International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES)
Impact Factor: 5.22 (SJIF-2017), e-ISSN: 2455-2585
Volume 5, Issue 04, April-2019

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

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Abstract— This study deals with the behaviour of Microwave towers under lateral loads. Different bracing systems are adopted and analyzed to study lateral displacement, natural mode of frequency, wind force, axial force, weight of structure, utilization ratio and economical aspect. To upgrade system of Microwave towers using a diaphragm bracing that could improve the performance of towers. Analytical models have been generated in STAAD Pro and Comparison of results will be done to suggest the most suitable lateral load resisting system. The analysis for the lattice tower will be based on provisions of IS 800-2007, IS 875(part-III) and IS 802.

Keywords— Lattice Tower, Self-Supporting Tower, GF Dynamic wind Analysis.

I. Introduction

In every country, the development of telecasting and broadcasting networks is continuing 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. These towers are mainly used for Radio transmission, Microwave transmission for communication, Television transmission, Satellite reception, Air traffic controls, Power transmission lines, Meteorological measurements, Derrick and Crawler Cranes, Oil drilling masts, Overhead water tanks. The characteristic 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.The communication industries have seen a tremendous increase in last few years which has resulted in installation of large towers to increase the coverage area and network consistency. These towers play a significant role in wireless communication network hence failure of such structure in disaster is a major concern.

While Communication Satellite is used for sending and receiving information signals, very tall towers are required for transmission of signals through antennae. Tall towers are being used by different agencies such as television and radio departments, telecommunication industry, defences, railways and police for their communication network. The microwave towers, which are space structures in steel, carry mainly communication antennae. These towers are mostly square in plan, made of standard steel angels and connected together by means of bolts and nuts. Microwave towers are usually fabricated using angles for the main legs and the bracing members. The members are bolted together, either directly or through gusset plates.

Microwave towers are telecommunications towers that use microwaves to transmit telephone and television signals to other microwave towers. Microwaves are in the form of electromagnetic radiation with wave lengths ranging from 1 meter to 1 millimeter, with frequencies between 300 MHz and 300 GHz.

Fig. 1 Microwave Tower

II. OBJECTIVES

The main objective for present work is as follows:

- 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.

- Analyse the axial force, bending moment, lateral displacement, frequency, wind force, weight of the structure and utilization ratio using gust response method.

