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INFLUENCE OF TELECOMMUNICATION TOWER ON RESPONSE OF HOST STRUCTURE

Vikaskumar Pandey, N.G.Gore, P.J.Salunke, V.G.Sayagavi
MGM's College of Engineering & Technology, Mumbai, Maharashtra
vikaspandey021@gmail.com

Abstract

In the contemporary era, 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. As telecommunication tower are the only means of enhancing both the coverage area and network reliability more and more telecommunications tower are installed nowadays. The direction and height of tower along with the antennas mounted on it is completely governed by the functional requirements of network. The most ideal place for tower is on ground but in urban areas the availability of land which would be most ideal is extremely limited giving no alternative but to adopt rooftop tower with marginal adjustment in terms of position.

In this present study, the seismic analysis of 4 legged angled section rooftop telecommunication tower has been studied under the effect of design spectrum from Indian seismic code of practice for zone-iii along with wind analysis as per IS 875 (part 3) 1987. The analysis has been performed on tower located on roof of host structure by varying the positions of tower in Etabs software. The stresses in beam grid of rooftop tower foundation, stresses in host structure, retrofitting in host structure, axial forces in tower are the main parameters considered for the study. The host structure also analyzed with flexible base, to see the effect of flexibility of soil on host structure and tower response.

1. 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.

Generally, the design of self-supporting towers takes into account the effect of 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. This practice is mainly due to the fact that lattice towers built on ground have shown good performance in past earthquakes. However, towers mounted on rooftops respond to seismic motions differently than those built on firm ground. It can be time consuming to perform a detailed dynamic analysis as part of a regular design project and such an analysis is not always necessary. Thus, simplified design checks need to be developed. The antenna towers are usually analyzed assuming the members to be concentrically connected using hinged joints so that the forces in the angle members are only axial. Under this assumption, the forces in the redundant are negligibly small or zero and hence are not included in the linear analysis models. However, the main legs and the bracing members are not axially loaded and the redundant forces are not negligibly small.

Siddesha H. (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. McClure G, Georgi L. and Assi R. (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. Reginald Nakamoto and Arthur Chiu (1985) Investigated Wind Effects on Tall Guyed Tower. In this investigation full-scale wind velocity and structural response data from a tall guyed tower have been analyzed to obtain information concerning wind characteristics and dynamic response for this analyzing and data collection Anemometers and accelerometers were installed at five stations along the height of the tower, and orthogonal components of wind velocities and tower accelerations were recorded. Amiri, Boostan and Massah S.R. (2007) studied the seismic sensitivity of 4-legged telecommunication towers based on modal superposition analysis. For this purpose, he was selected ten of the existing 4-legged self-supporting telecommunication towers in Iran and was studied under the effects of wind and earthquake loading. To consider the wind effects on the prototype, the provisions of the TIA/EIA code were employed and the wind was treated as a static load throughout the analysis. In addition, to consider the earthquake effects on the models, the standard design spectrum based on the Iranian seismic code of practice and the normalized spectra of manjil, tabas and naghan earthquakes have been applied. It was observed that in the case of towers with rectangular cross section, the effect of simultaneous earthquake loading in two orthogonal directions and number of empirical relations were presented that can help designers to approximate the dynamic response of towers under seismic loading.

2. MODELLING OF ROOFTOP TOWER AND HOST STRUCTURE

2.1. Modeling of Host Structure

The members of the building were modeled as space frame (3D) having six degrees of freedom at each node with rigid diaphragm action. The preliminary data required for analysis of building given in table 1

Table 1: Building description (Preliminary data)

Type of structural system	Concrete moment resisting frame
Number of storey's	Three storey
Infill wall	External:150mm thick, Internal 100mm thick
Slab thickness	150mm
Beam size	300 X 350mm
Column size	230 x 350mm, 230 x 400mm, 230 x 450mm, 450 x 250mm
Floor height	3m

Material Properties:

Concrete:

M30 grade, compressive strength of concrete, fck =30N/mm2

Modulus of Elasticity of concrete, Ec =5000√fck =27386.12 N/mm2

Steel:

