Analysis of Rooftop Telecommunication Tower with Base Isolation

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Abstract— The increasing trend of mobile communications has seen exponential growth in the last three years. The communication industries have seen a tremendous increase in last few years which have resulted in installation of large number of towers to increase the coverage area and network consistency. The availability of land which satisfies ideal installation conditions in urban areas is extremely limited giving no alternative but to adopt roof tops. In this present study, the seismic analysis of 4 legged self-supporting rooftop telecommunication towers has been studied under the effect of wind analysis as per IS 875 (part 3): 1987 along with seismic forces under Indian seismic code of practice. In this dissertation, the forces developed due to wind as well as dynamic analyses are considered and the base isolation is to be provided to the structure to overcome them. In the following study stresses in rooftop tower foundation, stresses in host structure, axial forces in tower are the main parameters considered for the study.

Key words: 4 Legged Rooftop Telecommunication Tower, Wind Analysis, Seismic Analysis, Base Isolation, Etabsv13

I. INTRODUCTION

Telecommunication towers are tall structure usually designed for supporting parabolic antennas which are normally used for microwave transmission for communication, also used for sending radio, television signals to remote places and they are installed at a specific height. These towers are self-supporting structures and categorized as three-legged and four-legged space trussed structures. The self-supporting towers are normally square or triangular in plan and are supported on ground or on buildings. Triangular towers attract lesser wind loads compared with square towers.

However they are used only for smaller heights of tower due to difficulties in joint detailing and fabrication using angle sections. Telecommunication towers or lattice towers are classified into three categories that are Guyed masts, monopole and self-supporting towers. Generally, they act as cantilever trusses and are designed to carry wind load as the only source of environmental loads. Except for critical structures built in high seismic hazard areas, earthquake-induced loads are generally neglected in design. The major cause of failures of telecommunication tower throughout the world though still remains to be high intensity winds (HIW). The major problem faced is the difficulty in estimating wind loads as they are based on a probabilistic approach. There have been several studies in telecommunication towers taking into consideration the wind as well as seismic effect. These towers even though demand more steel but cover less base area, due to which they are suitable in many situations. The availability of land which satisfies ideal installation conditions in urban areas is extremely limited giving no alternative but to adopt roof top towers with marginal adjustment in position but not in height. This practice is mainly due to the fact that telecommunication towers built on ground have shown good performance in past earthquakes. However, towers mounted on rooftops respond to lateral motions differently than those built on firm ground.

II. LITERATURE REVIEW

The various literatures have been referred from journals, preceding, books etc. to understand present status of project undertaken. From this literature data is summarized for work. These are explained in following ways.

Nitin Bhosale et al. [1], (2012) have carried out the seismic response of 4 legged telecommunication towers under the effect of design spectrum from the Indian code of practice for zone – IV. The axial forces of the tower member is considered, comparison is made between roof top tower and ground tower.

Richa Bhatt et al. [2], (2013) have carried out study on the influence of modelling in lattice mobile towers under wind loading where in the towers are analyzed for gust factor wind. Displacements, Member forces and maximum stress have been compared to find out the effect on towers.

McClure G. et al. [3], (2004) presented the seismic response of two self-supporting telecommunication lattice towers of height 30m and 40m, mounted on the rooftop of two medium-rise buildings: Burniside Hall, which is located on McGill Campus, and 2020 University, which is located nearby in downtown Montreal. The time history analyses were used to explore the correlation between the building accelerations and maximum seismic base shear as well as the base overturning moment of towers mounted on building rooftops.

Siddesha H. [4], (2010) presented the wind 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.

Amiri et al. [5], (2002) carried out the dynamic analysis of 10 existing self-supporting telecommunication towers varying height from 18 to 67m scaled using spectra of Tabas, Naghan and Manjil earthquake with respect to Iranian 2800 seismic code, which are among major earthquakes in Iran and comparison was made between the results of wind and seismic loading. It was observed that the values obtained from wind load exceed from earthquake load.