III. NUMERICAL STUDY

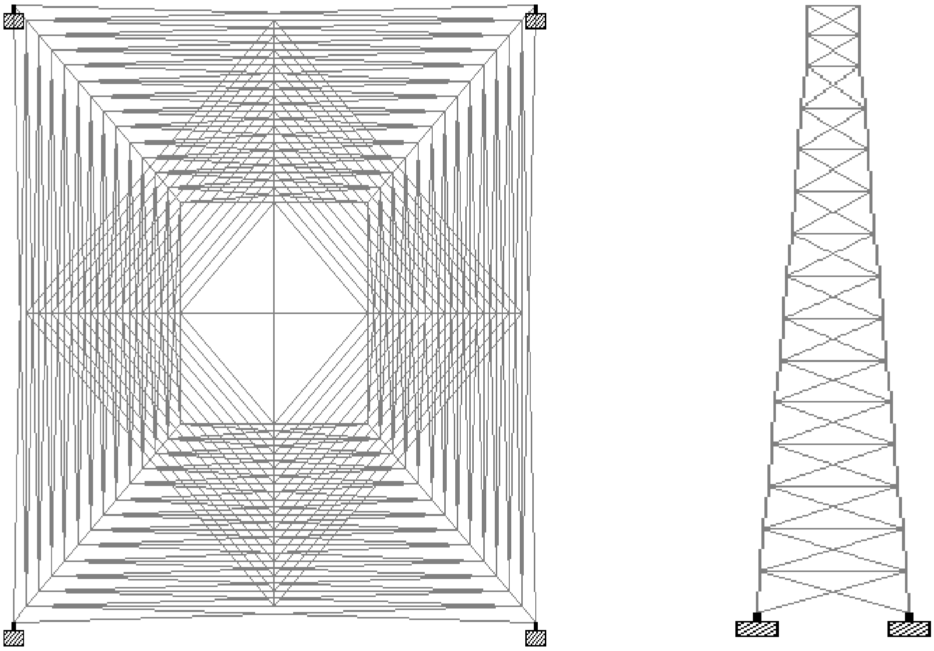


Fig. 2 Plan And Elevation Of Steel Tower

The numerical study carried out herein, the tower height 100m considered. Figure 2 and 3 show plan, elevation and 3D View of steel tower in STAAD Pro. V8i SS6. Assigning preliminary sizes for leg and bracing members. Assign the fixed supports. The member properties are added and assigned to each member of the tower. Calculating loads such as dead and wind and loads as per IS 875-part 3 2015 respectively.

The details for generating structural model in the software are given as follow:

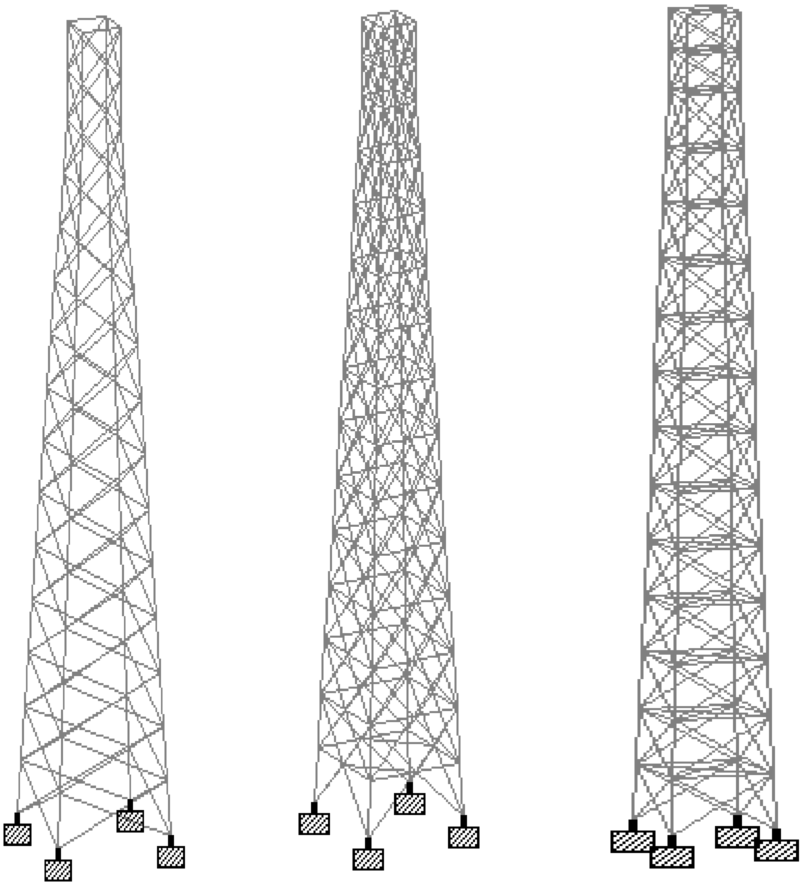
Tower configuration	
Geometry	Square
Height of tower	80 m and 100 m
Base width of tower	10 m, 12 m and 14m
Top width of tower	5 m
No of panels	15
Type of bracings	X, X & Horizontal, X& Diaphragm
Material Property	
Steel grade	Fe250
Wind Data	
Location	Bangalore
Basic wind speed	33 m/s
Life of Structure	100 Years
Topography	Flat
Terrain category	1.0
Risk Coefficient k_1	1.05
Importance factor k_4	1.3
Wind directionality factor K_d	0.9
Combination factor K_c	0.9
Damping Coefficient β	0.020 for bolted steel structure
Force Coefficient C_f	Depending on solidity ratio ø as per IS 875 (part-3) : 2015
Gust factor	Calculate as per IS 875(III) : 2015
Permissible Limit of displacement: Height/300 as per IS 800 :2007	

Fig shows that X, X & Horizontal and X & Diaphragm bracing are provided in tower.