Fe500 grade, yield stress, fy=500N/mm2

2.2. Combined Tower-Building Modeling

For this study a self-supporting 4-legged angle sections steel lattice telecommunication tower mounted on rooftop of existing building are considered. The combined modelling of building and tower has been adopted for rooftop tower considering various selected positions of tower at the top of roof as shown in figure 1. The angle section tower has been idealized as space frame and was modeled using frame element in Etabs software. The descriptions of tower are listed in table 2. The connections for tower are assumed to be rigid. The structure idealization and member section details of 30m angle section rooftop tower are shown in figure 2. The mass of main leg and their tributary members which are bracing spanning between the legs without any intermediate joints are lumped at the corresponding leg joints. All the secondary or redundant members used for stability purposes are removed from the stiffness model since they do not carry any load in linear analysis. However their mass is calculated and lumped at corresponding leg joints.

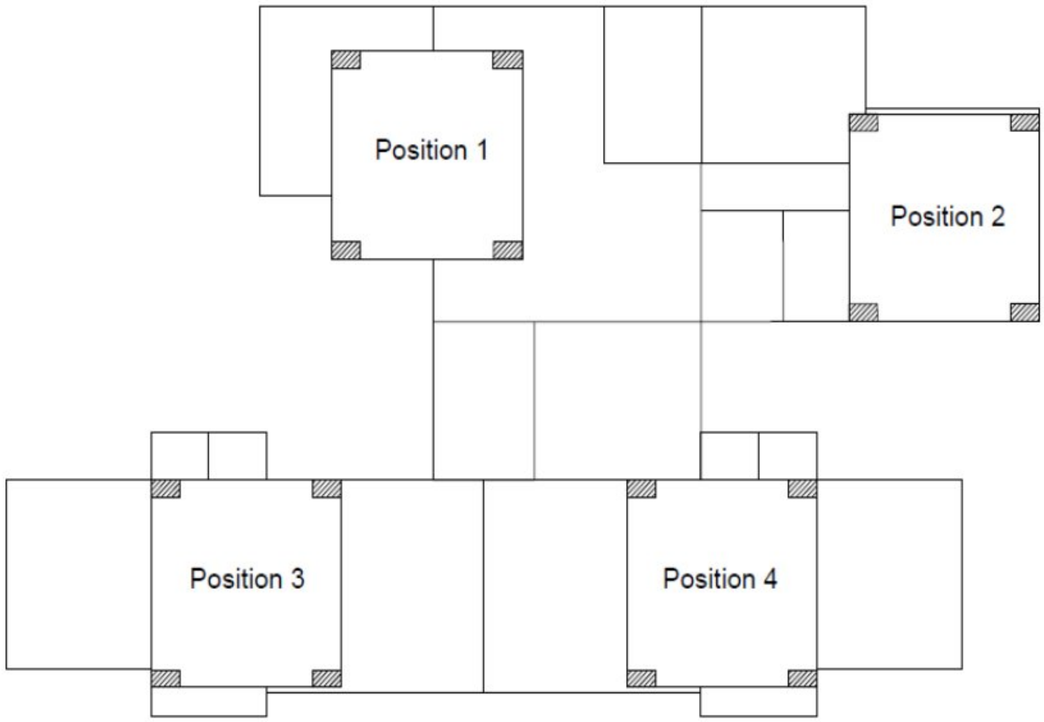

Figure 1: Various selected position of rooftop tower mounted on three storey building

Table 2: details of 30m rooftop tower

Height of tower	30m
Effective base width	4m
Effective top width	0.75m
No. of 3m high panels	7nos
No. of 4m high panels	1nos
No. of 5m high panels	1nos

