EFFECT OF MEDIUM WIND INTENSITY ON 21M 132kV TRANSMISSION TOWER

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Abstract

In this paper the performance of 21M high 132kV tower with medium wind intensity is observed. The Recommendations of IS 875-1987, Basic wind speeds, Influence of height above ground and terrain, Design wind speed, Design wind pressure, Design wind force is explained in detailed. An analysis is carried out for the tower and the performance of the tower and the member forces in all the vertical, horizontal and diagonal members are evaluated. The critical elements among each of three groups are identified. In subsequent chapters the performance of tower under abnormal conditions such as localized failures are evaluated. The details of load calculation, modeling and analysis are discussed. The wind intensity converted into point loads and loads are applied at panel joints.

Key Words: *Transmission line Towers, Wind Intensity, Failures*

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1. INTRODUCTION

Electric Power is today playing an increasingly important role in the life of the community. In the electric power system the production and transmission of power are two predominant factors. For the purpose of transmission of electricity towers are the main medium with some wires at required distances and altitudes. The remote hydroelectric power plants have given rise to the need for extra high voltage. Prior to 1950, 150 kV electric transmission lines were considered and still higher voltages are being considered these days. Hence it has given rise to the need for relative tall structures such as towers. Thus the study of designing and erection of steel towers has become a challenging task.

Transmission line tower normally comprise of several hundred-angle members eccentrically connected. Structural analysis of this type of structure requires extensive data generation. Conventional process of data generation in describing the topology, geometry, load and support conditions are very tedious, time consuming and susceptible to error. In general, most towers may be idealized as statically determinate and analyzed for forces.

2. PERFORMANCE OF THE TOWER DUE TO MEDIUM WIND INTENSITY

The main objective of this study is to assess the performance of various members of the transmission tower while is it subjected to its operating conditions and the unforeseen eventualities in the process of operation. The types of possible failures of the tower are discussed in subsequent chapters. Before assessing the effect of the fault in a structure first of all the intact structure need to be modeled.

In this paper the performance of the intact structure under medium wind load intensity of 1.5 kN/m^2 is presented. The configuration of tower consists of 21m height arranged in 9 height panels at different levels. The structure has 40 nodes and 145 members. The tower is to transmit tower voltage of 132kV.

The details of load calculation, modeling and analysis are discussed in previous chapter. The wind intensity converted into point loads and loads are applied at panel joints by taking medium wind intensity. The configuration of the tower is shown infigure1.

3. PARAMETERS FOR STUDY

The parameters involved in this study are axial deflections, axial forces and torsional forces in various members of the transmission tower under medium wind intensity. The tower is 3d space frame with the deflections are in three planes viz. u_{xy} deflection in xy plane i.e. opposite to z-axis, u_{yz} deflection in yz plane i.e. opposite to x-axis and u_{xz} deflection in xz plane i.e. opposite to y-axis are considered.

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The deflections of nodes in three planes are presented in Table 1. Axial forces and torsion of horizontal members are presented in Table 2. Axial forces and torsion of vertical members are presented in table 3. Axial forces and torsion of diagonal members are presented in Table 4.

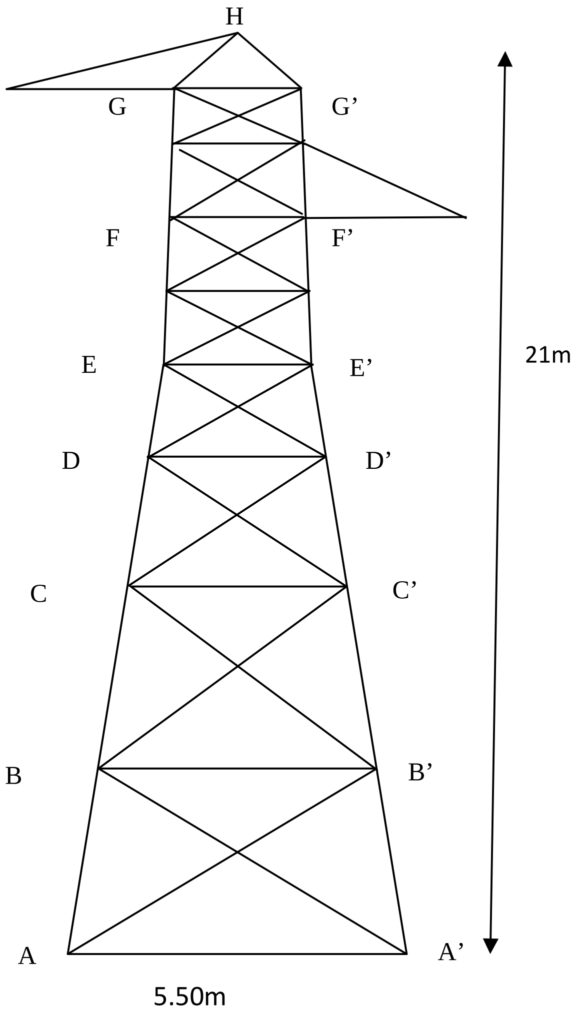

Fig.1 Tower Configuration

The details of deflections at various nodes are presented in figure 2. Similarly the axial forces in various horizontal, vertical and diagonal members are furnished in figure 3. The details of torsion forces in various horizontal, vertical and diagonal members are furnished in figure 4.