Type I : X bracing

Type II : X & Horizontal bracing

Type III : X & Diaphragm bracing



Type I **Type II** **Type III**

Fig. 3 3D View Of Steel Tower

IV. DYNAMIC WIND LOAD CALCULATION

Based on the specification to IS 875 Part (III) : 2015

- Along Wind Response :

➢ Calculation of base bending moment (M_a)

$M_a = \Sigma F_z Z$

➢ Calculation of dynamic wind load (F_z)

$F_z = C_{f,z} A_z \dot{P}_d G$

G = Gust factor

$$= 1 + r\sqrt{[g_v^2 B_s (1 + \phi)^2 + \frac{H_s g_R S E}{\beta}}$$

- Across Wind Response:

It gives base overturning moment for tall-enclosed structure. Therefore, it is not required for lattice towers.

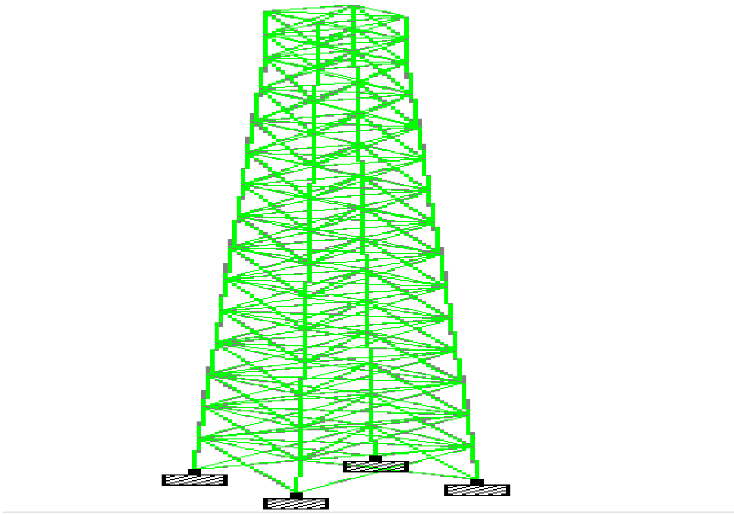


Fig. 4 Deflected Shape of Tower

V. RESULTS

Comparing the result for different base width with different vertical profile for displacement, axial force, wind force, frequency and total weight of tower.

