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Analysis of Transmission Tower using ANSYS

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Abstract - *Transmission tower is the main supporting aid for the transmission line, transmission tower should carry heavy electric conductors and safe height from the ground. In addition to this the transmission line should be capable of withstanding all the natural calamities, so transmission tower designing is an important engineering job where it involves all the three basic engineering branches like civil engineering, mechanical engineering and electrical engineering. Transmission line towers carry heavy electrical transmission conductors at a sufficient and safe height from ground, In addition to their self-weight they have to withstand all the forces of nature like seismic load, wind load and snow load, therefore transmission line should be designed considering both structural and electrical requirements. The tower is analyzed for failure due to dead load, wind load, seismic load and natural frequencies. An attempt has been made in analysis and modeling of transmission line tower using Autocad 3D and Finite element based ANSYS software. The model is created in Autocad 3D and then imported to ANSYS Workbench. The link element is used for the modeling. In the present study the behavioral changes due to deflection of transmission tower against static and dynamic loadings is carried out.*

Key Words: Transmission tower, ANSYS, Deflection, Seismic load, Wind load,

1. INTRODUCTION

Transmission towers are tall structures, their height is much larger when compared with the lateral dimension. These towers generally will have separate foundation for each leg. The electric power generated at power plants will be transmitted through transmission lines supported by transmission towers. Transmission line towers carry heavy electrical transmission conductors at a sufficient and safe height from ground. In addition to their self-weight they have to withstand all the forces of nature like seismic load, wind load and snow load, therefore transmission line should be designed considering both structural and electrical requirements.

Transmission tower line system damage often brings the huge direct loss and indirect loss for the national economy, but the causes of destruction of transmission tower line is very complex, and the earthquake is a serious natural disasters, the earthquake under impact loading of transmission tower structure mechanics characteristic is a line of complex characteristic and research hot spot problems of the current domestic and international research hot spot problems.

1.1 Types of Transmission towers

The electric transmission tower can be classified several ways. The most obvious and visible type towers are

1 Lattice structure
2 Tubular pole structure

Lattice structure

Lattice steel towers are made up of many different steel structural components connected together with bolts or welded. These towers are also called self-supporting transmission towers or free-standing towers, due to their ability to support themselves. These towers are not always made of steel, they can also be made of aluminium or galvanized steel.

Tubular pole structure

Tubular steel poles are another of the major types of transmission towers. They are made up of hollow steel poles. Tubular steel poles can be manufactured as one large piece, or as several small pieces which fit together

1.2 Components of transmission tower

Transmission tower consists of following parts

1 Boom of transmission tower
2 Cage of transmission tower
3 Cross arm of transmission tower
4 Peak of transmission tower
5 Transmission tower body

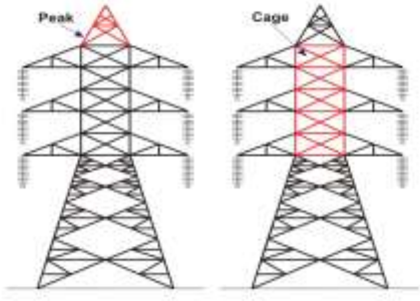

Fig-1:-Peak and cage of Transmission Tower

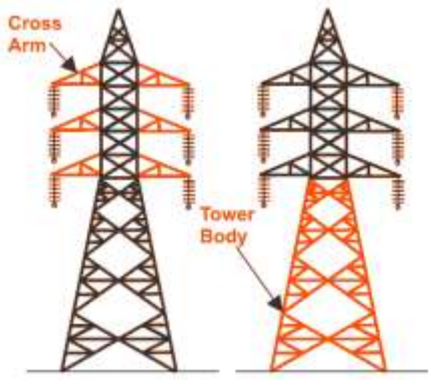

Fig-2:- Cross Arm and body of Transmission Tower

1.3 Objectives

- The main objective of this study is to analyse the behaviour of transmission tower system when subjected to dead load, seismic loads and wind loads by using Finite Element Method [FEM] and ANSYS.

1.4 Methodology

- This study presents a general finite element method framework for collapse simulation of the transmission tower subjected to earthquake and wind loads.
- Modelling of Transmission tower as per codal provisions.
- To find out the static response of transmission tower like deflections due to self-weight of the transmission tower using ANSYS.
- To study free vibrational or modal analysis characteristics of the transmission tower by determine the frequencies and mode shapes of transmission tower using ANSYS.
- Dynamic analysis of a transmission tower using ANSYS. To determine static response of transmission tower structure due to wind load using ANSYS.

