

Impact Of Earthquake and Wind Force on The Structural Behavior of Monopole and Self-Supporting Towers

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Abstract—With the rapid and exponential increase in the usage of mobiles, a lot of attention is being paid on the telecommunication industry and telecommunication towers in the recent past. Each and every individual is carrying a mobile with him/her nowadays and the demand for telecommunication services has increased. Telecommunication Towers are the only means for coverage area and network reliability. Civil Engineers are involved in the analysis and design of the towers that support the panel antennas, telecommunication equipment, platforms and their foundations. All the equipment's like mounts, antennas etc. are mounted on the tower which requires Civil engineering expertise. Tower structural calculations include Applied Loads like wind load, dead load, seismic load and design strength of structural steel member on superstructure including connections and foundation.

Index Terms—Civil engineering, Steel. Dynamic, Wind Load, FEM, Telecommunication Towers.

I. INTRODUCTION

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. 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 centres. 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.

Besides the need of telecommunication towers in day-to-day life, during the events of the earthquake telecommunication and TV towers have the crucial task of instant transmission of information from the affected areas to the rescue centres so that help could reach the needed as early as possible. These towers can also be used for the installation of the solar cells and special collectors for absorbing the solar energy further to their application for the TV and radio communications.

Thus, the purpose of this study is to investigate the seismic response of the self-supporting telecommunication towers using nonlinear dynamic analysis method.

Telecommunication towers are mainly of three types depending structural action as follows;

- Self-Supporting towers
- Guyed towers
- Monopoles

II. PROBLEM STATEMENT

The analysis of 3D modelling of telecommunication towers

- 1) Self-Support Telecommunication
- 2) Monopole
- 3) Monopole with Rope

A. Model Details

- 1) Monopole
 - The height of the Monopole is 30 m.
 - Diameter of Monopole is 1.5
 - Thickness of plate for Monopole is 15 mm
 - Material- constructed using high-strength steel
- 2) Self-Support Telecommunication
 - The height of the tower is 30 m.
 - The base width of the tower is 5 m.
 - The top width of the tower is 2 m
 - The bracing systems used - D Bracing