Node No	U_{YZ} (m)	U_{XZ} (m)	U_{XY} (m)
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	0.00	0.00	0.00
4	0.00	0.00	0.00
5	2.278E-04	2.871E-03	-1.145E-03
6	-2.174E-04	2.991E-03	9.980E-04
7	2.029E-04	2589E-03	1.023E-03
8	-2.213E-04	2.538E-03	-1.173E-03
9	9.536E-05	9.185E-03	-1.505E-03
10	-1.130E-04	9.203E-03	1.285E-03
11	7.182E-05	8.961E-03	1.306E-03
12	-1.004E-04	8.943E-03	-1.543E-03
13	3.830E-05	0.0120	-1.498E-03
14	-7.140E-05	0.0120	1.253E-03
15	2.306E-05	0.0118	1.270E-03
16	-6.241E-05	0.0118	-1.531E-03
17	-1.882E-05	0.0153	-1.331E-03
18	-3.549E-05	0.0153	1.066E-03
19	-2.232E-05	0.0152	1.075E-03
20	-2.924E-05	0.0152	-1.356E-03
21	-3.157E-05	0.0172	-1.419E-03
22	-3.536E-05	0.0172	1.148E-03
23	-7.734E-06	0.0171	1.154E-03
24	-6.404E-05	0.0171	-1.443E-03
25	-5.723E-05	0.0191	-1.476E-03
26	-2.381E-05	0.0191	1.200E-03
27	-1.232E-05	0.0191	1.204E-03
28	-6.758E-05	0.0190	-1.496E-03
29	-6.141E-05	0.0211	-1.507E-03
30	-2.345E-05	0.0211	1.229E-03
31	-1.622E-05	0.0210	1.231E-03
32	-7.098E-05	0.0210	-1.526E-03
33	-7.396E-05	0.0230	-1.518E-03
34	-2.492E-05	0.0230	1.241E-03
35	-1.414E-05	0.0230	1.242E-03
36	-8.331E-05	0.0229	-1.538E-03
37	-6.178E-05	0.0249	-1.284E-04
38	-2.597E-05	0.0152	-1.783E-04
39	-3.970E-05	0.0192	-1.425E-04
40	-5.048E-05	0.0228	-2.058E-04

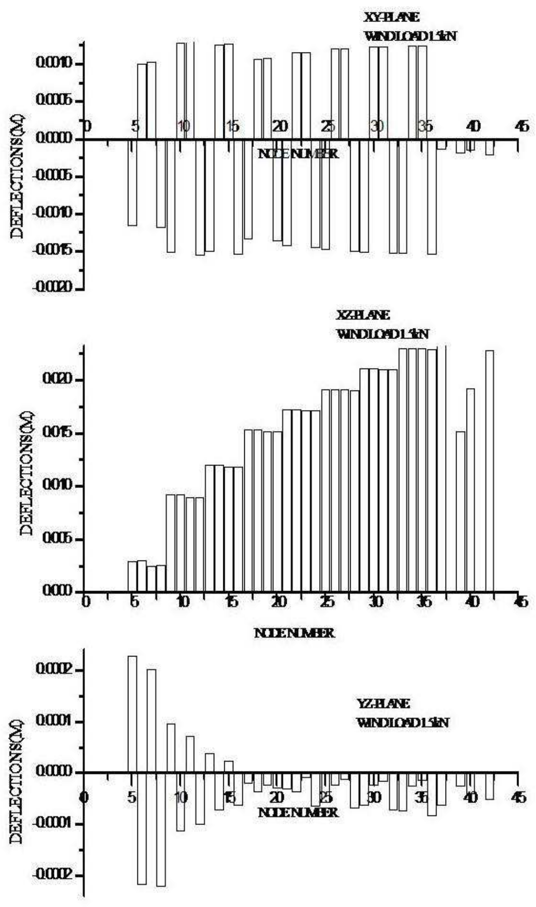

Fig. 2 Deflections at different nodes

4. PERFORMANCE OF TOWER BASED ON DEFLECTIONS

The members in first tier had largest deformation with node 5 recording peak deformation in the direction of wind flow in YZ plane. The deformations are symmetric with positive and negative values alternatively in bottom four tiers and all nodes subsequent tiers had deformation bending the tower in one direction as shown in figure 1.

