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

Analysis of Tubular Telecommunication Tower

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Abstract* – 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. Etab2015 structural analysis software is used to analyze the tower under the effect of earthquake forces and wind forces in zone III. Seismic analysis done by Response Spectrum Analysis. The behaviour of tower was examined and compared on the basis of displacement and base shear.

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I. INTRODUCTION

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. The Indian telecom service business is the fastest growing one in the world, with over seven million mobile subscribers being added every month. This expanding base possesses challenges to mobile operators in terms of augmenting and upgrading infrastructure to maintain to quality of services. During the natural disasters such as the earthquakes telecommunication towers have the crucial task of instant transmission of information from the affected areas to the rescue centres. The general availability of a wide range of square, rectangular, and round structural tubing increased. The use of tubular joints greatly improved the aesthetic qualities of the truss, and the higher load carrying capacity of the structural capacity of the structural tube members provided a wide range of applications for a triangular cross section truss. Tubular sections are used for truss members, the range of different standard shapes and sizes produced is much less than wide flange shapes and availability of some standard shapes is still limited. Due to these important roles, towers should preserve their immediate occupancy level when strong ground motion happen. Fastest growing telecommunication market has increased the demand of steel towers. The major loads considered for design of these towers are self-weight, wind load, seismic load, antenna load, platform load, steel ladder load etc. Failure of towers is generally due to high intensity winds. Several studies have been carried out by considering wind and earthquake loads. 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. The tubular sections are more efficient sections which are adoptable to many different situations. The tubular section cannot be surprised in its efficiency by other sections.

Fig 1 Telecommunication Towers

TUBE STRUCTURE

The tubular sections are used as structural component since along. A large no of tubular structures have been constructed in the past. The tubular section are effectively used in large space frame, lattice structures for antennas, stadium exhibition hall, where appearance as well as weight become an important design consideration. The mast and transmission towers are other examples where tubular section are utilized effectively. In the past, the use of tube was hampered because of connection details.

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Bracing System

When a tall structure is subjected to lateral or torsional deflections under the action of fluctuating wind loads, the resulting oscillatory movement can induce a wide range of responses in the structure's occupants from mild discomfort to acute nausea. As far as the ultimate limit state is concerned, lateral deflections must be limited to prevent second order p-delta effect due to gravity loading being of such a magnitude which may be sufficient to precipitate collapse. To satisfy strength and serviceability limit stares, lateral stiffness is a major consideration in the design of tall buildings. The simple parameter that is used to estimate the lateral stiffness of a structure is the drift index defined as the ratio of the maximum deflections at the top of the structure to the total height. Different structural forms of tall structures can be used to improve the lateral stiffness and to reduce the drift index. In this research the study is conducted for braced frame structures. Bracing is a highly efficient and economical method to laterally stiffen the frame structures against wind loads. A braced bent consists of usual columns and girders whose primary purpose is to support the gravity loading, and diagonal bracing members that are connected so that total set of members forms a vertical cantilever truss to resist the horizontal forces. Bracing is efficient because the diagonals work in axial stress and therefore call for minimum member sizes in providing the stiffness and strength against horizontal shear.

BEHAVIOUR

Because lateral loading on a structure is Reversible, braces will be subjected in turn to both tension and compression, consequently, they are usually designed For the more stringent case of compression. For this Reason, bracing systems with shorter braces, for example K bracing, may be preferred to the full diagonal types. As An exception to designing braces for compression, the Braces in the double diagonal is designed to carry in Tension the full shear in panel. A significant advantage of The fully triangulated bracing types is that the girders Moments and shears are independent of the lateral loading on the structure.

II. LITERATURE REVIEW

Following are some theories and researches carried out till now :-

1. **Keshav Kr. Sharma, S.K.Duggal, Deepa Kumar Singh And A.K.Sachan (2015)[6] :** Over the past 30 years, the growing demand for wireless and broadcast communication has spurred a dramatic increase in communication tower construction and maintenance. Failure of such structures is a major concern. In this paper a comparative analysis is being 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 is used for wind load analysis, modal analysis and response spectrum analysis are 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.

2. **Siddesha.H (2010)[2]:** Open latticed steel towers are used widely in a variety of civil engineering applications. The angle sections are commonly used in microwave antenna towers. This paper presents, the analysis of microwave antenna tower with Static and Gust Factor Method (GFM). The comparison is made between the tower with angle and square hollow section. The displacement at the top of the tower is considered as the main parameter. The analysis is also done for different configuration by removing one member as present in the regular tower at lower panels.