III. STAAD MODELING

A. Self-Support Telecommunication

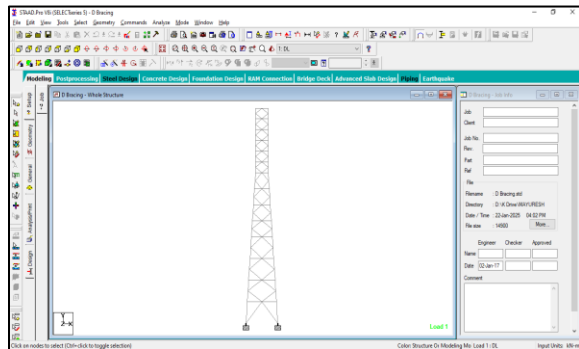


Fig 1 Modelling - Self-Support Telecommunication

B. Monopole

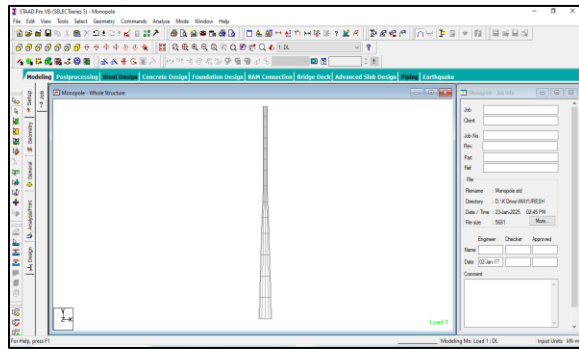


Fig 2 Modelling – Monopole

C. Monopole with Rope

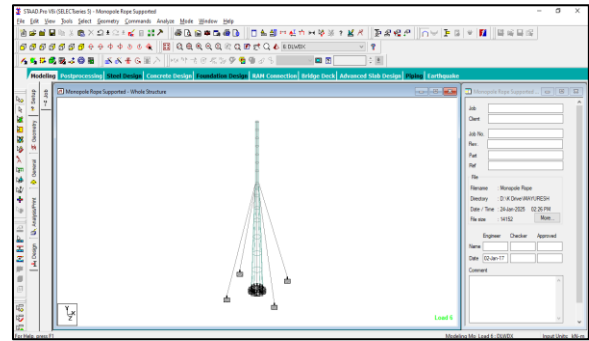


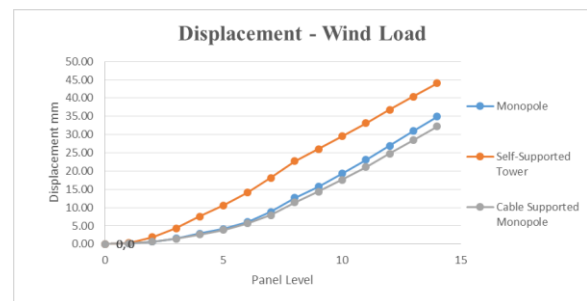
Fig 3 Modelling Monopole with Rope

IV. RESULT AND DISCUSSION

A. Results for Wind Load Analysis

Table 1 Displacement in mm

Displacement in mm			
Panel Level	Monopole	Self-Supported Tower	Cable Supported Monopole
14	34.94	44.03	32.20
13	30.93	40.42	28.46
12	26.94	36.78	24.74
11	23.03	33.14	21.10
10	19.27	29.54	17.61
9	15.76	26.03	14.36
8	12.63	22.67	11.44
7	8.81	18.18	7.89
6	6.04	14.14	5.63
5	4.15	10.60	3.92
4	2.85	7.58	2.65
3	1.55	4.31	1.45
2	0.68	1.88	0.63
1	0.17	0.32	0.16
0	0	0	0

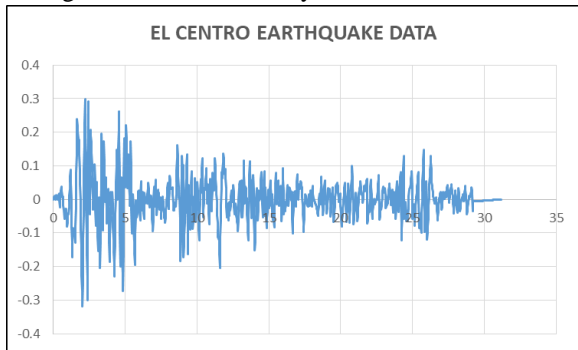


Graph 1 Displacement in mm

Above Graph shows results of the Displacement for wind load on Self-Supported Tower, Monopole, and Cable Supported Monopole. As per the results monopole gives better results than the Self-Supported Tower by 20-30% and Cable Supported monopole gives better results than Monopole by 5-10%.

B. Results for Time History Analysis

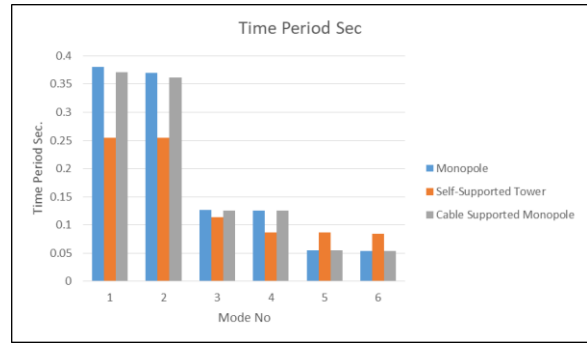
Dynamic analysis using the time history analysis calculates the building responses at discrete time steps using discredited record of synthetic time history as base motion. If three or more-time history analyses are performed, only the maximum responses of the parameter of interest are selected. Time history analysis is the study of the dynamic response of the structure at every addition of time, when its base is exposed to a particular ground motion. Static techniques are applicable when higher mode effects are not important. This is for the most part valid for short, regular structures. Thus, for tall structures, structures with torsional asymmetries, or no orthogonal frameworks, a dynamic method is needed.



Graph 2 El Centro Earthquake Data – Time Vs Acceleration

Table 2 Time Period Sec

Time Period Sec.			
Mode No	Mono pole	Self-Supported Tower	Cable Supported Monopole
1	0.38	0.255	0.371
2	0.37	0.255	0.362
3	0.127	0.114	0.126
4	0.126	0.087	0.125
5	0.055	0.087	0.055
6	0.054	0.085	0.054

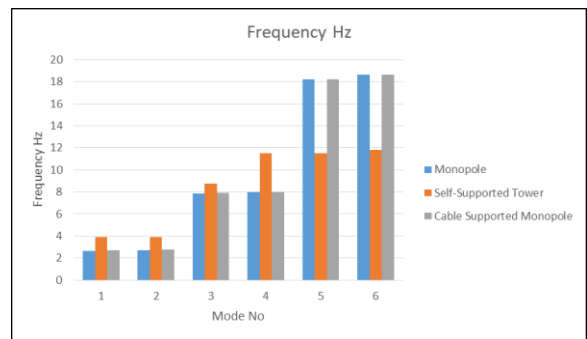


Graph 3 Time Period Sec.

Above Graph shows results of the Time Period for time history load on Self-Supported Tower, Monopole, and Cable Supported Monopole. As per the results Self-Supported Tower have less time period for mode 1- 4 and then it gets incised for mode 5-6 than monopole and Cable Supported Monopole.

