Static-Analysis and Design of 220-KV Double Circuit Transmission-Tower with X & K Type of Bracing

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Abstract— In this work an attempt has been made that 220-KV double circuit Transmission-Tower with X and K type of bracing has been modeled using Stadd Pro. Static analysis has been done for the tower by considering Earth quake Zone III, Steel frame with concentric bracing, damping ratio 2%. The wind loads are calculated using IS 802(part1/sec1) by considering wind zone III. The towers are modeled using parameter such as constant height, constant base width, and then varying the Bracing system as X and K type of bracing. After completing the analysis a comparative study is done with respect to Nodal displacement, axial force, axial stress, maximum deflection, maximum compressive stress, and maximum tensile stress. The design of tower member is done by considering the member as compression and tension member. After designing the again a comparison is done on amount of steel angle section required X –bracing tower and K-bracing tower for the safe erection.

Key words: X & K Type of Bracing, Double Circuit Transmission-Tower

I. Introduction

In every country there is need supply the electricity there required a transmission of electricity, to tower. Transmission tower are defined as a cantilever structure which are used to carry an electrical conductor to transfer the electric current from one place to another place. Generally the transmission tower are divided based on circuit system, they are single circuit, double circuit and multiple circuit. In this work an attempt has been made that 220-KV double circuit Transmission-Tower with X and K type of bracing has been modeled using STADD Pro. Static analysis has been done for the tower by considering Earth quake Zone III, Steel frame with concentric bracing, damping ratio 2%.The wind loads are calculated using IS 802(part1/sec1) by considering wind zone III. The towers are modeled using parameter such as constant height, constant base width, and then varying the Bracing system as X and K type of bracing. After completing the analysis a comparative study is done with respect to Nodal displacement, axial force, axial stress, maximum deflection, maximum compressive stress, and maximum tensile stress. The design of tower member is done by considering the member as compression and tension member. After designing the again a comparison is done on amount of steel angle section required X –bracing tower and K-bracing tower for the safe erection.

S. No	Description	Conductor	Earth Wire
1	Material	ACSR	G.S
2	Name	ZEBRA	GSS
3	Stranding (Alum.)	54/3.18	-
4	Stranding (Steel)	7/3.18	7/3.15
5	Stranding (Optical Fiber)	-	-
6	Diameter (mm)	28.62	9.45
7	C.S. Area (sq.mm)	482.8	54.57
8	Ultimate Tensile Strength (Kg)	13316	5710
9	Unit Weight (Kg/m)	1.621	0.428
10	Modulus of Elasticity (Kg/sq.mm)	6860	19330
11	Coeff. of Linear Expansion (/ °C)	1.93E-05	1.15E-05

Table 1: Material Properties

II. Geometrical Configuration

The factors that govern the height of the tower are:

1) GND clearance (h1) as per table no 1, p.no 26 of IS-5613 part 2/sec1 1985.
2) Maximum sag of the conductor wires (h2) as per Maximum sag of the conductor wires (h2) as per parabolic equations as discussed in the I.S. 5613: Part 2: Sec: 1: 1989.
3) Conductor Spacing (h3) as per cl: 7.3.2.1, p.no 22 of IS-5613 part 2/sec1 1985.
4) Minimum-Distance between GND-wire and top conductor (h4) as per cl: 13.2, p.no 28 of IS-5613 part 2/sec1 1985.
5) Width of the tower at Base Level = 1/3 to 1/6 of the total height.
6) Minimum Horizontal Spacing of conductor as per cl: 7.3.2.1, p.no 22 of IS-5613 part 2/sec1 1985.