3. **Ismail (2014)[3]** : Telecommunication structures are essential components of communication and post-disaster networks that must remain operational after a designlevel of earthquake. This study provides dynamic field measurements of 138 m guyed tower located at Qussia city, Upper Egypt. In situ measurements of ambient tower vibrations are used to determine the dominant natural frequencies of the tower. The measurements were made using a LMS SCADAS system and four wireless vibration sensors for recording the ambient vibrations of the mast. The tension in the guy wires was measured by mechanical equipment. The dynamic properties of the guyed mast (natural frequencies and mode shapes) were extracted from these measurements. Results of the eigenvalue analysis of numerical models of the tower were compared with the natural frequencies and mode shapes extracted from the in situ measurements.

The field measurements were used to update the finite element model. The nonlinear static analysis based on the updated finite element model was carried out. Seismic assessment and comparison between the original and updated models taking into account the deterioration in elements are presented.

III. METHODOLOGY.

Modelling and Loading Details:

A. Structural data

Ht of tower	58m	66m	74m
Base width	4.1m	4.6m	4.8m
Top width	1m	1m	1.2m

B. Seismic data (As per IS: 1893-2002)

1) Zone factor: 0.16 (Zone III)

2) Response reduction factor: 4

3) Important factor: 1

4) Type of Soil: II, (Medium Soil)

C. Wind data (As per IS:875-1987)

1) Wind speed: 39 m/s

2) Terrain category: 4

3) Structure class: c

4) Risk Coefficient k: 1

5) Topography factor k3: 1

D. Loading data

LIVE LOAD: 1 KN/m (Only one side of tower)

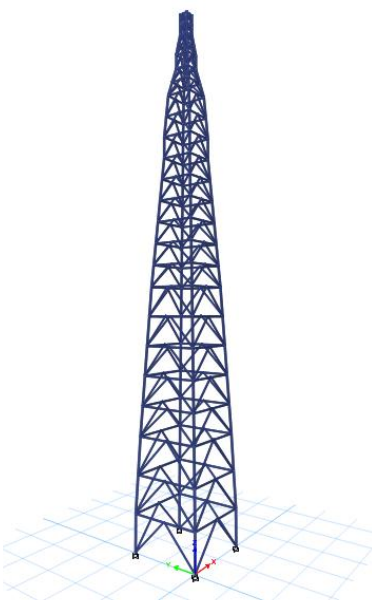
ANTEENA LOAD:

Items	CDMA	CDMA	GSM	GSM
Quantity	2	2	2	2
Size	0.26X2.5	0.26X2.5	0.3X2.6	0.3X2.6
Weight (kg)	20	20	25	25
Total Load (KN/m^2)	0.615	0.615	0.641	0.641

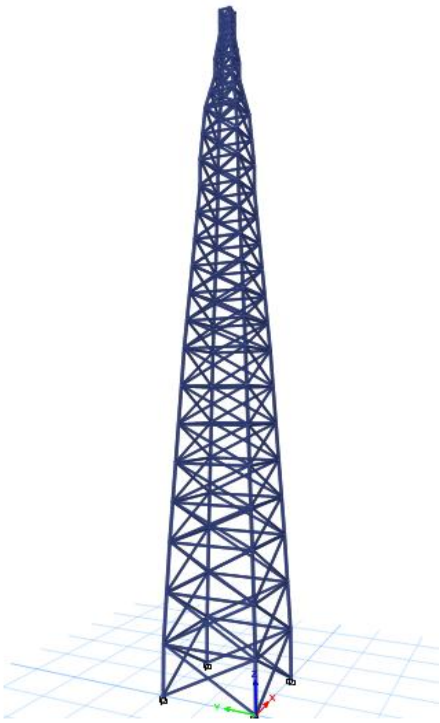
Table 1

Static equivalent loads EQX & EQY are applied in ETABS. Also Response spectrum cases SPEC X & SPEC Y are applied in ETABS

