Review on Wind and Non-Linear Dynamic Analysis of Self-Supporting Telecommunication Tower

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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. So 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. Lot of literature is available which proposes different formulas to determine seismic parameters. Also previously, designers considered safety of towers only against overturning. During the seismic event some members of towers reach its ultimate strength causing failure. However, performance of the different configurations of telecommunication tower against earthquake is not much discussed in the literatures. So there is need of in-depth study of behaviour of telecommunication tower for different configurations and its analysis for earthquake effect. 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.

Keywords: Telecommunication Tower, Wind Analysis, Bracings, Non-Linear Dynamic Analysis

I. INTRODUCTION

In this age of communication and networking telecommunication towers plays important role in human society. At times of occurrence of natural disasters, telecommunication towers have the crucial task of instant transmission of information from the affected areas to the rescue centers. In addition, performance of infrastructure such as dams, electric, gas, and fuel transmission stations, depends extensively on the information being transmitted via these telecommunication towers. Military and defence industries in addition to television, radio, and telecommunication industries are other areas of application for such towers and thus create the necessity for further research on telecommunication towers.

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. They act as cantilever trusses and are designed to carry wind and seismic loads. These towers even though demand more steel but cover less base area, due to which they are suitable in many situations.

II. LITERATURE REVIEW

Khedr and McClure (1999), studied, earthquake amplification factors for the base shear and the total vertical reaction of self-supporting latticed telecommunication towers were suggested based on modal superposition analysis performed on 10 existing towers, each being subjected to a set of strong-motion accelerograms acting in the horizontal and the vertical directions separately. Results were calculated displayed for two towers of height 61m and 121m respectively. Simple regression analyses are performed on the results from which the base shear and vertical reaction amplification factors were found.

Venkateswarlu et al. (1993), performed a numerical study on the response of lattice microware towers subjected to random wind loadings. The dynamic response could be estimated by the use of a stochastic approach. A spectral analysis method for evaluating the along-wind response and the corresponding gust response factor were introduced. The gust response factor is defined as the ratio of the expected maximum wind load effect in a specified time period to the corresponding mean value in the same time period. A 4-legged 101-m self-supporting tower was considered in their study. The gust response factor along the tower height was calculated with and without the contributions of second and higher modes of vibration. The results showed a maximum of 2 % change in the gust factor when employing higher modes of vibration.

Ghyslaine McClure et al (2004), to study the seismic response of two different lattice towers mounted on the rooftop of two medium-rise buildings (Burnside Hall and 2020 University, located in Montreal, Canada). The aim was to find whether simple linear relations could represent the variation of the tower response as a function of the peak roof acceleration. In this study, time history analyses are used to explore the correlation between the building accelerations and the maximum seismic base shear as well as the base overturning moment of towers mounted on building rooftops. The models include two medium-rise buildings combined with two self-supporting lattice steel towers subjected to 45 horizontal accelerograms with varied frequency content. The tower base shear results are compared with the predictions based on a simplified formula proposed in building codes for secondary structures.

J.G.S. da Silva.et.al. (2005), presented paper on an alternative structural analysis modelling strategy for the steel tower design considering all the actual structural forces and moments combining three dimensional beam and truss finite elements. Comparisons of the two above-mentioned design methods with a third method based on the use of spatial beam finite elements to model the main structure and the bracing system on two actually built steel telecommunication towers (40 and 75 m high steel towers) have been described. Generally in all the cases studied the maximum stress values for the structural tower modelling based on the three investigated methodologies were significantly modified. The lateral displacement values were not significantly changed when the usual truss model, the beam model or the combined beam and truss model were considered.

Amiri and Massah (2007), studied the seismic sensitivity of 4-legged telecommunication towers is investigated based on modal superposition analysis. For this purpose ten existing 4- legged self-supporting telecommunication towers in Iran were studied under the effects of wind and earthquake loadings. 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. They observed that in the case of towers with rectangular cross section, the effect of simultaneous earthquake loading in two orthogonal directions is important. At the end, a number of empirical relations are presented that can help designers to approximate the dynamic response of towers under seismic loadings.

Siddesha. H et. Al. (2010), presented the analysis of microwave antenna tower with Static and Gust factor method and compared the towers with angle and square hollow sections. The displacement at the top of the tower was considered as the main parameter. The towers with different configuration have also been analyzed by removing one member present in the regular tower in lower panels. Square sections were found to be most effective for legs as compared to the angle sections. Square hollow sections used in bracing along with the leg members did not show any appreciable reduction of displacement. X-type and M-type bracings in square hollow sections for legs and bracings in the lower first panel of towers showed maximum reduction in displacement as compared to the regular towers with angle sections.