Jithesh Rajasekharan et al. [6], (2014) In this dissertation, studies are been carried out on models of varying heights with different bracing for seismic along with the wind effect. The wind effect on the structure is studied by using the gust factor method and the seismic effect on the structure is studied by carrying out the modal analysis and response spectrum analysis. The results obtained from the above analysis are tabulated, compared and Hemal J shah et al. [7], (2014) In the present study earthquake response of 4 towers

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of different height are studied considering different bracing system of the tower. The towers of different height are modeled in SAP 2000 software and static and dynamic analysis of the tower has been carried out. In addition to this time history of the bhuj earthquake is applied on all towers and the response of the tower is studied.

Konno et al. [8], (1973) presented the effects of earthquake loads on lattice telecommunication towers atop buildings and obtained the mode shapes, the natural frequencies, and the damping properties of such structures. Simulation of a stick model of the tower using lumped masses and a viscous damping ratio of 1% was used in their studies and observed that in some of the members, the forces due to earthquake were greater than those due to wind.

Pozo et al., [9], (2006) studied the active-passive base-isolation systems used for the seismic response control of structures appears to be effective for small to medium strength earthquakes. Hybrid base isolation systems, which use an active system together with the passive base isolation system, may be used to control the response of structures subjected to larger ground motions created by larger magnitude earthquakes. The hybrid base isolation system using passive base isolation pads together with hydraulic type actuators is proposed. The system, placed between the foundation of the building and its superstructure, is used to minimize the forces imposed on the superstructure by the earthquake induced ground motion.

Iskhakov et al. [10], (2007) In some cases the displacements at the base isolation level are rather big and exceed the allowed limits. In such cases it is recommended to add dampers to the base isolation system.

Matsagar et al. [11], (2008) Analytical seismic responses of structures retrofitted using base isolation devices are investigated by Matsagar and Jangid for the retrofitting of various important structures as historical buildings, bridges, and liquid storage tanks are selected to investigate the effectiveness of the base isolation in seismic retrofitting. It is observed that the seismic response of the retrofitted structures reduces significantly in comparison with the conventional structures depicting effectiveness of the retrofitting done through the base isolation technique.

Chia-Ming et al. [12], (2010) Chia-Ming and Spencer presented development and experimental verification of an active base isolation system for a seismically excited building and modeling the complex nature of control-structure interaction (CSI).

Jung et al [13], (2011) have investigated a smart base-isolation system using magneto-rheological (MR) elastomers, which are a new class of smart materials whose elastic modulus or stiffness can be adjusted depending on the magnitude of the applied magnetic field. The results further suggest that the feasibility of using MR elastomers as variable stiffness elements for enhancing the performance of conventional base-isolation systems.

Zhang et al. [14], (2011) have studied the influence of the action of coupling earthquake to sliding base-isolation structure for 6 story building. The results by exemplification show that the peak values of relative acceleration, relative displacement and inter-storey shear force of sliding base-isolation structure increase in different degree under the action of coupling earthquake.

III. PROBLEM STATEMENT

Recently various studies have been done on design of Telecommunication Towers, but in most studies the researchers have considered the effect of wind and seismic forces on the four legged self-supporting towers. However, no researches have provided the measure to overcome the effects of lateral forces. In this study, the prevention of the structure with preventive measure in the form of Base Isolation is to be provided.

IV. METHODOLOGY OF WORK

1) Extensive literature survey by referring books, technical papers carried out to understand basic concept of topic.
2) Identification of need of research.
3) Formulation of stages in analytical work which is to be carried out.
4) Data collection.
5) Analytical work is to be carried out.
6) Interpretation of results & conclusion.

V. STRUCTURAL MODELING AND ANALYSIS

ETABS software is used for the response of (G+10+30m Tower) building for wind and seismic analysis is done. Results from equivalent static analysis is observed for storey drift, storey displacement and base shear. Related factor taken are seismic zone factor 0.24, Response reduction factor 5.

