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Static Analysis and Design of 220-Kv Double Circuit Transmission-Towerwith Combination of X & K Type Of Bracing

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Abstract— In this work an endeavor has been made that 220-KV double circuit Transmission-Tower with combination of X and K type of bracings has been modeled using STAAD Pro. Static investigation has been improved the situation the pinnacle by considering Earth quake Zone III, Steel outline with concentric supporting, damping proportion 2%.The wind loads are calculated utilizing IS 802(part1/sec1) by considering wind zone I. The towers are modeled utilizing parameter, for example, steady height, consistent base width, and afterward differing the Bracing framework as combination of X and K sort of bracing. Subsequent to finishing the investigation a relative report is finished with regard to Nodal displacement, axial force, and maximum deflection. Comparative study has been done.

Keywords—Transmission Tower, combination of x & k type of bracing, Geometry of the Tower, STAAD Pro, Static Analysis , Deflections.

1 INTRODUCTION

In each nation, the necessity of power utilization has kept on expanding the rate of demand ismore prominent in the creating country. Transmission tower lines are one of most critical lifeline structures. Transmission towers are essential to supply power to different region of the country.

This has prompted the expansion in the working of power stations and ensuing increment in control transmission lines from the creating stations to the distinctive corners where it's required. Interconnections between systems are additionally expanding to improve quality and economy. Transmission lines are designed carefully so that they do not fail during natural disaster. It ought to likewise fit in with the national and universal standard.

In the arranging and outline of a transmission line, various necessities must be met from both structural and electrical perspective. From the electrical perspective, the most essential insulators and safe clearances of the power conveying conductors from the ground. Transmission tower are characterized as a cantilever structure which are utilized to convey an electrical transmitter to exchange the electric current starting with one place then onto the next put. For the most single circuit, double circuit and multiple circuit.

1.1 Objectives

- Analysis and design of transmission tower with combination of X and K type of bracing in the wind zone I using STAAD Pro.
- Comparison of deflections of X and K bracing with XKX and KXK bracings.
- Suggesting stable and economic bracing of the transmission tower by comparing the steel take off.

1.2 Methodology

In this work an endeavor has been made that 220-KV double circuit Transmission-Tower with combination of X and K type of bracings has been modeled utilizing STAAD Pro. Static investigation has been improved the situation the pinnacle by considering Earth quake Zone III, Steel outline with concentric supporting, damping proportion 2%.The wind loads are calculated utilizing IS 802(part1/sec1) by considering wind zone I. The towers are modeled utilizing parameter, for example, steady height, consistent base width, and afterward differing the Bracing framework as X and K sort of bracing. Subsequent to finishing the investigation a relative report is finished with regard to Nodal displacement, axial force, and maximum deflection. Subsequent to planning the again an examination is finished on measure of steel angle required for X and K type bracing tower for the safe erection.

2. LITERATURE SURVEY`

Some of the research papers are referred to decide objectives for this research work. The analysis and observations of research papers are made as follows.

Ch. Sudheer, et.al. have designed the 230 KV towers are designed in two wind zones I & V with three different base width 1/4,1/5 &1/6 of total height of tower 33.52m.The loads are calculated from IS:802(1995).Wind loads are calculated as per IS-875 part 3 Transmission line tower is modeled Using STADD Pro 2006. After completing the analysis, the comparative study is done with Respect to deflections, stresses, axial forces and weight of tower for all 6 different towers. And concluded that At a base width of 6.704m, in all directions, deflections are found to be. The maximum axial Deflection at a base width of 6.704m is having 15% more than the values at base width of 5.5866m and 35% more than the values at base width of 8.380m in all X, Y & Z directions For both Zone - I & Zone - V. The tensile stresses are maximum at member 402 in Zone –I is 128.716 N/mm2 & at member 109 in Zone –V is 130.641 N/mm2 .The compressive stresses Are maximum at member 404 in Zone – I is 175.039 N/mm2 & in Zone –V is 156.617 N/mm2 at base width 6.704 m