2. ANALYSIS OF TRANSMISSION TOWERS

3.1 Geometrical Data

1. Height of tower- 21.98 m
2. Bottom width of tower -5.6 m
3. Importance factor - 1.5
4. Response Reduction factor of – 4 [Steel frame with concentric braces].
5. Seismic zone– Z=0.16.
6. Wind zone –I
7. Minimum ground clearance plus maximum sag of lower most wire = 15.42m
8. Vertical spacing between the conductor = 3.9m
9. Vertical spacing between conductor and the ground wire = 4.26

3.2 Basic Assumptions

For the structural analysis of transmission towers the following assumptions are considered, the assumptions considered are,

1. All the members are considered to be thin three dimensional beams.
2. Damping of the system is neglected.
3. All the members are perfectly connected.
4. Effect of power conveying cables are isolated.
5. Tower frame is rigidly connected to the ground.

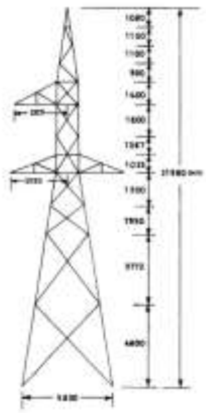

Fig-3:-Typical tower drawing

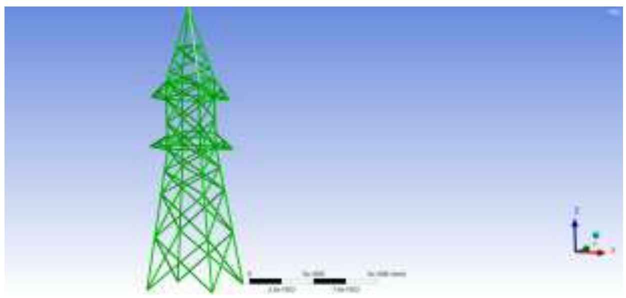

Fig-4:- Model of transmission tower in ANSYS workbench

3. RESULT AND DISCUSSIONS

Static analysis is carried out by modeling the transmission line tower in AUTOCAD 3D. The prepared model is imported to ANSYS Workbench and then material properties, loads are assigned

3.1 Deformation due to self-weight and dead load in tower structure

Maximum total deformation found on electric tower structure is **0.458 mm**

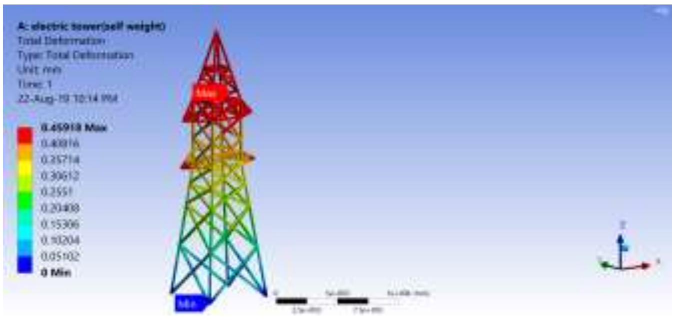

Fig-5:- Total Deformation due to self-weight

3.2 Modal Analysis of tower structure in Natural frequency modes

Modal analysis in structural mechanics is used to determine the vibration characteristics (natural frequencies and mode shapes) of a structure. The natural frequencies and mode shapes are important parameters in the design of a structure for dynamic loading conditions.