Table 3 Frequency Hz

Frequency Hz			
Mode No	Mono pole	Self-Supported Tower	Cable Supported Monopole
1	2.634	3.917	2.694
2	2.701	3.917	2.761
3	7.883	8.78	7.919
4	7.95	11.494	7.984
5	18.20	11.494	18.202
6	18.65	11.822	18.654



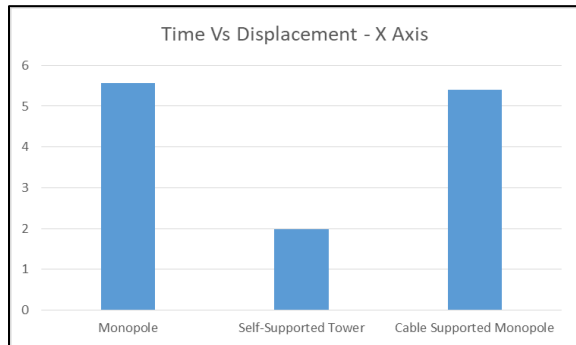
Graph 4 Frequency Hz

Above Graph shows results of the Frequency for time history load on Self-Supported Tower, Monopole, and Cable Supported Monopole. As per the results Self-Supported Tower have high Frequency for mode 1- 4

and then it get decreased for mode 5-6 than monopole and Cable Supported Monopole.

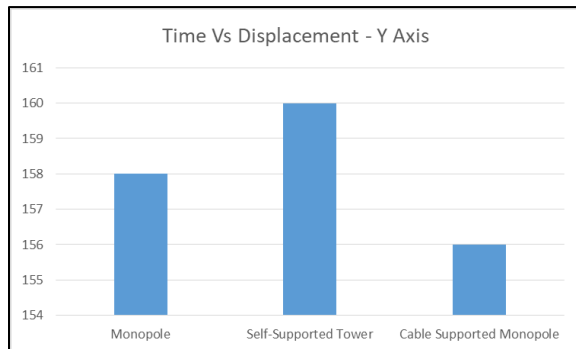
Table 4 Time Vs Displacement

Time Vs Displacement			
Direction	Monopole	Self-Supported Tower	Cable Supported Monopole
X Axis	5.56	1.98	5.4
Y Axis	158	160	156
Z Axis	5.76	1.98	5.5



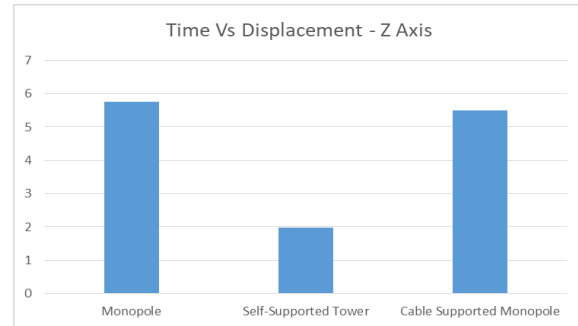
Graph 5 Time Vs Displacement- X Axis

Above graph shows result of Time Vs Displacement for X Axis the Self-Supported Tower have less results than both Monopole and Cable Supported Monopole.



Graph 6 Time Vs Displacement - Y Axis

Above graph shows result of Time Vs Displacement for Y Axis the Self-Supported Tower have High results than both Monopole and Cable Supported Monopole.



Graph 7 Time Vs Displacement - Z Axis

Above graph shows result of Time Vs Displacement for Z Axis the Self-Supported Tower have less results than both Monopole and Cable Supported Monopole.

V. CONCLUSION

- Depending on their structural makeup and design, monopole and self-support telecommunication towers behave quite differently during seismic activity and in relation to wind speed.
- For the wind load analysis due to the circular surface area monopole and cable supported monopole are have less displacement and base share results than the self-supporting tower.
- For the Dynamic analysis self-supporting tower gives better results than the monopole and cable supported monopole
- It should also be noted that strengthening a monopole is difficult compared to Self-support Tower. Unlike Self-Supporting Towers, where reinforcement is as simple as replacing a smaller, over-stressed member with a larger, stronger one, a monopole has only one member, thus replacement means installing a new pole.
- Monopoles have lower lateral stiffness as compared to Self-Supporting Towers. Although the monopole may be structurally stable, its lack of stiffness may exceed the twist and sway tolerances of some antenna or dish equipment.
- Based on the above-mentioned observation & conclusions, it is recommended to adopt monopole and cable supported monopole for the wind region and Self-Support Tower at the higher seismic area.

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IS Codes

- IS 800: 2007 - Code of Practice General construction in steel?
- IS 875 part I- Dead load
- IS 875 Part II- Live load
- IS 875 Part III- wind load
- IS 875 Part V- load combination