A. Structural properties of RC Building

- Total depth of slab : 115 mm
- External wall thickness : 150 mm including plaster
- Internal wall thickness : 150 mm including plaster
- Size of column : 230x450mm
- Size of beam in longitudinal : 230x750 mm

B. And transverse direction

- Zone factor (Z) : 0.24
- Importance factor (I) : 1
- Response reduction factor (R) : 5
- Wind speed (Vb) :47m/s
- Risk coefficient (k_1) :1.07
- Topography factor (k_3) : 1.00

Terrain category 4 considered.

C. Structural properties of Steel Structure

- Section for column: 2ISA150mmx150mmx10mm (Back to Back)
- Section for beam: ISA90mmx90mmx8mm
- Section for braces: ISA 90mmx90mmx8mm

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D. 3D view of RCC building with Rooftop Telecommunication Tower

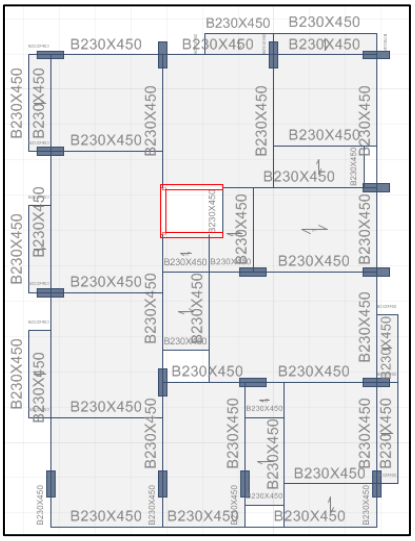

Fig. 1: Plan view of RCC Building with Rooftop Telecommunication Tower

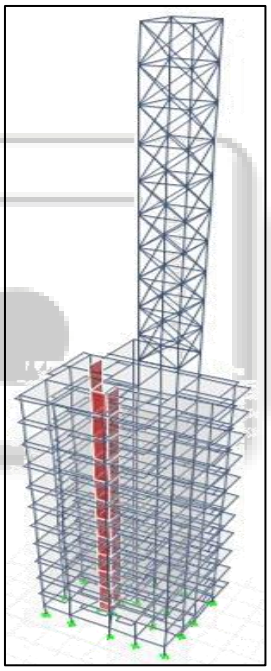

Fig. 2: 3D view of RCC Building with Rooftop Telecommunication Tower

VI. RESULT

A. Storey Displacement

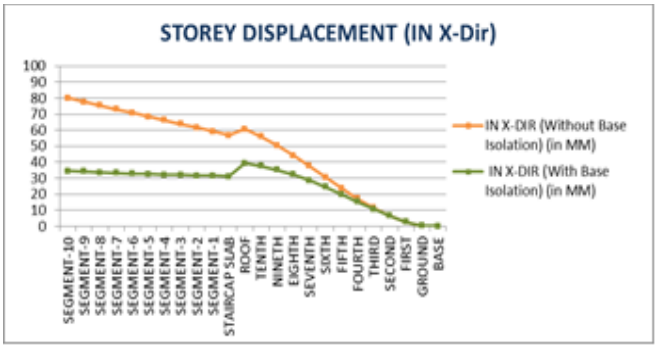

Fig. 3: Comparative storey displacement in X-direction (X - bracing)

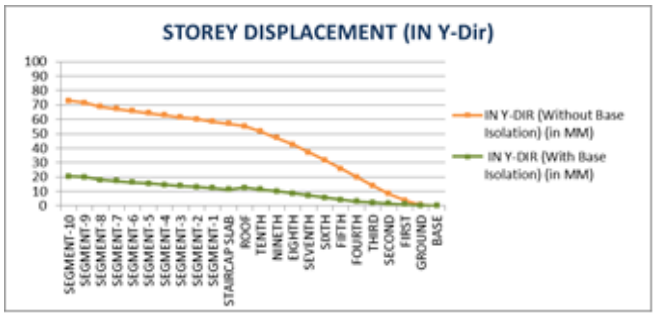

Fig. 4: Comparative storey displacement in Y-direction (X - bracing)