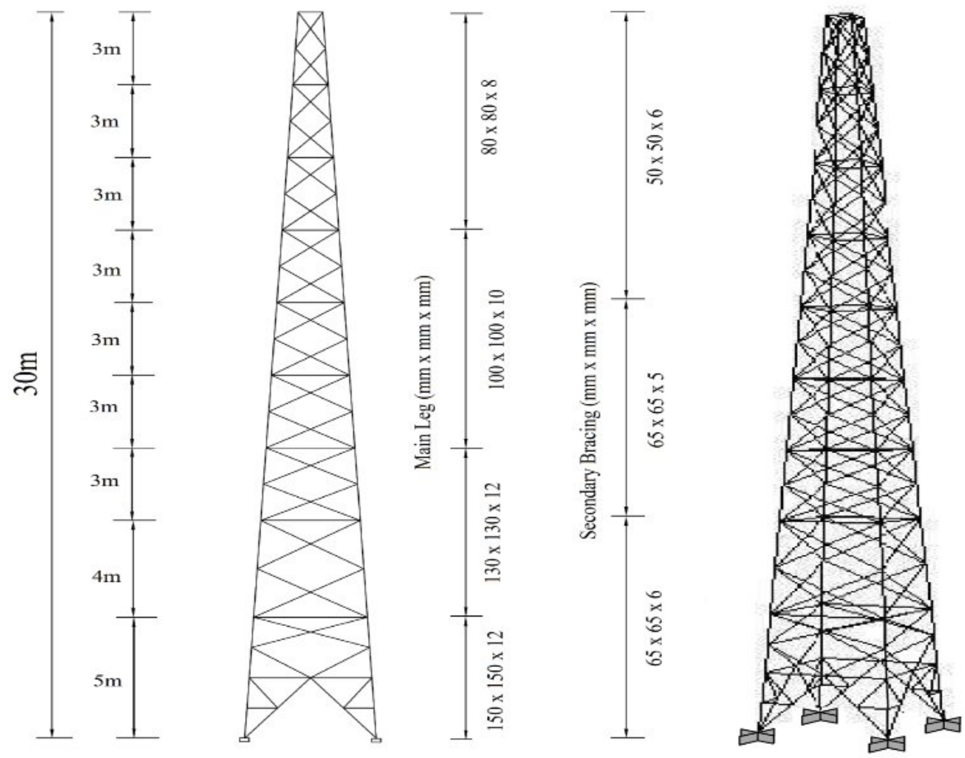

Figure 2: structure idealization and member section details of 30m antenna tower

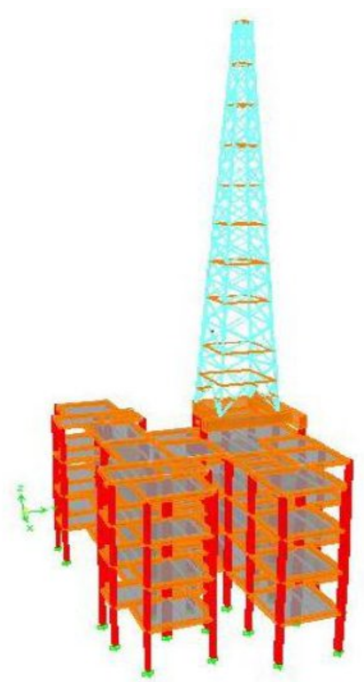

Figure 3: Typical model of rooftop tower mounted on existing three storey building

3. LOADING DETAILS OF TOWER

Gravity load acting on both the towers composed of its own weight and weight of antennas along with other appurtenances attached to it. The loading details of antennas on tower are given in table 3.3. The weight of platform at top is assumed to be0.82 KN/m2 *(Dayaratnam, 2008).* Normally weight of the ladder and cage assembly is 10% of the total weight of the tower

Table 3: Antenna loading for 30m angle sections rooftop tower

Items	Nos.	Dia (W x D x H) (m)	Weight of antenna (Kg)	Location of antenna from base of tower
CDMA	6	0.26 x 2.5	20	27
Microwave	1	1.2	77	30
Microwave	1	0.6	45	30
Microwave	2	0.3	25	30

4. DYNAMIC ANALYSIS

The dynamic analysis (Response spectrum analysis) has been carried out on rooftop towers using Codal response spectra given by Seismic code (IS 1893: part 1, 2002) shown in figure 4. The analysis has been performed by assuming fixed base at the base of the building on rock site (hard soil)