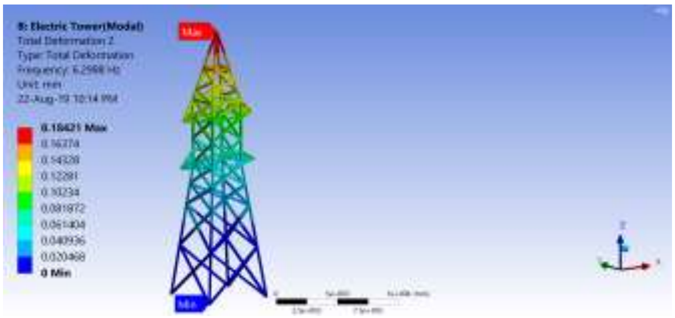

Fig-6: Total deformation in mode 1

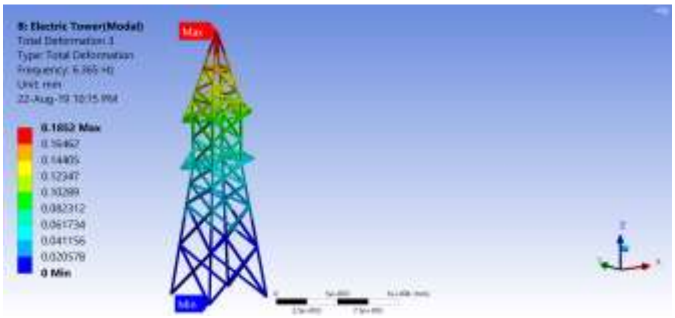

Fig-7: Total deformation in mode 2

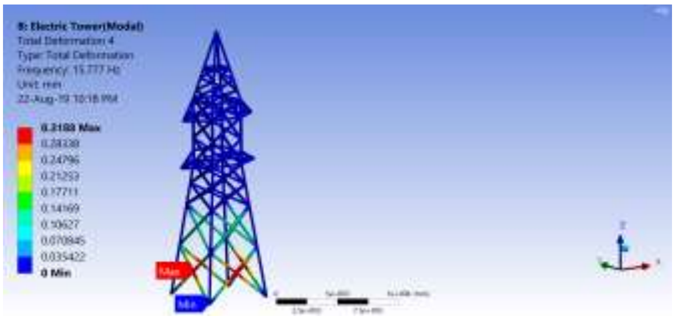

Fig-8: Total deformation in mode 3

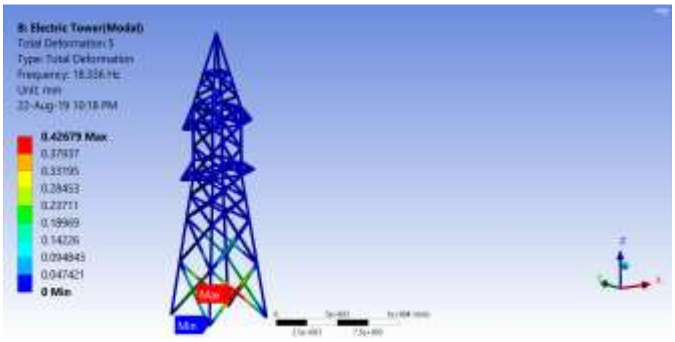

Fig-9: Total deformation in mode 4

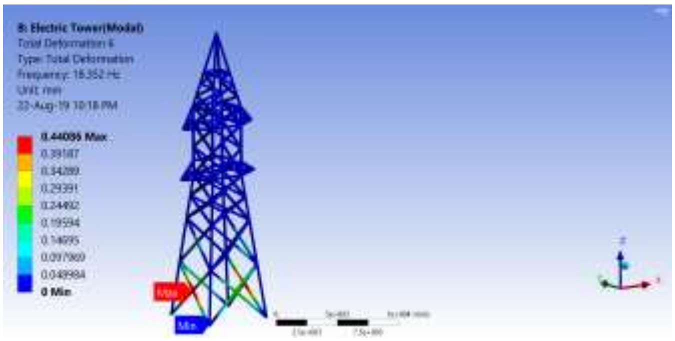

Fig-10: Total deformation in mode 5

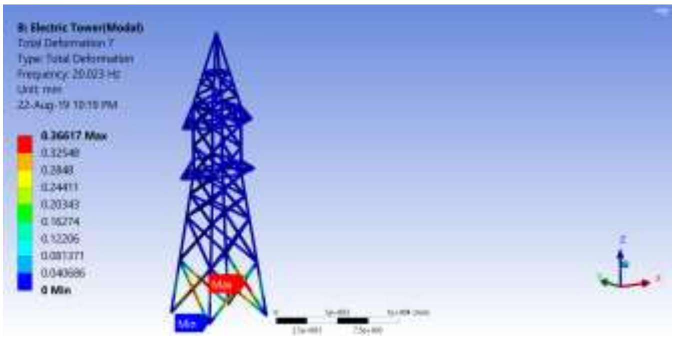

Fig-11: Total deformation in mode 6

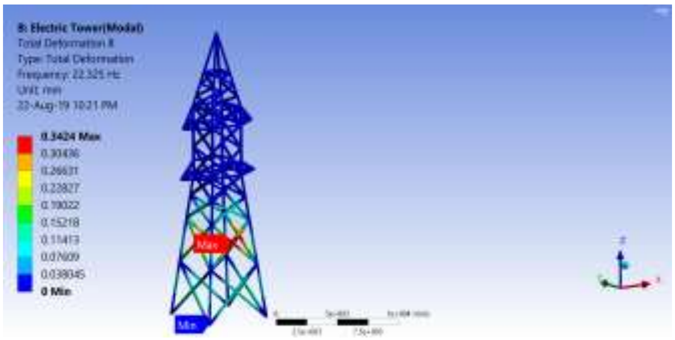

Fig-12: Total deformation in mode 7

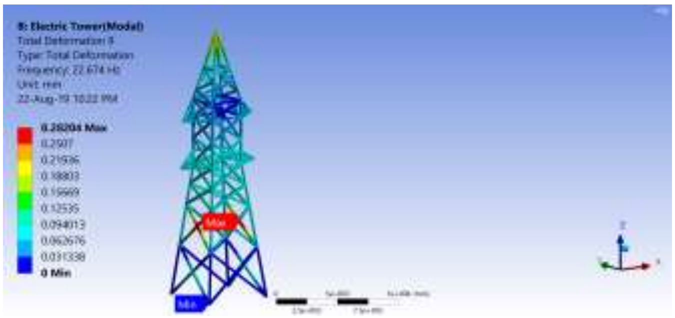

Fig-13: Total deformation in mode 8

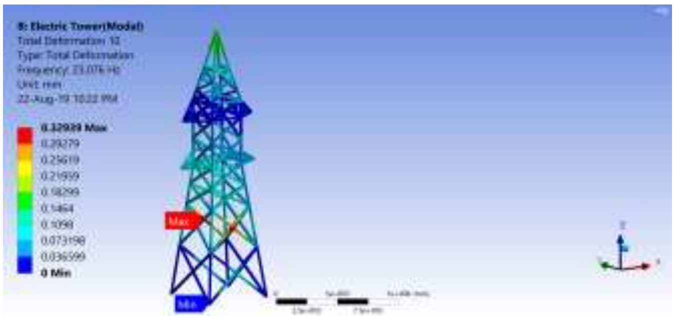

Fig-14: Total deformation in mode 9