Preeti [2013] et.al they have modeled transmission tower with a 220 KV single circuit transmission line Carryingsquare base self-supporting pinnacle, Triangular base and square Guyed pole. Utilizing STAAD, At that point, the pinnacle individuals are planned as angle sections. And concluded that Wind stacking is figured for each pinnacle prompting the accompanying outcomes: Square Tower 2775 kg, Triangular Tower 2519 kg, Guyed Mast 1666 kg. Consequently, the triangular pinnacle is More efficient than the square pinnacle. The triangular pinnacle is found to have the lesser Amount of hub avoidance all through the stature of the pinnacle as contrasted and the square Tower. This infers the triangular pinnacle is carrying on more inflexibly than the square pinnacle. The triangular pinnacle is found to have minimal higher measure of hub powers in the leg individuals In correlation with the square pinnacle. This may be on the grounds that the powers are being exchanged By three legs rather than four.

Alaa C. Galeb[2013]et.al studied that they have designed Transmission towers (132 KV) subjected to different combination of wind, seismic and deadLoads are ideally intended for lower weight. Individuals are intended to fulfill stress. The areas utilized are: point and pipe segments and tube segment which speak to the commonlyutilized segments in cross section transmission towers. The basic investigation and the completely Stressed plan are performed using STAAD ace 2006.finally come to the conclusion that the pinnacle with angle section and X-bracing has the more prominent diminished in weight after Optimization (achieving 21%).The pinnacle with pipe segment and X-supporting has an ideal Weight littler than the other segment shapes (around 22% of reduction.)Tube segment isn't Economic to use in this sort of transmission tower. The transmission tower with X bracing is Lighter than that with K-bracing with point, pipe and tube areas under breeze and seismic Load conditions.

Mr. Vijaykumar. P. Suryavanshi [2016]In this work an endeavor has been made that 220-KV twofold circuit Transmission Tower with X and K kind of supporting has been displayed using STAAD Pro. Static analysis has been improved the situation the pinnacle by considering Earth shake Zone III .The wind loads are computed utilizing IS 802(part1/sec1) by considering wind zone III. The towers are modeled with X and K bracing. And comparative study is done with respect to Nodal displacement, axial force, axial stress, maximum deflection, maximum compressive stress, and maximum tensile stress. Comparing the Steel take off Result X type bracing proves economic than K type of bracing.

3 MODELING AND ANALYSIS

In this present study220-KV double circuit Transmission-Tower with the combination of X and K type ofBracing has been modeled using Staad 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 I. The towers are modeled using parameter such as constant height, constant base width, and then the combination of X and K type of bracing.

3.1 Material Properties:

The material properties of Conductor and Earth wire are recorded as below in the table.These properties are used as a part of the estimation of Sag of the conductor and wind load Computation on Conductor and Earth wire.

Table 1. Material Properties.

S.NO	**Description**	**Conductor**	**Earth Wire**
1	Material	ACSR	GS
2	Name	ZEBRA	GSS
3	Stranding(alum)	54/4.13	-
4	Stranding(steel)	7/3.53	7/3.15
5	Stranding (optical fiber)	-	-
6	Diameter (mm)	31.77	9.45
7	C.S. Area (sq.mm)	597	54.55
8	Ultimate Tensile Strength (Kg)	13316	5600
9	Unit Weight (Kg/m)	1.998	0.428
10	Modulus of Elasticity (Kg/sq.mm)	6900	19631
11	Coeff. of Linear Expansion (/ °C)	19.3x10^-6	11.5x10^-6

3.2 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 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. Minimum Horizontal Spacing of conductor as per cl: 7.3.2.1, p.no 22 of IS-5613 part 2/sec1 1985

