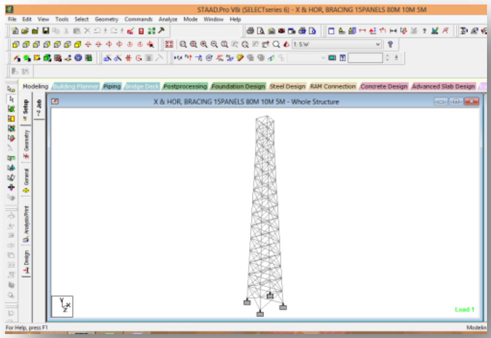

Fig 2: Whole view of structure

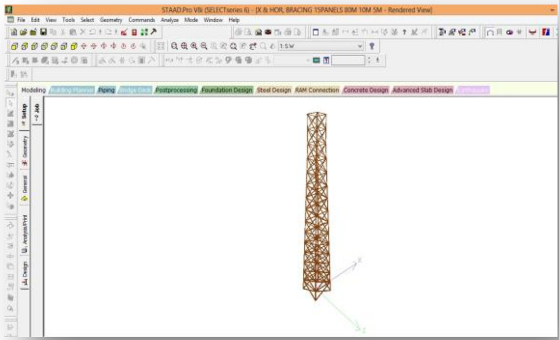

Fig 3: 3-D view of structure

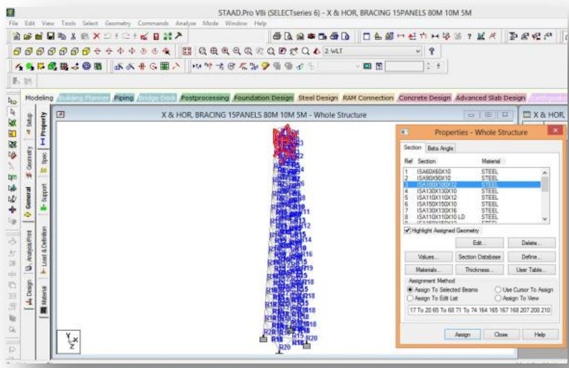

Fig 4: Properties applied on a structure

Elevation	Member	Size (mm)	No. & Length
80 – 75.083	Horizontal	ISA 60 x 60 x 10	1, 5
	Vertical	ISA 100 x 100 x 12	1, 5
	Diagonal	ISA 100 x 100 x 12	1, 7.07107
75.083-70.089	Horizontal	ISA 60 x 60 x 10	1, 5
	Vertical	ISA 90 x 90 x 10	1, 5
	Diagonal	ISA 100 x 100 x 12	1, 7.07107
70.089 – 64.698	Horizontal	ISA 60 x 60 x 10	1, 5
	Vertical	ISA 130 x 130 x 10	1, 5.39148
	Diagonal	ISA 110 x 110 x 12	1, 7.48272
64.698 – 59.306	Horizontal	ISA 110 x 110 x 12	1, 5.385
	Vertical	ISA 150 x 150 x 10	1, 5.39148
	Diagonal	ISA 130 x 130 x 16	1, 7.75456
59.306 – 53.915	Horizontal	ISA 110 x 110 x 12	1, 5.769
	Vertical	ISA 110 x 110 x 10	2, 5.39148
	Diagonal	ISA 150 x 150 x 10	1, 8.03561
53.915 – 48.523	Horizontal	ISA 150 x 150 x 12	1, 6.154
	Vertical	ISA 120 x 120 x 12	2, 5.39148
	Diagonal	ISA 200 x 200 x 12	1, 8.32495
48.523 – 43.132	Horizontal	ISA 150 x 150 x 10	1, 6.538
	Vertical	ISA 130 x 130 x 12	2, 5.39148
	Diagonal	ISA 200 x 200 x 12	2, 8.62173
43.132 – 37.740	Horizontal	ISA 150 x 150 x 10	1, 6.923
	Vertical	ISA 200 x 200 x 25	1, 5.39148
	Diagonal	ISA 200 x 200 x 20	1, 8.92523
37.740 – 32.349	Horizontal	ISA 150 x 150 x 10	1, 7.308
	Vertical	ISA 150 x 150 x 20	2, 5.39148
	Diagonal	ISA 200 x 200 x 12	1, 9.23478
32.349 – 26.957	Horizontal	ISA 150 x 150 x 10	1, 7.692
	Vertical	ISA 180 x 180 x 20	2. 5.39148
	Diagonal	ISA 200 x 200 x 20	1, 9.54978
26.957 – 21.566	Horizontal	ISA 150 x 150 x 20	1, 8.077
	Vertical	ISA 200 x 200 x 20	2, 5.39148
	Diagonal	ISA 200 x 200 x 20	1, 9.86971
21.566 – 16.174	Horizontal	ISA 150 x 150 x 20	1, 8.462
	Vertical	ISA 200 x 200 x 20	2, 5.39148
	Diagonal	ISA 200 x 200 x 20	1, 10.1941
16.174 – 10.783	Horizontal	ISA 150 x 150 x 20	1, 8.846
	Vertical	ISA 200 x 200 x 20	2, 5.39148
	Diagonal	ISA 200 x 200 x 20	1, 10.5226
10.783 – 5.391	Horizontal	ISA 200 x 200 x 20	1, 9.231
	Vertical	ISA 200 x 200 x 20	2, 5.39148
	Diagonal	ISA 200 x 200 x 20	2, 10.8547
5.391 – 0	Horizontal	ISA 200 x 200 x 20	1, 9.615
	Vertical	ISA 200 x 200 x 25	2, 5.39148
	Diagonal	ISA 200 x 200 x 20	2, 11.1903