Jesumi.et al. (2013), modelled five steel lattice towers with different bracing configurations such as the X-B, single diagonal, X-X, K and Y bracings for a given range of height. The heights of the towers are 40m and 50m with a base width of 2m and 5m respectively. The tower of height 40m has 13 panels and the tower of height 50m has 16 panels. 70-72% of the height is provided for the tapered part and 28-30% of the height is provided for the straight part of the tower. The towers have been analyzed for wind loads with STAAD Pro.V8i. To compare the maximum joint displacement of each tower. Optimized design has been carried out to estimate and to compare the weight of each tower. From the results obtained, Y bracing has been found to be the most economical bracing system up to a height of 50m.

Richa Bhatt et al. (2013), have carried out study on the influence of modelling in lattice mobile towers under wind loading where in the towers are analysed for gust factor wind. Displacements, Member forces and maximum stress have been compared to find out the effect on towers. In this paper concluded that the wind analysis results showed that irrespective of the tower height modelling strategy does not significantly affect the displacement pattern, particularly maximum lateral displacement at the top of the tower. Truss model, in general, reflects the lower bound on stresses, irrespective of height, due to dominance of the axial stresses. The bending components normal to the plane of the element are of a lower order. The prototype as fabricated has members which are likely to be subjected to in-plane and out of plane moments. The frame idealization, hence, provides a better estimate of the design forces. Deviations, if any, are easily accounted for by the conventionally adopted factor of safety. The combined model involves more rigorous analysis, whereas the frame model is the safest to adopt due to highest stresses. As the tower height increases, the difference in the stresses among the different idealizations do change, but the generic trend remains the same.

Shad et al. (2014), studied seismic performances of ten existing 4-legged telecommunication towers with heights ranging from 18 to 67 meter installed in Iran. For this purpose, three different vertical distributions of lateral load had been utilized. Target displacement approach and design spectrum approach was considered to calculate the seismic performance of towers. It was exhibited that all towers had satisfied immediate occupancy level for both design base earthquake hazard level and maximum probable earthquake hazard level. Also, three equations was presented to estimate towers yield base shear and base shear that corresponds to immediate occupancy level for 4-legged self-supporting telecommunication towers.

Jithesh Rajasekharan et al. (2014), designed the lattice tower for three heights of 30m, 40m and 50m with different types of bracings to study the effect of wind load on 4- legged lattice tower for wind zone V and VI using gust factor method. They also studied the seismic effect on the tower structures by carrying out the modal analysis and response spectrum analysis for zone II to zone V and concluded that the member stresses in bottom leg of XX braced tower are higher as compared to other tower models. The frequency of the tower with Y bracing displayed the least natural frequency since its stiffness was found to be higher due to more weight of the structure as compared to other models. It was observed that from 30m to 40m tower height, the increase in displacement is nearly linear but as the height increases from 40m to 50m there is a steep increase in the displacement in all the zones.

Keshav Kr. Sharma et al (2015), In this paper a comparative analysis is being carried out for different three heights of towers i.e. 25m, 35m, 45m 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. In this paper concluded that the wind is the predominate factor in the tower modeling than the seismic forces but the seismic effect cannot be fully neglected as observed from the results and V-Bracing gives satisfactory result in wind analysis, modal analysis and response spectrum analysis for all considered wind and earthquake zones mentioned in IS code. The results of displacement at the top of the towers and stresses in the bottom leg of the towers are compared.

Hemal J shah & Dr. Atul K Desai (2014), In this paper a Television towers are constructed to transmit the television signals on the wider areas and this television towers are also used for the purpose of transmitting the radio as well as telecommunication signals. These towers must be properly designed so that they will not fail during the natural disasters such as earthquakes. In past researchers had studied the effect of different earthquakes on 3 legged tall telecommunication towers. In the present study earthquake response of 4 towers 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.

III. CONCLUSION

Most of the researchers have done wind and response spectrum analysis of model having different bracings as wells as different base plan like triangular, square in plan. Most of them used SAP software for modeling and analysis of telecommunication tower. But still there is a less study carried on time history analysis on telecommunication of tower. So now it is necessary to find out the dynamic behavior of telecommunication tower and compare the various results and parameters of the structure.

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