1. Lateral Displacement

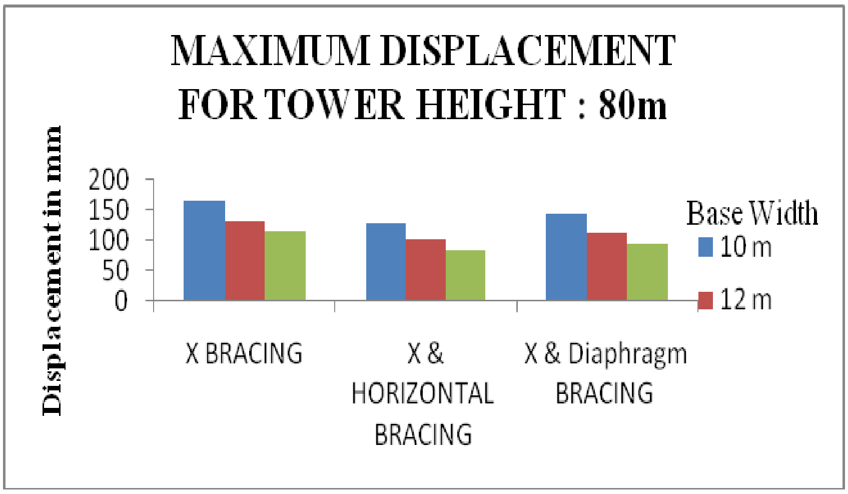


Fig. 5 Maximum displacement at top node for tower height 80m

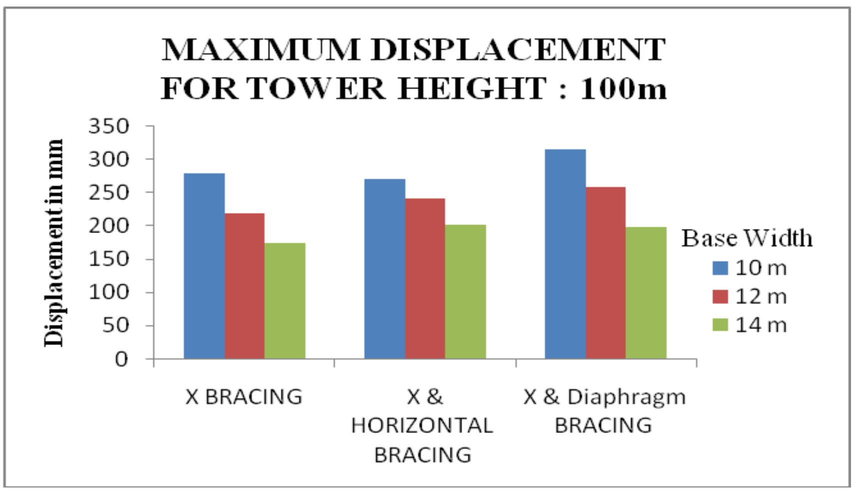


Fig. 6 Maximum displacement at top node for tower height 100m

2. Axial Force

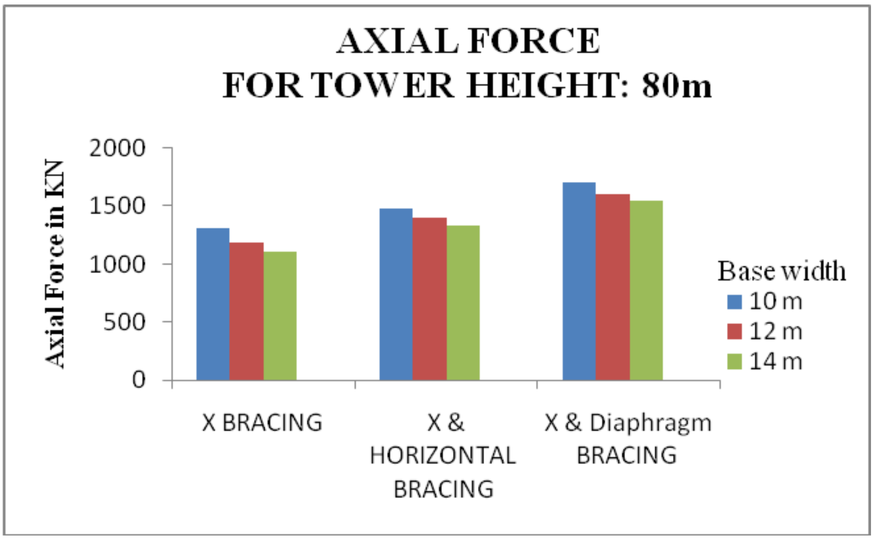


Fig. 7 Axial force for tower height 80m

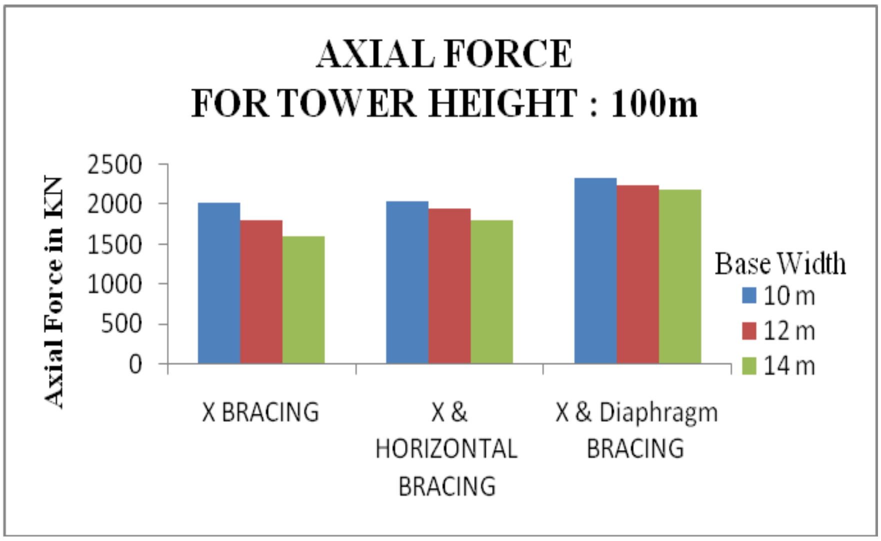


Fig. 8 Axial force for tower height 100m

3. Wind Force

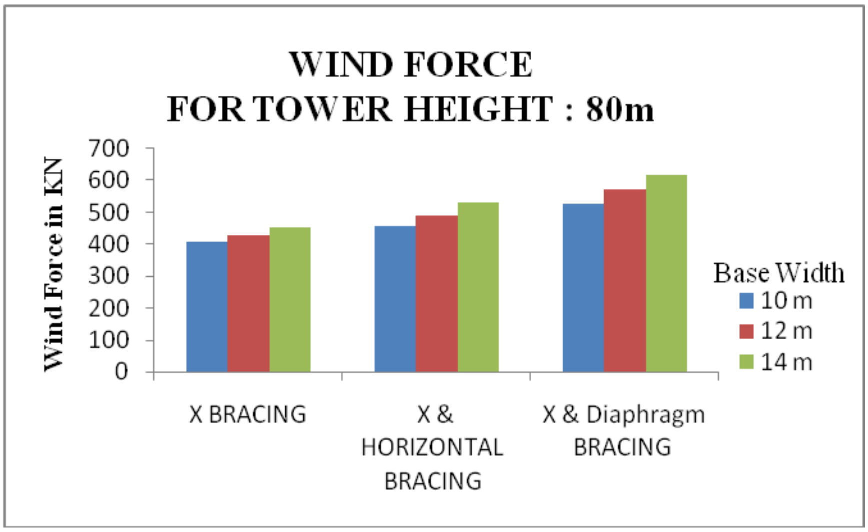


Fig. 9 Wind force for tower height 100m

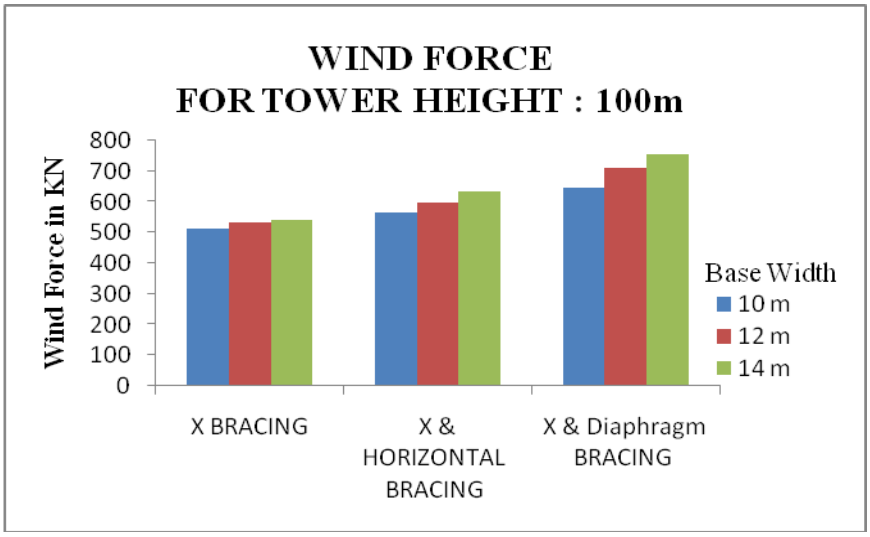


Fig. 10 Wind force for tower height 100m

4. Frequency

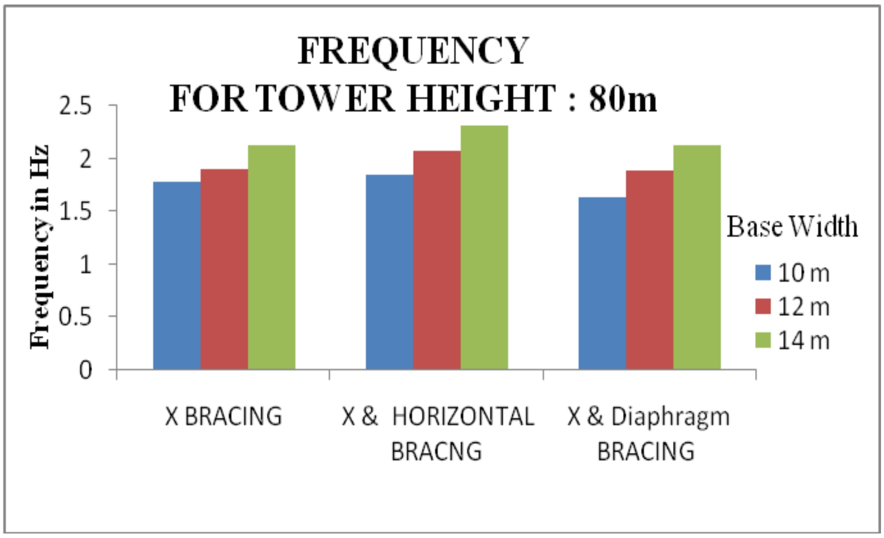


Fig. 11 First mode natural frequency for tower height 80m