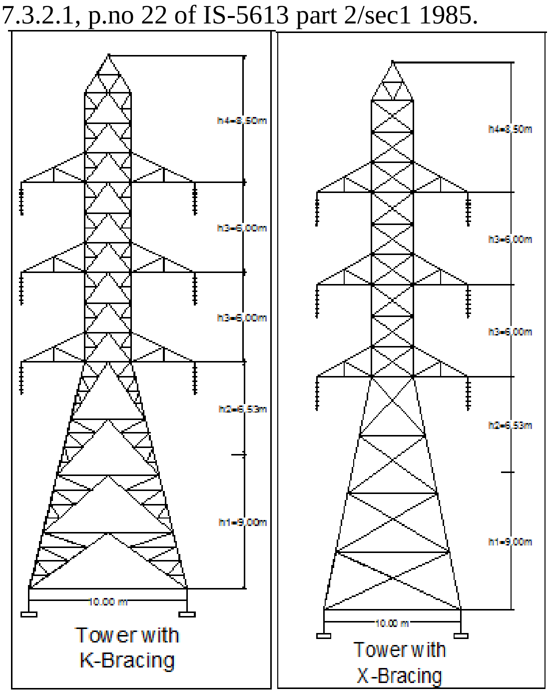

Fig 1. Tower Configuration

III. LOAD CONSIDERATION

1) Dead Load: Self weight of tower, weight of the conductor.
2) Live Load: As per cl: 12.2.3 IS 802(Part-l/Sec-1) is 3500N.
3) Wind Load: Wind load in terms of wind pressure depend on the Basic wind speed. Tower location: Vijayapur, Karnataka, INDIA, with basic wind speed (Vb=44.0m/sec.) and Design wind pressure (Vd=716.636N/mm^2).
4) Earthquake load: Tower location: Vijayapur, Karnataka, INDIA, With Z=III, R=4.0,I=1.5,Soil Type=Medium soil, Structure Type=steel frame Building, Damping Ration=2%.
5) Wind load calculation is done as per cl: 9.0, 9.1, 9.2, and 9.3, of IS 801 part1/sec 1.

IV. STAADPRO MODEL

The Tower is modeled using coordinated system, and the beam angle section ranging from 90x90x8 to 40x40x6. As the lower part of the tower has to withstand more load compared to upper part hence higher angle-section has to be provided for the lower part of the tower.

V. ASSIGNMENT OF LOAD

Dead load and Live load: The loads are assigned as a joint load, the Dead Load of the Conductor and Insulator will act as point load at the end of the cross arm and Live load includes the weight of tools and workmen during erection time will be act as point load at the ends of cross arm.

Wind pressure is converted into joint load and the values are calculated and listed as above, the joint load is applied by selecting each panel joint and assigning the respective joint load in X+ and Z+ direction.

Load Combination as per IS 800-2007 3.5.1 and 5.3.3 Load factors for Elastic design of steel structures.

VI. ANALYSIS

In this analysis the various loads such as vertical loads which includes weight of tower structure, fittings, power conductors, ground wire and lateral loads like wind and earthquake loads Static analysis has been done for the tower by considering Earth quake Zone III, Steel frame with concentric bracing, damping ratio 2%.The wind loads are calculated using IS 802(part1/sec1) by considering wind zone III. The towers are modeled using parameter such as constant height, constant base width, and then varying the Bracing system as X and K type of bracing.

VII. DISCUSSIONS AND RESULTS

The parameters of this study are Nodal Displacement, Axial forces, Axial Stress, Maximum Deflection in the Tower Member, Maximum compressive Stress in the tower members, Tensile stresses in the tower members of X type and K type bracing tower.

Load Case : 1.0(DL+WLx)		
Panel no	**X-Bracing**	**K-Bracing**
2	-4.86	-296.765
4	-21.321	-31.984
5	-31.682	-43.55
8	-57.286	-74.918
9	-71.627	-93.308
11	-103.572	-132.198
12	-120.305	-153.141
14	-176.088	-207.131

Table 2: Nodal Displacement All values are in mm.