The bent shape can be clearly felt along XZ plane with least deformation at all nodes near the base and as we approach to top of the tower having largest deformation. Symmetric deformation among all the nodes of one plane is observed from the figure. Both the nodes facing the wind and nodes away from wind direction in one plane had same deflection

5. PERFORMANCE OF TOWER BASED ON MEMBER FORCES

After determination of the external loads acting on the tower is calculated, the deflections in different planes are observed in previous section. In this section the truss is analyzed for lateral wind loads for the forces in various members with a view to fixing up their sizes. Since axial force for a truss element, the member has to be designed for either compression or tension. When there are multiple load conditions certain members may be subjected to both compression and tensile forces under different loading conditions. Reversal of loads may induce alternate nature of forces. The total compression or tensile forces in horizontal, vertical and diagonal members are given in table 2, 3, and 4.

To critical elements are also observed from the figures indicating both deflections and member forces and torsion. The graphs are drawn between node numbers and deflections in figure 1 and member numbers and axial forces in figure 2. and node numbers and torsion in figure 3.

The tower is unsymmetrical in one way as it has three power conductors at different elevations due to power conductors. The cable is suspended at these three power conductors and as the conductors are acting in one direction the system is likely to have torsion forces as well.

6. PERFORMANCE OF THE TOWER

Axial forces:

As shown in figure 3 the horizontal members in lower tier members had larger compressive stresses when compared to the members in top tiers. The members had largest compressive stress in first tier members and the compressive tresses diminished to almost nil in top tiers. At 5th and 8th tiers the axial force is more as compared to its successive bottom tiers, which accommodate of conductors.

Table 2 Performance of Horizontal members		
Member	Axial Force kN	Torsion kN-m
2	-19.41	-7.793 E-06
6	-13.65	7.437 E-06
10	-8.73	5.233 E-06
14	-1.62	11.66 E-06
18	-2.74	8.807 E-06
22	-1.14	7.398 E-06
26	-0.7166	5.268 E-06
30	-1.07	7.582 E-06
Table 2 Performance of Vertical members		
Member	Axial Force kN	Torsion kN-m
75	-19.81	-2.627E-05
83	-18.62	-4.991E-05
92	-5.76	-4.955E-05
100.	-8.42	-6.036E-05
102	-3.01	-3.179E-05
115	1.01	0.00
123	3.798E-01	8.145E-06
131	-8.959E-02	1.870E-05
Table 3 Performance of Diagonal members		
Member	Axial force kN	Torsion kN-m
35	111.43	6.548E-05
39	86.44	-1.041E-04
43	75.63	-1.463E-04
47	55.12	-2.510E-04
51	39.84	6.982E-05
55	25.05	-1.218E-04
59	13.39	5.995E-05

Similar trend is observed in diagonal members. The members in lower tiers are in compression and tensile forces are observed in tillers, which accommodated the cable conductors.

In vertical members as shown figure 3 clear uniform reduction in tensile forces is observed as we approach members in top tier from bottom tier.

Considering the above diagram the members in the bottom two tiers are critical in taking the cable load under medium wind intensity. more over the vertical members in the bottom ties are likely to have larger contribution of the loads and are vital in stability of the tower under any loading conditions. any abnormality in the cross sectional properties or the material properties are likely to result in abnormal functioning of the entire structure.

Torsion:

Torsion induced in the horizontal elements are negligible (10^{-6}) in elements however there are very marginal difference in members of different levels due to power conductors being slightly unsymmetrical with reference to z axis as shown in figure 4.

Considerable amount of torsion moments are observed at vertical members at level 1 and levels 4 and 6 as both these levels are just below the positions of conductor supports as shown in figure. Considerable amount of torsion moments are observed at diagonal members at higher level 6, 7 and 8 as both these levels are just below the positions of conductor supports as shown in figure.

5. CONCLUSIONS

Based on the study investigations the following conclusions can be tentatively drawn.

1. Configuration of the structure of the tower plays a vital role in its performance especially while considering eccentric loading conditions.

2. The bottom tier members have more role in performance of the tower in taking axial forces and the members supporting the cables are likely to have localized role.

3. The vertical members are more prominent in taking the loads of the tower than the horizontal and diagonal members. the members supporting the cables at higher elevation are likely to have larger influence on the behavior of the tower structure.

4. The effect of twisting moment of the intact structure is not significant.

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