International Journal For Recent Developments in Science & Technology
2581-4575
Crossref
A Peer Reviewed Research Journal

ANALYSIS AND DESIGN OF COMMUNICATION TOWER USING ETABS

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Abstract :
Telecommunication towers are classified among the tallest man-made structures and can be discovered standing high on each Parts of the world of varying sizes and purposes. A tower is a tall steel structure used for a variety of purposes, including Communication towers, radio and power transmission, aviation authorities, etc. Supporting individuals are organized in numerous structures that transmit not only tension, but also pressure . Towers are even subjected to gravitational loads and stresses. The taller the structure, the more likely it is to sway, and therefore the greater the horizontal load, such as a rotating chimney. This project explores Mobile Pinnacle using various supporting designs. The critical loads considered in the planning of these towers are self weight, wind loads and seismic loads.In this study, a 30m high steel communication tower is planned with bottom width of 6m and top width of 1.5m, provided with three types of braces: X braces, inverted V braces or K braces. The main objective of this project is to understand loads affecting on the telecommunication tower in wind zone IV and seismic zone II. Keywords: Wind loads, Displacement, Bracings, Types of bracings.

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 centers. 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 sectiontruss. 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 is an economic miracle that has transformed the lives of millions and contributed immensely towards India's socio-economic development. Telecommunication towers are tall structures designed for supporting parabolic antennas installed at a specific height. The telecommunication industry plays a great role in the present societies and thus more attention is now being paid to telecommunication towers compared to the past. The direction and height of tower along with the antennas mounted on it is completely governed by the functional requirements. Communication towers act as vertical trusses and resists wind load by cantilever action. The bracing members are arranged in many forms, that carry only tension, or alternatively tension and compression.The bracing is made up of crossed diagonals, when it is designed to resist only tension. Based on the direction of wind, one diagonal takes all the tension while the other diagonal is assumed to remain inactive. Tensile bracing is smaller in cross-section and is usually made up of a back-to back channel or angle sections. Communication Towers are classified under three categories, i.e. guyed masts, monopole, and self-supporting tower.

OBJECTIVES :

Analyzing the communication tower by considering the various loads. Wind Load Calculation: The wind stack on the pinnacle structure is calculated using IS 875 (section 3): 1987. Researching the Equivalent static technique according to IS 1893-2002. The various stacking parameters were described, and the Earthquake Load was assigned to the models. Analysis of model with various bracing configurations such as X bracing, K bracings or inverted V bracings. Tower models are created using ETABS in accordance with IS 800:2007. The members were tested to ensure they passed. If a section failed, its properties were altered, examined, and rebuilt.

METHODOLOGY :

Modelling Of Tower

Fixing the Geometrical Parameters such as height, width, bracing system and initial member sections. Modeling the Tower in the ETABS software. The tower is provided with three different types of bracings, a. X Bracing, b. V Bracing or K bracing

- These three models were modeled in ETABS Software as follows. Define Storey data like storey height, no. of storey etc.
- Define material properties.
- Define Frame Section from Define menu like members and bracings.
- Draw tower Elements from draw menu.
- Give Support Conditions.

- Define Load cases and Load combinations.
- Assign gravity Load (As per clause IS 875:1987 part1and Part2).
- Assign wind Load (As per clause IS 875: 1987 part3).
- Assign seismic Load (As per clause IS 1893: 2002).

Analysis Methods:

This topic reveals the basic considerations of earthquake analysis of a self- supporting trussed tower. The seismic loads are considered to act as a result of horizontal relative acceleration among the different panels which causes drifts in the structures. Earthquake is an unpredictable phenomenon for which the analysis of a structure under seismic load condition has to be done with the previous collected statistics of earthquakes for a particular zone and soil. The particular collected statistical data has been taken into account with a probabilistic approach to obtain the optimum possible safety. Therefore, basically the structures are analyzed by the previous seismic loads with the highest intensities for the certain design criteria. IS 1893:2005 (Part4) gives the provisions for static analysis of seismic load for communication towers with consideration of different zones and soil structures. IS 1893:2002 (Part-1) provides the basic adaptation of different methods of analysis of building structures subjected to seismic loads. There are three 20 basic methods of analysis for seismic loads which are asfollows: Equivalent Static Load Method(ESL) Response Spectrum Method(RSM) Time History Method(THM)