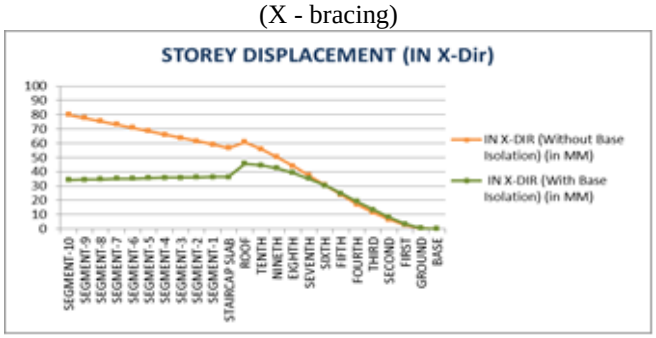

Fig. 5: Comparative storey displacement in X-direction (XB - bracing)

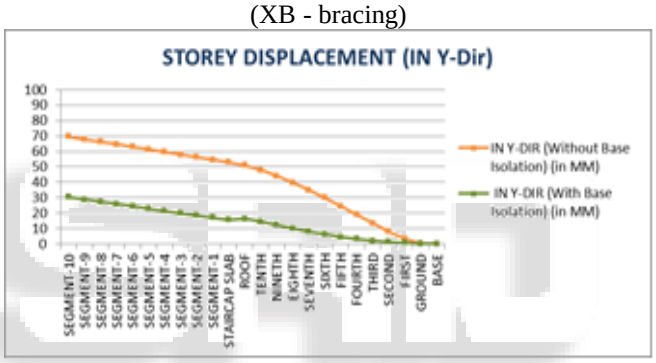

Fig. 6: Comparative storey displacement in Y-direction (XB - bracing)

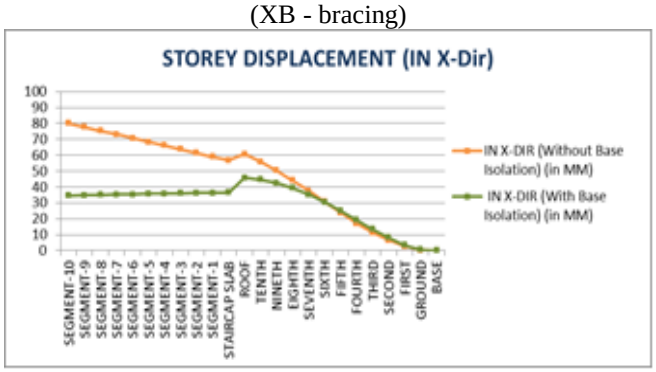

Fig. 7: Comparative storey displacement in X-direction (K - bracing)

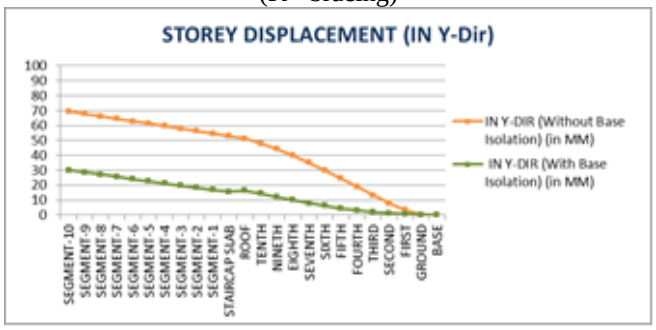

Fig. 8: Comparative storey displacement in Y-direction (K - bracing)