Load Case : 1.0(DL+WLx)		
Panel no	X-Bracing	K-Bracing
2	196.257	200.315
5	174.468	167.295
8	80.501	72.743
11	20.962	19.371
14	4.43	5.223

Table 3: Axial Forces All values are in KN.

Load Case	X direction	Y direction	Z direction	Resultant
1.0(DL+LL)	9.027	-5.551	6.657	7.304
1.0DL+0.8LL+0.8ELx	66.127	-24.154	6.658	66.181
1.0DL+0.8LL+0.8ELz	-7.121	-7.759	65.926	65.979
1.0DL+0.8LL+0.8WLx	-497.899	-114.844	288.093	510.972
1.0DL+0.8LL+0.8WLz	287.331	-114.673	-497.101	510.156
1.0(DL+ELx)	82.66	-28.225	-6.658	82.695
1.0(DL+ELz)	7.122	-8.772	82.461	82.497
1.0(DL+WLx)	-620.593	-143.148	361.115	653.985
1.0(DL+WLz)	360.26	-142.951	-619.712	653.887

Table 4: Maximum Deflection of Tower with K Bracing. All values are in mm

Load Case	X direction	Y direction	Z direction	Resultant
1.0(DL+LL)	9.027	-5.551	6.657	7.304
1.0DL+0.8LL+0.8ELx	66.127	-24.154	6.658	66.181
1.0DL+0.8LL+0.8ELz	-7.121	-7.759	65.926	65.979
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Table 5: Maximum Deflection of Tower with K Bracing. All values are in mm

Member	X Bracing	K Bracing
	Maximum Compressive Stress in N/mm^2	Maximum Compressive Stress in N/mm^2
M-188	265.866	112.732
M-15	289.72	289.72

M-39	160.66	160.66
M-63	91.221	48.788
M-123	404.839	335.972
M-147	425.224	410.6
M-171	458.893	447.372

Table 6: Compressive Stress

Member	X Bracing	K Bracing
	Maximum Tensile Stress in N/mm^2	Maximum Tensile Stress in N/mm^2
M-188	-222.957	-276.406
M-15	-245.379	-245.379
M-39	-119.988	-30.244
M-63	-63.708	-27.215
M-123	-450.861	-414.732
M-147	-471.796	-418.386
M-171	-506.038	-446.846

Table 7: Tensile Stress

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STEEL TAKE-OFF
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   PROFILE                      LENGTH(METE)     WEIGHT(KN  )

ST  ISA70X70X8                      16.00            1.303
ST  ISA40X40X6                     922.73           31.685
ST  ISA60X60X8                      16.00            1.101
ST  ISA90X90X8                      47.87            5.075
ST  ISA80X80X8                      15.96            1.495
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                                TOTAL =           40.660
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Fig. 2: Steel take-off result from STAAD-PRO.

VIII. Conclusion

Nodal Displacement is maximum in X Direction for a Load Case: 1.0(DL+WLx) is 207.131mm for K bracing compared with all other load cases. Comparing Axial Forces for whole tower for X and K Type of Bracing the results shows that the maximum axial force 216.108KN for K type of bracing tower for a load case 1.0(DL+WLx).Axial Stress for whole tower for X and K Type of Bracing the results shows that the maximum axial Stress 177.137 N/mm2 for K type of bracing tower for a load case 1.0(DL+WLx).

Deflection for whole tower for X and K Type of Bracing the results shows that the maximum Deflection 653.985mm for K type of bracing tower for a load case 1.0 (DL+WLx).Compressive Stress for whole tower for X and K Type of Bracing the results shows that the maximum Compressive Stress 458.893 N/mm2 for a member 171 of X type of bracing tower. Comparing Tensile Stress for whole tower for X and K Type of Bracing the results shows that the maximum Tensile Stress 506.030N/mm2 for a member 171 X type of bracing tower. Comparing the Steel take off Result X type bracing proves economic than K type of bracing bracing need 4.55 tons of steel were as K type bracing needs 40.66tons of steel.

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