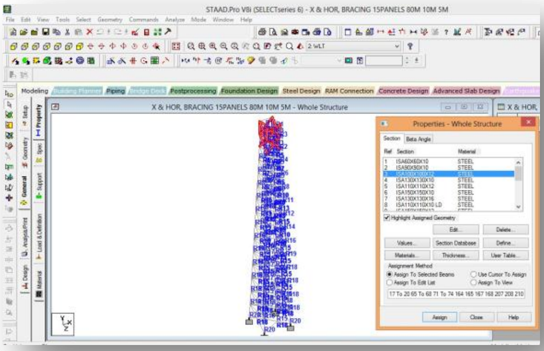

Fig 5: Properties applied on a structure

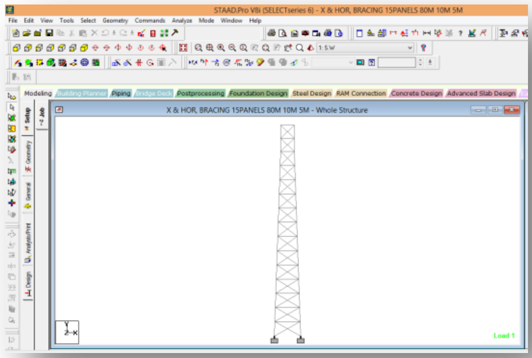

Fig 8: Y-X Plane of structure

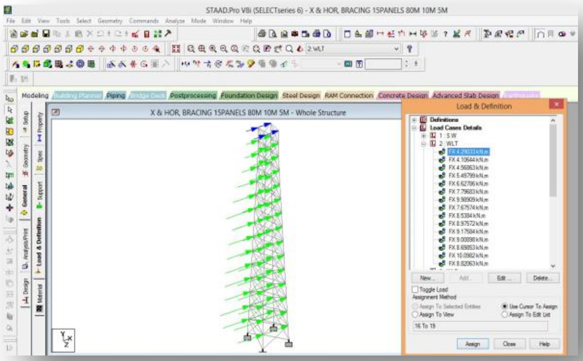

Fig 6: Typical view of wind load acting on a structure

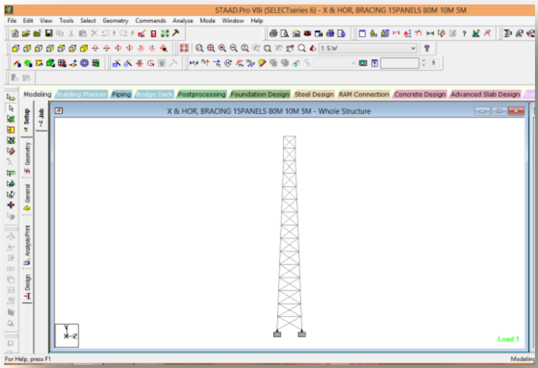

Fig 9: Y-Z Plane of structure

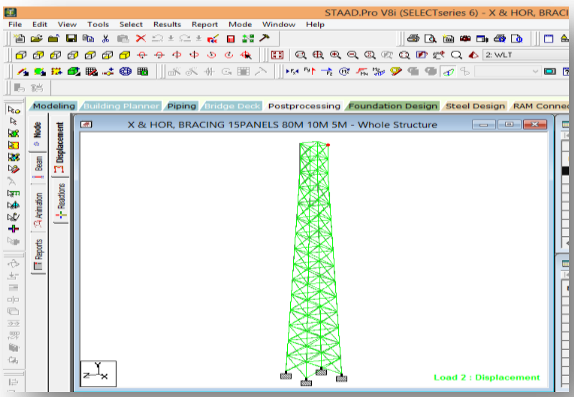

Fig 7: Displacement of structure

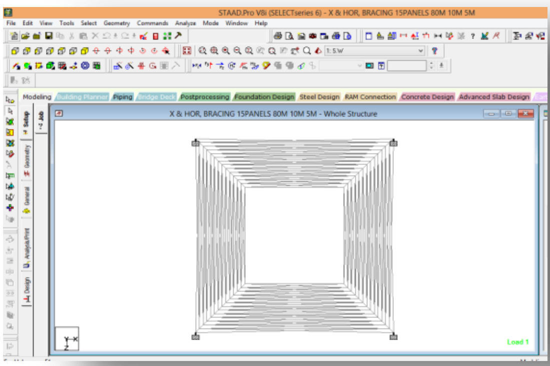

Fig 10: X-Z Plane of structure

4.3 ASSIGNING LOADS

- Live load
  Live load intensity= 3 kN/m^2

5. SEISMIC ANALYSIS OF BUILDING

Table -3: Loads on Tower

Panel from Top	Level (m)	Design wind pressure (N/m^2)	Dynamic Wind Load(KN)
1	80.078	932.52502	17.161
2	75.083	921.224618	16.425
3	70.089	818.302164	18.274
4	64.698	805.832651	21.991
5	59.306	792.383631	26.511
6	53.915	777.784471	31.187
7	48.523	761.800857	39.956
8	43.132	744.132396	30.702
9	37.74	724.348611	34.153
10	32.349	701.845503	35.902
11	26.957	675.683464	36.703
12	21.566	644.345701	36.035
13	16.174	605.034919	34.794
14	10.783	551.739727	40.392
15	5.391	466.303527	35.282

6. RESULT COMPARISON

6.1 GUST FACTOR

Graphical representation of Gust Factor values for all models as shown in Chart 1