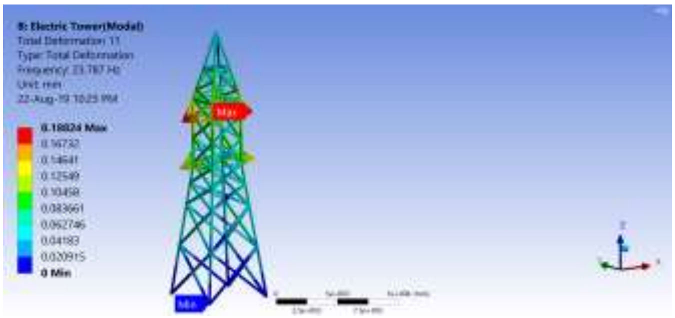

Fig-15: Total deformation in mode 10

Table 1:-Deformation due to natural frequency with various modes

Mode Number	Frequency (Hz)	Deformation (mm)	Type of mode shape for various DOF
Mode 1	6.2988	0.18421	Mode shape for Longitudinal DOF
Mode 2	6.365	0.1852	Mode shape for Lateral DOF
Mode 3	15.777	0.3188	Mode shape for Twisting DOF
Mode 4	18.336	0.42679	Mode shape for Longitudinal DOF
Mode 5	18.352	0.44086	Mode shape for Lateral DOF
Mode 6	20.023	0.36617	Mode shape for Twisting DOF
Mode 7	22.325	0.3424	Mode shape for Longitudinal DOF
Mode 8	22.674	0.28264	Mode shape for Lateral DOF
Mode 9	23.076	0.32939	Mode shape for Twisting DOF
Mode10	23.787	0.18824	Mode shape for Longitudinal DOF