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B. Storey Drift

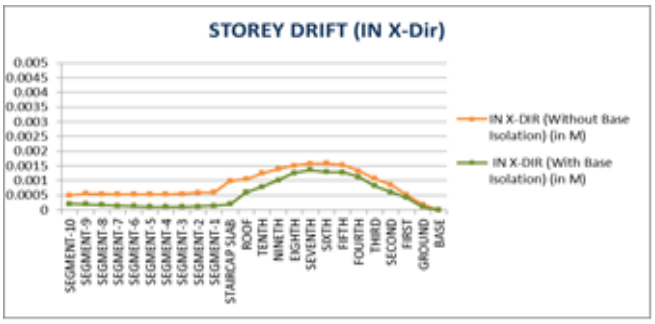

Fig. 9: Comparative storey drift in X-direction (X - bracing)

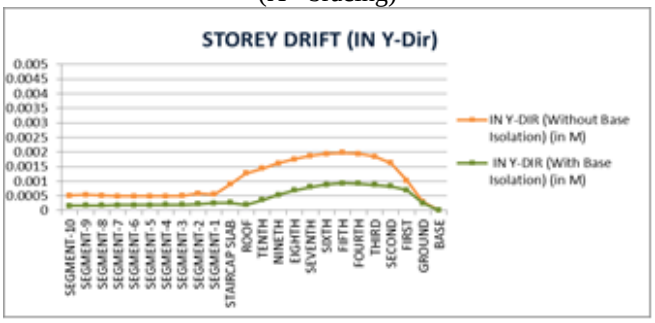

Fig. 10: Comparative storey drift in Y-direction (X - bracing)

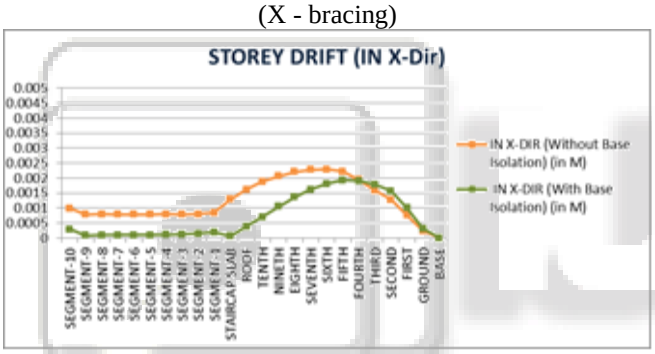

Fig. 11: Comparative storey drift in X-direction (XB - bracing)

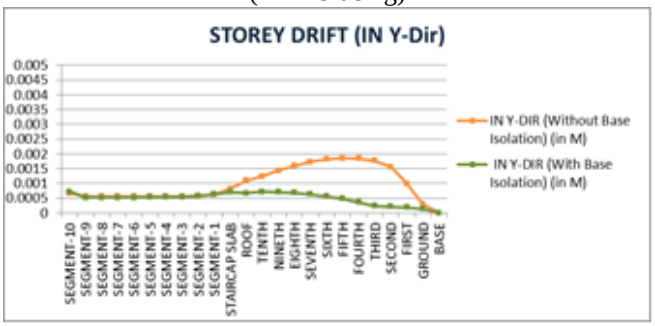

Fig. 12: Comparative storey drift in Y-direction (XB - bracing)

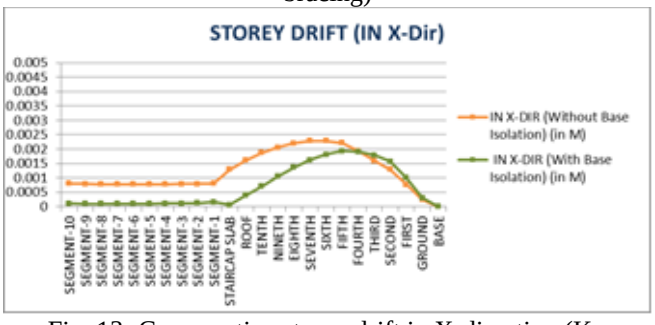

Fig. 13: Comparative storey drift in X-direction (K - bracing)