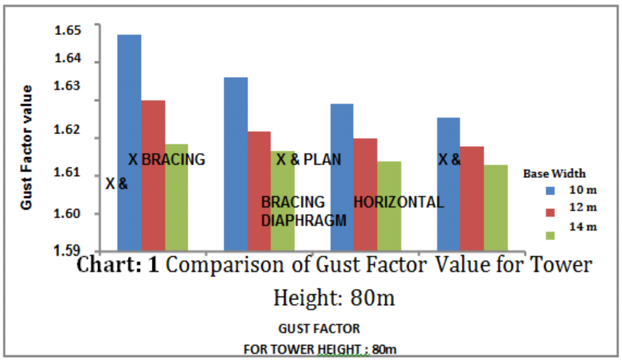

Chart: 1 Comparison of Gust Factor Value for Tower Height: 80m

6.2 MAXIMUM WIND FORCE

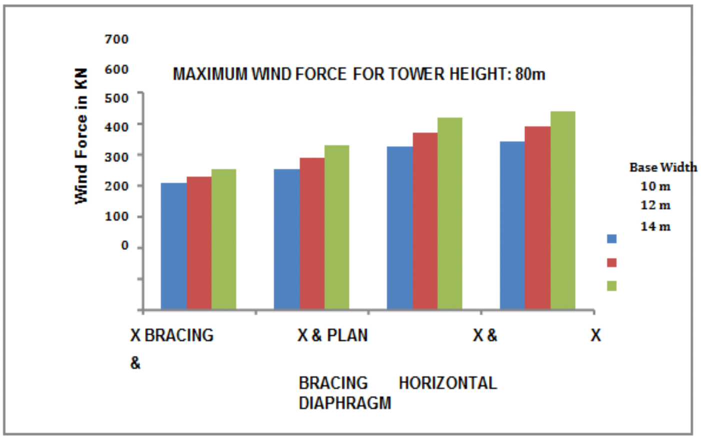

Chart: 2 Comparison of Maximum Wind Force for Tower Height: 80m

6.3 MAXIMUM AXIAL FORCE

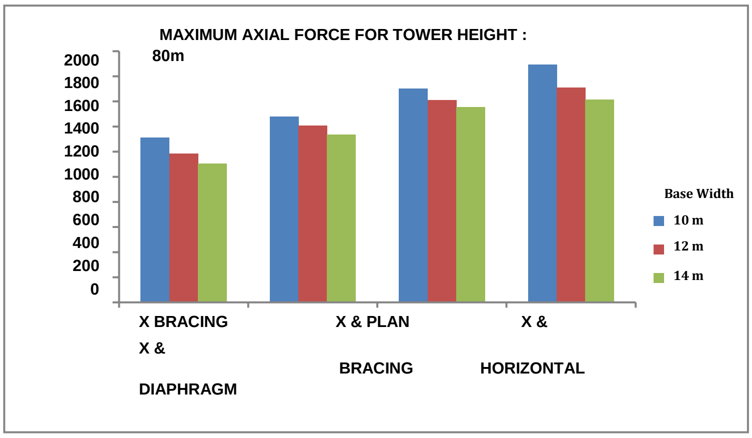

Chart: 3 Comparison of Maximum Axial Force for Tower Height: 80m

6.4 MAXIMUM DISPLACEMENT

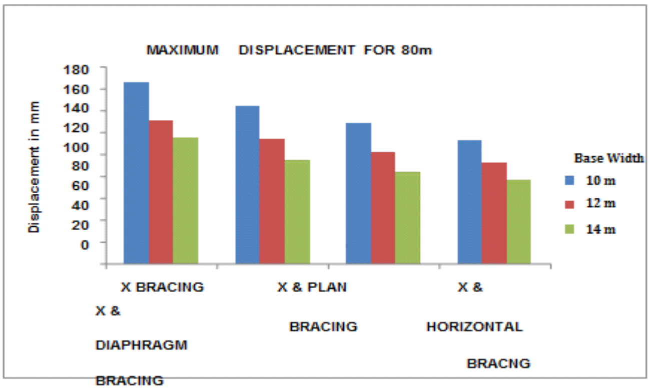

Chart 4: Comparison of Maximum Displacement for Tower Height: 80m

6.5 TOTAL WEIGHT OF TOWER

Graphical representation of total weight of tower values for all models as shown in Chart 5.

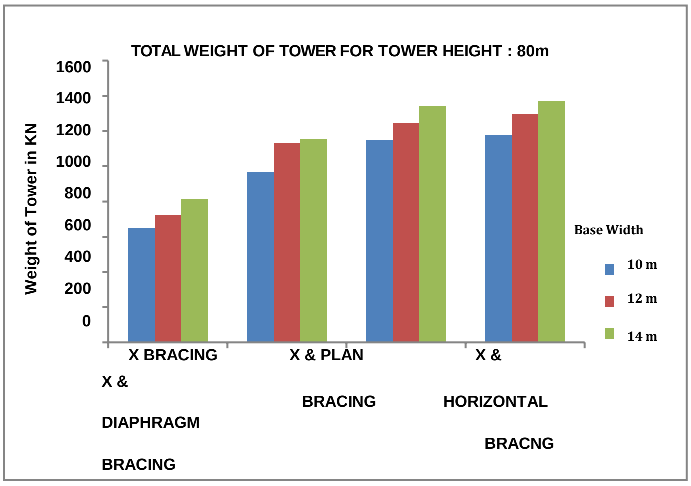

Chart 5: Comparison of Total Weight of Tower for Tower Height: 80m

6.5 TOTAL COST OF TOWER

Graphical representation of total cost of tower values for all models as shown in Chart 6.

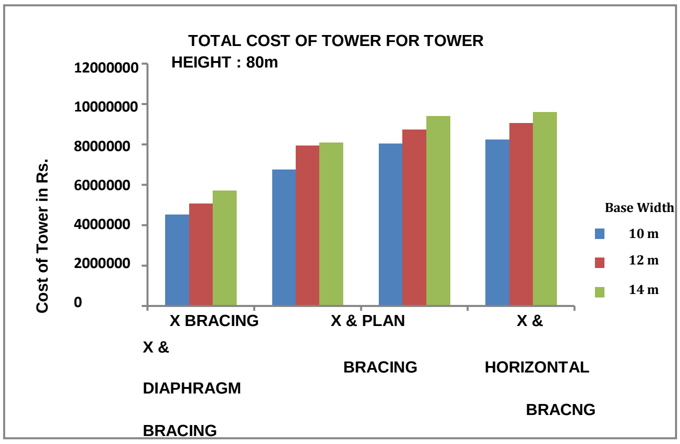

Chart 6: Comparison of Total Cost of Tower for Tower Height: 80m

7. CONCLUSION

Analysis of the microwave tower subjected to dynamic loading has been carried out and the results are extracted and compared in the form of para meters Natural mode frequency, Gust Factor, Maximum displacement, Maximum Axial force, Maximum wind force, Total weight of tower and total cost of Tower respectively.

- Towers of different height and different base width have been analyzing for different load combinations and the analysis results of the critical loading are taken in consideration.
- The stiffness of structure increases because of their slanting legs which slant more with increase in the base width making the tower more sensitive for vertical deflection compared to horizontal deflection.
- The results show that the behavior of the microwave tower is greatly influence by the different bracing patterns. X with Diaphragm bracing gives maximum natural mode of frequency than other bracing patterns. Therefore, it also improves stiffness of towers.
- The deflection may become important design criteria because excessive antenna deflection caused by high wind load may result in signal loss or distortion.
- The maximum force in the bracings and main legs are observed at location when the trapezoidal portion converts in to the straight portion.

Hence we conclude that For the towers of 80m and 100m height, maximum permissible deflection is 266.66 mm and 333.33mm respectively as per BS:8100, and the results of this study shows deflection within the safe permissible limits.

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IS code:

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