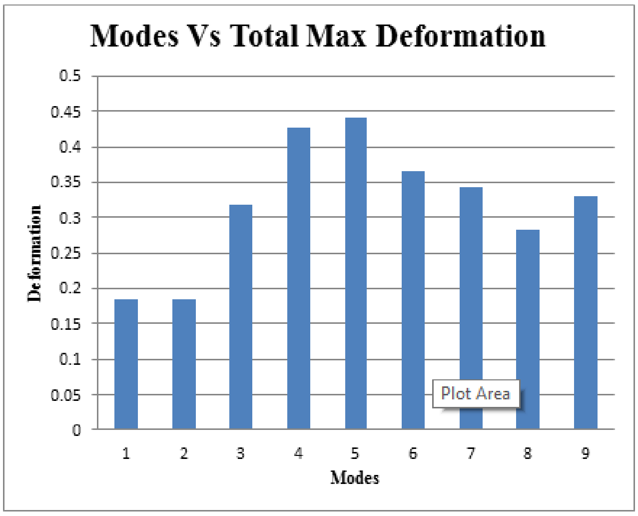

Chart -1: Maximum deformation of various modes due to Natural frequency

3.3 Response spectrum analysis

Response spectra can also be used in assessing the response of linear systems with multiple modes of oscillation (multi-degree of freedom systems), although they are only accurate for low levels of damping. Modal analysis is performed to identify the modes, and the response in that mode can be picked from the response spectrum. These peak responses are then combined to estimate a total response. A typical combination method is the square root of the sum of the squares (SRSS) if the modal frequencies are not close

The below graph shows the first 100 RS acceleration values that are recorded during the EL-Centro earthquake

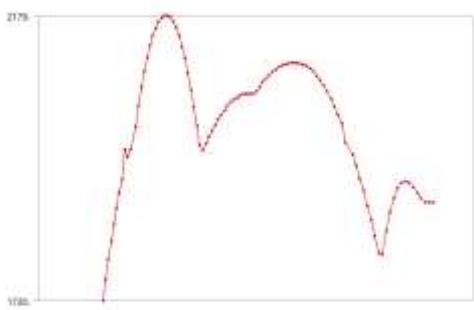

Fig-1.6: RS acceleration plot of first 100 values

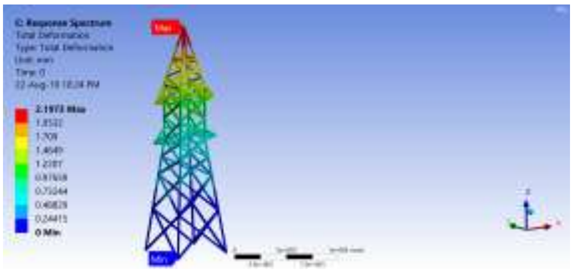

Fig-1.7: Total deformation due to RS analysis

Maximum total deformation due to RS acceleration of EL-Centro earthquake is **2.197mm**

3.4. Deformation due to wind load in tower structure

The Transmission tower is analyzed statically by considering the wind load acting at an instant of time. There should not be large deflection which may cause extra bending in the transmission tower. The result of the static analysis is obtained in the form of maximum deformation and directional deformations.

Fig-1.8: Wind load application

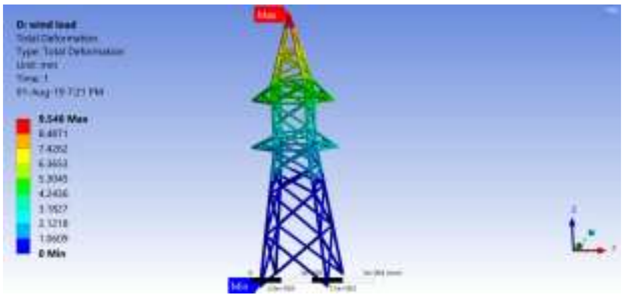

Fig-1.9: Total deformation due to wind load

Maximum total deformation due to wind load is **15.698mm**

4. CONCLUSIONS

The tower is analyzed for failure due to dead load, wind load seismic load and natural frequencies. An attempt has been made in analysis and modeling of transmission line tower using Autocad 3D and Finite element based ANSYS software. The model is created in Autocad and then imported to ANSYS Workbench. The link element is used for the modeling. In the present study the behavioral changes due to deflection of transmission tower against static and dynamic loadings is carried out. Following are the conclusions drawn from the analysis.

- The Value of Maximum total deformation obtained in the case of static analysis is 0.458 mm due to dead load and 15.698 mm obtained due to wind load.
- In Dynamic analysis, wind loads are dominating as compared to earthquake forces in zone I.
- The total deformation obtained from Response spectrum Analysis by considering RS acceleration of El Centro earthquake is 2.197mm.
- Thus wind load prove to be dominant among all loads for present tower.
- The analysis carried out using finite element analysis (ANSYS software) gives appropriate solutions including nodal, element, and member solutions.

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