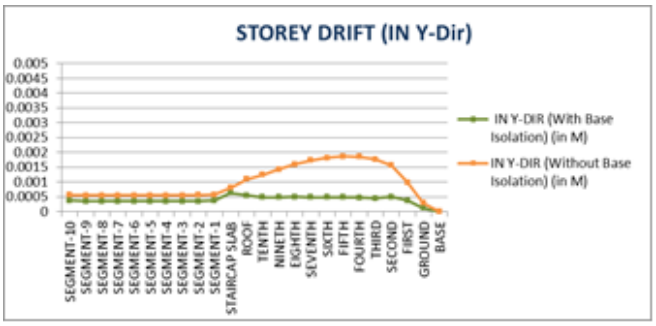

Fig. 14: Comparative storey drift in Y-direction (K - bracing)

C. Axial force

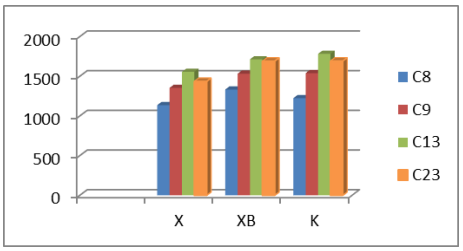

Fig. 15: Axial force (X. XB & K- bracing)

D. Base Shear

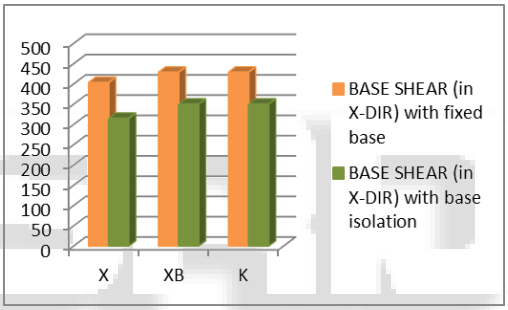

Fig. 16: Base Shear (X - direction)

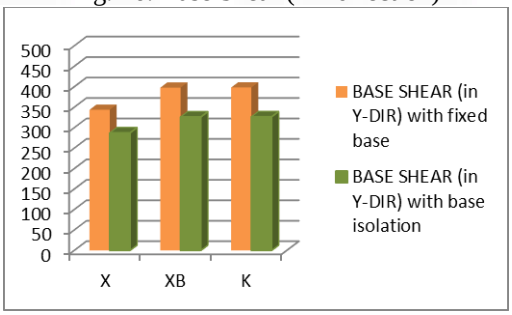

Fig. 17: Base Shear (Y - direction)

VII. CONCLUSION

Lot of research has carried on the effect of wind and seismic analysis of telecommunication towers. No study has provided the measure to counteract the effects of lateral forces. In this study, various parameters such as story drift, story displacement, axial forces and base shear are found out for structures with fixed base and structures with base isolation at the bottom of telecommunication tower. The base isolation is provided in terms of Lead rubber bearing. The parameters are calculated and provided at base of the tower.

Due to addition of base isolation the story displacement in X-direction of X, XB & K bracing reduced by 29.71%, 32.43% & 32.35% respectively & in Y-direction of X, XB & K bracing reduced by 72.05%, 56.32% & 56.75%

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respectively. Due to addition of base isolation the story drift in X-direction of X, XB & K bracing reduced by 14.09%, 15.58% & 15.46% respectively & in Y-direction of X, XB & K bracing reduced by 52.79%, 61.82% & 65.79% respectively. Due to addition of base isolation the base shear in X-direction of X, XB & K bracing reduced by 21.91%, 18.32% & 18.33% respectively & in Y-direction of X, XB & K bracing reduced by 16.42%, 17.99% & 18.02% respectively.

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