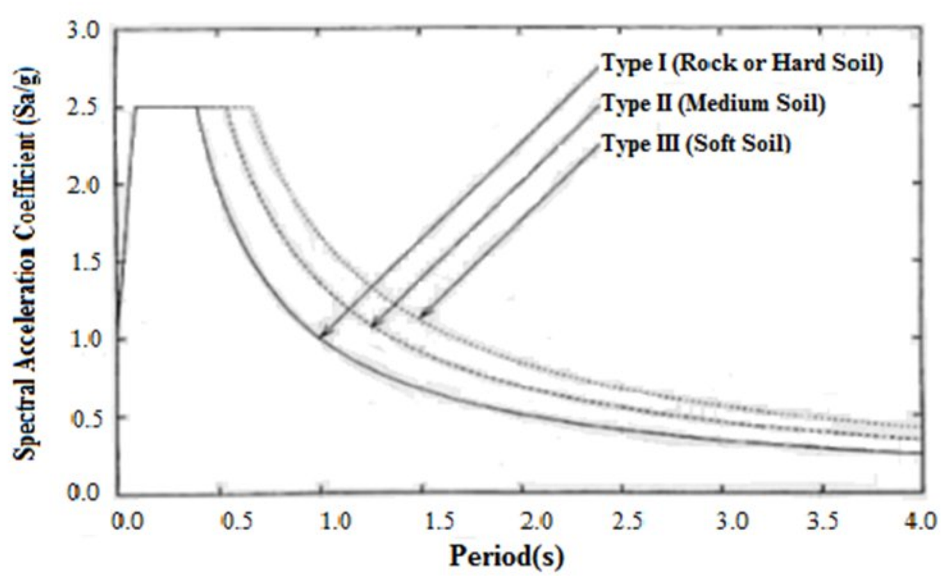

Figure 4: Codal (IS 1893: 2002) response spectra for hard soil (Type-1)

The structure analyzed for earthquake loading using response spectrum as per IS 1893:2002 in zone 3 with PGA 0.24g, importance factor (I) = 1 (importance factor depending upon the functional use of the structure, characterized by post-earthquake functional needs and economic importance) and response reduction factor (R) = 3 (depending upon the perceived seismic damage performance of the structure characterized by ductile or brittle deformations*)*. In case of rooftop tower case the input acceleration for analysis should be at roof of the structure (building) on which it is supported, so floor spectra of building is required but due to combined modelling of building and tower, the design spectrum have been used in the analysis for whole structure.

5. SUMMARY AND CONCLUSIONS

5.1. Summary

In order to study the influence of rooftop tower on the host structure and influence of host structure on the tower, wind analysis and dynamic seismic analysis were carried out on all structures. For this purpose, three angle sections towers having similar height and similar configuration were selected and simultaneously kept on the selected positions on the roof of the host structure. The stresses in beam grid of rooftop tower foundation, stresses in host structure, retrofitting in host structure, axial forces in tower are the main parameters considered for the study. The host structure also analyzed with flexible base, to see the flexibility of soil effect on host structure and tower response.

5.2. Conclusions

Based on the work carried out, following conclusions are drawn,

I. As existing building is torsionally irregular, the tower placed on the rigid side of host structure shows better performance compared to tower placed on the flexible side.

II. The consideration of flexibility soil effect on host structure, the axial forces in tower decreased by 17% (maximum) w.r.t. fixed base structure.

III. The stresses in member of host structure increased 35% (max) by considering the effect of tower on roof of host structure.

IV. Due to consideration of flexibility of soil resulting an increasing fundamental time period of structure and decreasing forces, stresses in member of host structure.

V. Due to the load of tower on host structure retrofitting measures become necessary in some host structure elements and general method like jacketing may be adopted.

VI. The tower position 2 is the most feasible as the stress in building is less as compared to other position of tower and this may be mainly because the tower position 2 is on the rigid side of building.

5.3. Future scope of work

The IS: 875 (Part 3) – 1987 has not developed wind dynamic analysis for any structure so; the wind dynamic analysis can be performed on this structure. In this study response spectrum analysis is performed for consideration of dynamic effect for earthquake load, so linear time history analysis can be performed on this structure. Also the SSI can be performed for three types of soil on these structures. As the stresses in host structure increases other retrofitting methods can also be studied for these structures.

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