Response Spectrum Analysis:

The dynamic analysis is defined as the analysis of structure considering the motion of the structure which depicts that all the parameters are taken as time-dependant. In case of the seismic analysis, the ground vibration is considered as random vibration which can be evaluated using probabilistic approach. The random vibration is idealized as the summation of different series or “modes” of elementary harmonic vibrations. The theoretical analysis of any stack-like structure is done by idealizing the structure as continuous system and with the help of the dynamic matrix method the elemental segments are analyzed to get the response of the whole structure for each modes of vibrations. From the first mode of vibration, the natural time period is being calculated. In case of the assignment of the seismic loads in the software viz. ETABS the calculations of the parameters that have to be made for the RS analysis are according to the provisions of IS 1893: 2002 (Part-1) and IS 1893: 2005 (Part-4). The analysis has been done using ETABS and the parameters which have to be put in the software for the analysis are as follows: Zone Factor (Z) is a factor that deals with the ratio of Probable average intensity of earthquakes in case of particular zones. [Cl. 6.4.2, Table 2, Pg-16 of IS 1893: 2002(Part-1)] Large number of telecommunication towers has been constructed in Sri Lanka during last few decades with the rapid development of telecommunication sector in the country. These towers play a significant role especially in wireless communication and failure of such tower in a disaster like an earthquake is major concern mainly in two ways. One is the failure of communication facilities will become a major setback to carry out rescue operations during disaster while failure of tower will itself cause a considerable economic loss as well as damages to human life in most of thecases. Therefore, design of telecommunication towers considering all possible extreme conditions is of utmost importance and a good design can be considered as a step

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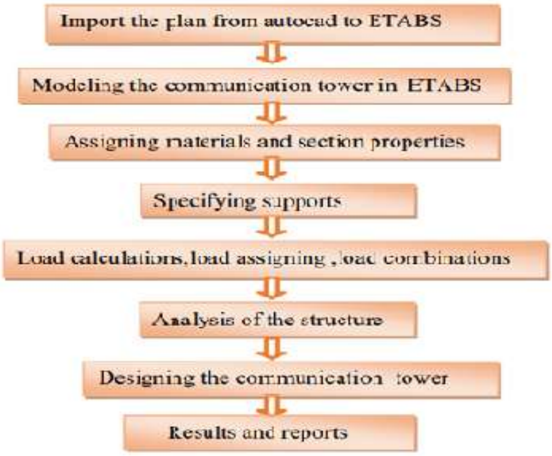
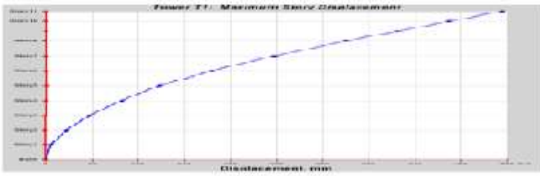
towards a greater degree of sustainability. However, almost all telecommunication towers in this country have not been checked for earthquake loading since most of people believe that 21 earthquake threats are not that much of significance to Sri Lanka until recently. With many tremors recorded in recent past, designers have started to rethink about earthquake design of structures and main objective of this research is assessing the performance of exiting towers (which were not initially designed considering earthquake loading) under possible earthquake loading and find cost effective strategies for retrofitting in case such action has to be effected.