E. Modeling of Tower structure



Tower with Inverted V Bracing



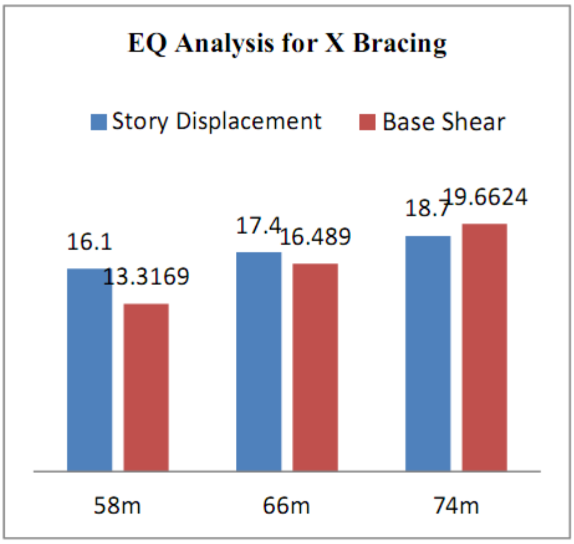
Tower with X Bracing

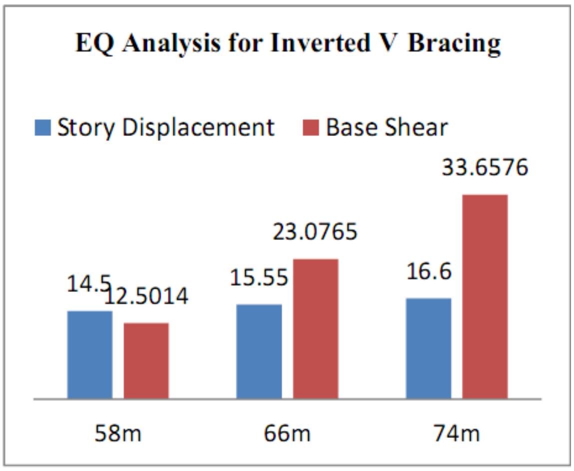
ANALYSIS RESULTS

- **Earthquake Analysis for Tubular Telecommunication Tower**

EQ analysis for X Bracing			
Tower Ht.	**58m**	**66m**	**74m**
Story Displacement	16.1	17.4	18.7
Base Shear	13.3169	16.489	19.6624

EQ analysis for k Bracing			
Tower Ht.	**58m**	**66m**	**74m**
Story Displacement	14.5	15.55	16.6
Base Shear	12.5014	23.0765	33.6576

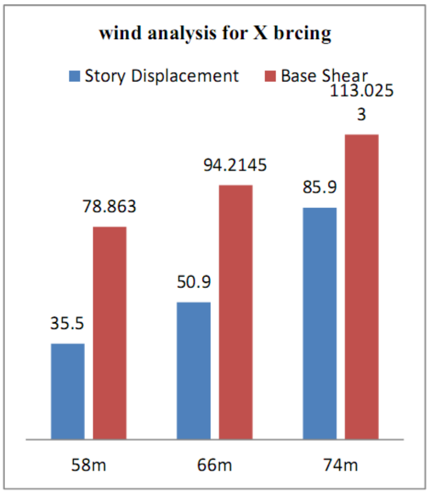




- **Wind Analysis for Tubular Telecommunication Tower**

wind analysis for X bracing			
Tower Ht.	**58m**	**66m**	**74m**
Story Displacement	35.5	50.9	85.9
Base Shear	78.863	94.2145	113.0253

wind analysis for X bracing			
Tower Ht.	**58m**	**66m**	**74m**
Story Displacement	30.9	42.7	66.6
Base Shear	67.7916	79.7234	93.5808



Comparison between story displacement & base shear for inverted V bracing

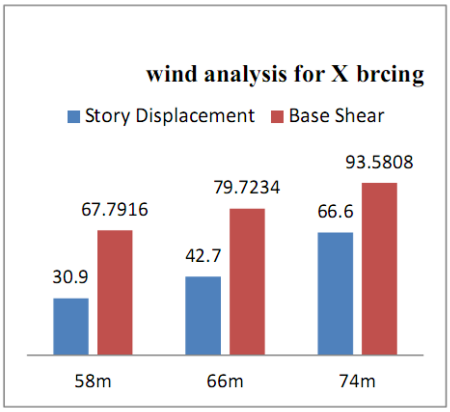


Fig 5 Comparison between story displacement & base shear for X bracing

IV. CONCLUSION

1. The lateral displacement goes on increasing as the height of tower increases.
2. The base shear goes on increasing as the height of tower increases.
3. The inverted V bracing has less displacement as compare to X bracing.
4. Inverted V bracing is efficient than X Bracing under the seismic loading.
5. The lateral displacement goes on increasing as the height of tower increases.
6. The base shear goes on increasing as the height of tower increases.
7. The inverted V bracing has less displacement as compare to X bracing.
8. Inverted V bracing is efficient than X Bracing under the wind loading.

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