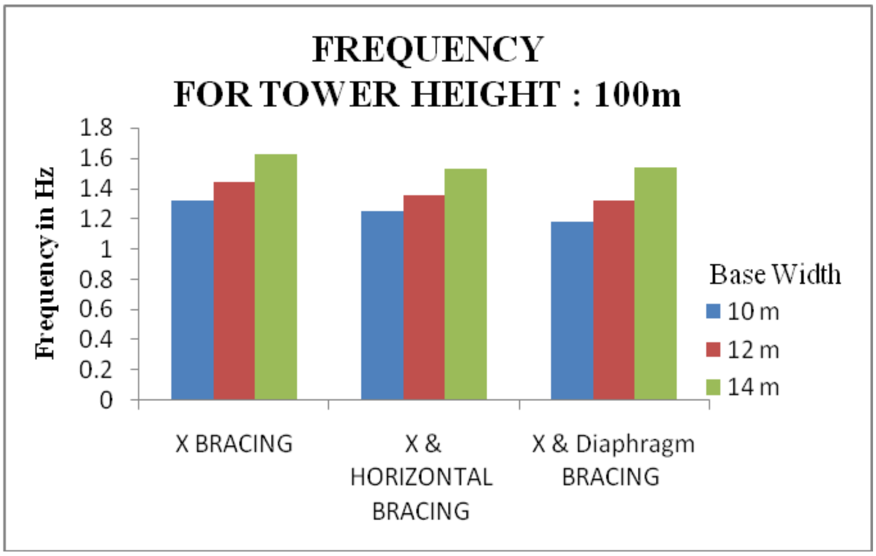


Fig. 12 First mode natural frequency for tower height 80m

5. Total Weight of Tower

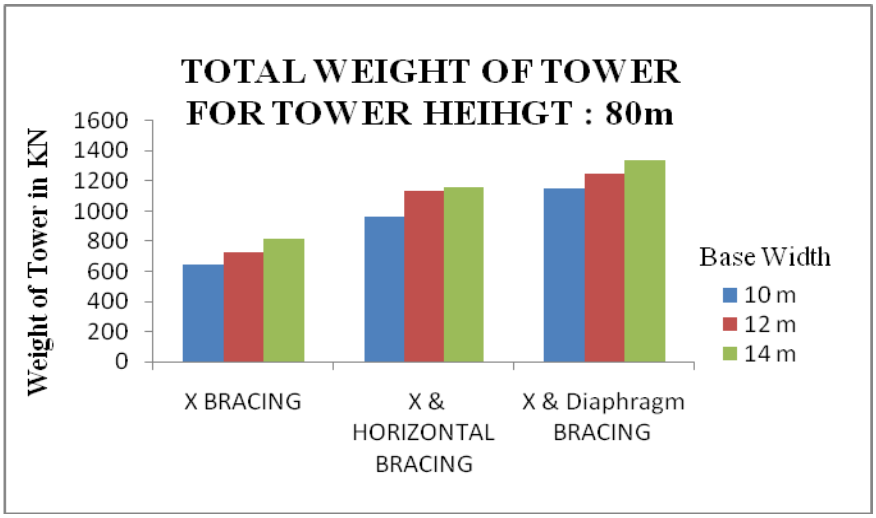


Fig. 13 Total Weight of Tower for tower height 80m

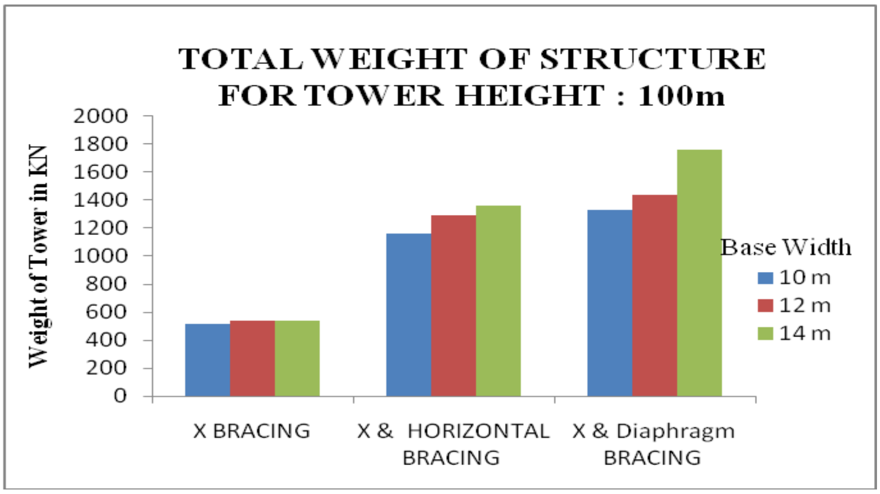


Fig. 14 Total Weight of Tower for tower height 80m

VI. CONCLUSIONS

Due to expanding communication system, a large number of lattice towers to support cellular antennas are extensively used. The main features in designing the tower is the height of tower as due to antennae mounted on top of tower for receiving and transmitting the signals. There are two main parameters, deflection of the tower and weight of the tower which are to be optimized for the economical condition. The various configurations are to be optimized for the economical condition. The various configurations are to be adopted and analyzed for different comparison of forces.

By studying the values of deflection and weight for different Bracing systems, the following points are observed :

- The tower behaves essentially as a cantilever structure fixed at the base (ground level).
- The deflection goes on reducing as the height of tapering portion increases. At the same time there is reduction in deflection as the base width increases.
- The axial forces and wind force values were observed to increase linearly with increase in height and base width of the tower.
- The first mode of natural frequency of tower evaluated in along wind direction. This is increase with respect to height and base width of tower.
- The stiffness of structure is increased because of their slanting legs which slant more with increase in base width making the tower more sensitive for vertical deflection compared to Horizontal deflection.
- The maximum force in the bracings and main legs are observed at location when the trapezoidal portion converts in to the straight portion.
- As the tapering portion increases, the weight of tower and total deflection at top also reduce, which further lead to the economical design of the tower.

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