RESULTS:

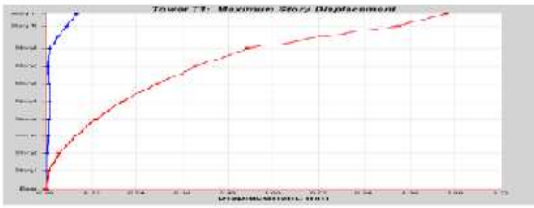
4.1Maximum Story Displacement of Communication Tower: Maximum Displacement of the communication tower in seismic X direction: Story displacement is the lateral displacement of the story relative to the base. The lateral force-resisting system can limit the excessive lateral displacement of the building. The maximum story displacement at seismic X direction for a communication tower will depend on several factors, such as the seismic hazard of the location, the structural design and detailing, and the characteristics of the ground on which the building is constructed. In general, the maximum story displacement can be estimated using the following formula: Dx = (Sa/g) * (T/2π) * Cd * R * Ie where Dx is the maximum story displacement in the seismic X direction, Sa is the spectral acceleration at the building site, g is the acceleration due to gravity, T is the fundamental period of the building, Cd is the deflection amplification factor, R is the seismic response coefficient, and Ie is the seismic importance factor.



Story	Elevation m	Location	X-Dir mm	Y-Dir mm
Story11	30	Top	0.79	0.002
Story10	28	Top	[illegible]	0.001
Story9	[illegible]	Top	[illegible]	0.001
Story8	24	Top	0.510	1.868E-04
Story7	21	Top	0.396	0.001
Story6	18	Top	0.286	0.002
Story5	15	Top	0.196	0.003
Story4	12	Top	0.131	0.001
Story3	9	Top	0.076	[illegible]
Story2	6	Top	0.034	3.504E-05
Story1	3	Top	0.000	[illegible]
Base	0	Top	0	0

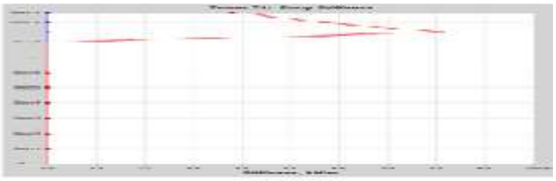
Graph 1: Maximum Displacement of the communication tower in seismic X direction

Graph 2:Maximum Displacement of the communication tower in seismic Y direction:



Story	Elevation m	Location	X-Dir mm	Y-Dir mm
Story11	30	Top	0.061	1.057
Story10	28	Top	0.054	0.911
Story9	26	Top	[illegible]	[illegible]
Story8	24	Top	0.009	0.631
Story7	21	Top	0.004	0.306
Story6	18	Top	0.009	0.203
Story5	15	Top	0.01	0.205
Story4	12	Top	[illegible]	[illegible]
Story3	9	Top	[illegible]	[illegible]
Story2	6	Top	0.003	0.054
Story1	3	Top	0.001	0.020
Base	0	Top	0	0

Graph 3:Stirey stiffness of the communication tower in wind y direction



Story	Elevation	Location	X-Dir	Y-Dir
	m		kN/m	kN/m
[illegible]	[illegible]	Top	[illegible]	[illegible]
[illegible]	[illegible]	Top	[illegible]	[illegible]
[illegible]	[illegible]	Top	[illegible]	[illegible]
[illegible]	[illegible]	Top	[illegible]	[illegible]
[illegible]	[illegible]	Top	[illegible]	[illegible]
[illegible]	[illegible]	Top	[illegible]	[illegible]
[illegible]	[illegible]	Top	[illegible]	[illegible]
[illegible]	[illegible]	Top	[illegible]	[illegible]
[illegible]	[illegible]	Top	[illegible]	[illegible]
[illegible]	[illegible]	Top	[illegible]	[illegible]
[illegible]	[illegible]	Top	[illegible]	[illegible]
[illegible]	[illegible]	Top	[illegible]	[illegible]

CONCLUSION:

The model when subjected to wind loads, displacement in tower with X bracing is found to be least and that in tower with K bracing is found to be more. This is because, stiffness is found to be higher in tower with X bracing due to more structure weight as compared to other models. The tower's displacement with K bracing is least when subjected to earthquake loads, since the seismic weight of the structure is less and attracts less force Maximum story displacement is more in wind load than the seismic loads. Maximum story displacement, maximum story drift, story shears, story overturning moment and story stiffness the analysis results is given in the above graphs and tables. The bottom part of the tower is constructed with the K bracings and top is constructed with the X bracings The vertical members are more important in taking the loads of the tower than the horizontal diagonal member. The member supporting the antenna structures at higher elevation are expected to have large influence on the behavior of the tower. Future Improvement: A future study can be extended for studying effects of mounting solar panels on the towers that can help generation of electricity for ground equipment. 50

REFERENCES:

[1] Chiu, A. N. L., and Taoka, G. T., "Tower response to actual and simulated wind forces," Journal of The Structural Division, ASCE, 99(9), 1973, pp. 1911-1929.

[2] Konno, T. and Kimura, E., "Earthquake effects on steel tower structures atop buildings," Proceedings of the 5th World Conference on Earthquake Engineering, 1, 1973, pp. 184- 193. [3] Badruddin Ahmed.A, Pande Promod.K., and Prem Krishna., "Self Supporting Towers under Wind loads," Journal of the Structural Division, ASCE, 110(2), 1984, pp.715-728.

[4] Mikus J. "Seismic analysis of self-supporting telecommunication towers," M. Eng. Project Report, Department of Civil Engineering and Applied Mechanics, McGill University, Montreal, Canada, G94-10, 1994.

[5] Galvez C. "Static method for a seismic design of self-supporting towers," M. Eng. Project Report, Department of Civil Engineering and Applied Mechanics, McGill University, Montreal, Canada, G95-08, 1995.

[6] Silva, J.G.S., Da S. Vellasco, P.C.G., De Andrade, S.A.L. & De Oliveir, M.I.R., "Structural assessment of current steel design models for transmission and telecommunication tower,", Journal of Constructional Steel Research, 61(8), 2005, pp. 1108-1134.

[7] G. Ghodrati Amiri, M.A. Barkhordari, and S. R. Massah, "Seismic Behavior of 4-Legged Self-Supporting Telecommunication Towers," 13th World Conference on Earthquake Engineering Vancouver, B.C., Canada, August 2004.

[8] Efthymiou E and Gerasimidis S., Baniotopoulos C.C., "On the application of robustness criteria to steel lattice masts", POLLACK Periodica, 4(1), 2009, pp. 17□28.

[9] Dr. Swami. B.L.P and B. Dean kumar., "Criticality of Gust Pressures on the Members of Self Standing Towers," Proc. of Int. Conf. on Advances in Civil

Engineering, 2010, pp. 89- 93. [10] Siddesha. H "Wind Analysis of Microwave Antenna Towers," International Journal of Applied Engineering Research, Dindigul, 1(3), 2010, pp. 574-584.

[10] Sujihelen, L., Boddu, R., Murugaveni, S., Arnika, M., Haldorai, A., Reddy, P.C.S., Feng, S., Qin, J., 2022, Node Replication Attack Detection in Distributed Wireless Sensor Networks, Wireless Communications and Mobile Computing, 10.1155/2022/7252791

[11] Venkataiah, V., Nagaratna, M., Mohanty, R., 2022, Application of Chaotic Increasing Linear Inertia Weight and Diversity Improved Particle Swarm Optimization to Predict Accurate Software Cost Estimation, International Journal of Electrical and Electronics Research, 10.37391/IJEER.100218

[12] Narasimha, V., Dhanalakshmi, M., 2022, Risk Factor of Diabetes with Comorbidity Using Machine Learning Techniques, Lecture Notes in Electrical Engineering, 10.1007/978-981-16-7985-8_37

[13] Rashid, E., Ansari, M.D., Gunjan, V.K., 2022, Innovation and Entrepreneurship in the Technical Education, Lecture Notes in Electrical Engineering, 10.1007/978-981-16-7985-8_125

[14] Sunitha, P., Ahmad, N., Barbhuiya, R.K., Gunjan, V.K., Ansari, M.D., 2022, Impact ofÂ Covid-19 onÂ Education, Lecture Notes in Electrical Engineering, 10.1007/978-981-16-7985-8_124