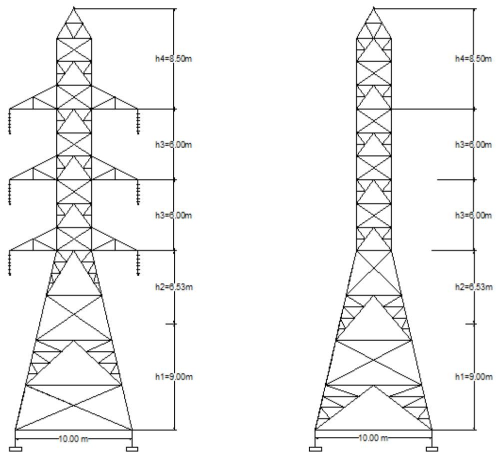


Fig 1. Tower configuration

3.3. Load Consideration:

a. Dead Load: Self weight of tower, weight of the conductor.
b. Live Load: As per cl: 12.2.3 IS 802(Part-l/Sec-1) is 3500N.
c. Wind Load: Wind load in terms of wind pressure depend on the Basic wind speed. Tower location: Vijayapur, Karnataka, INDIA ,wind zone I with basic wind speed (Vb=24.0m/sec.) and Design wind pressure (pd=354.6N/mm^2).
d. 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%.
e. Wind load calculation is done as per cl: 9.0, 9.1, 9.2, and 9.3, of IS 801 part1/sec 1.

3.4 Assignment Of Loads:

3.4.1 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.

3.4.2 Wind Load

Wind pressure is converted into joint load , it is applied by selecting each panel node and assigning as 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**.**

4 DISCUSSIONS AND RESULTS

The parameters of this study are,

1. Nodal Displacement

2. Axial forces.

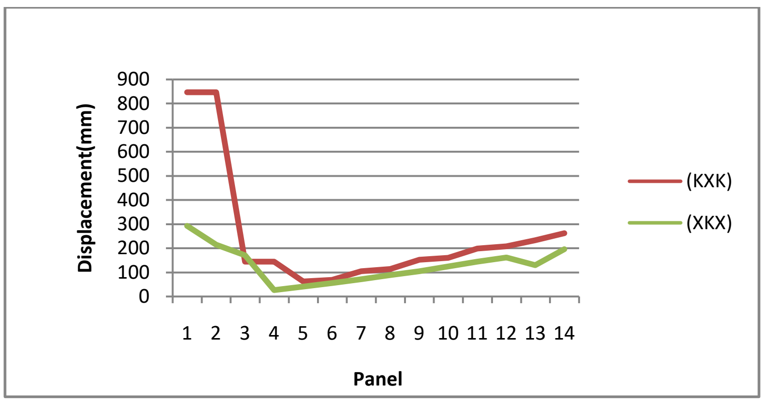
3. Maximum Deflection in the Tower Member.

4. Steel Take Off

4.1 Nodal Displacement in X direction

Table2.Nodal Displacement in X direction

PANEL	XKX BARCING (mm)	KXK BRACING (mm)
1	847.4	292.103
2	847.4	214.362
3	144.93	170.2
4	144.93	26.51
5	62.548	40.671
6	68.761	55.754
7	104.5	71.027
8	114.65	88.89
9	152.38	105.075
10	161.06	124.47
11	199.2	143.50
12	208.6	161.50
13	234.15	129.29
14	262.71	195.9

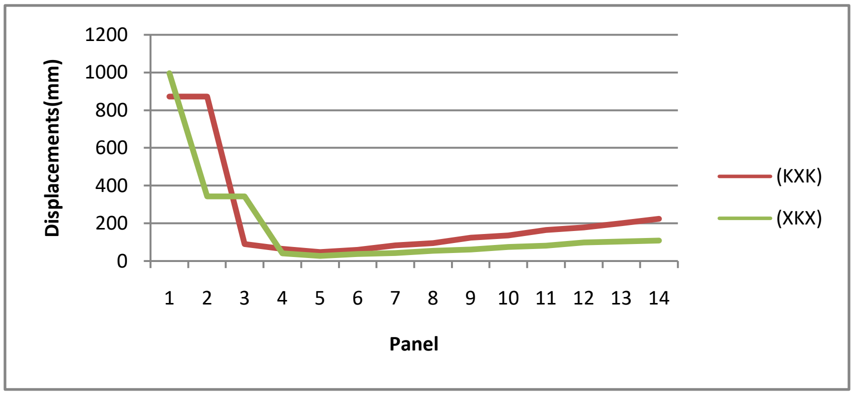


Graph 1 Nodal Displacement in x direction v/s Panel

4.*2 Nodal Displacement in Z direction*

Table 3 Nodal Displacement in Z direction

Panel no	XKX BARCING (mm)	KXK BRACING (mm)
1	872.40	995.7
2	872.40	342.9
3	90.913	342.945
4	65.9	41.45
5	48.595	27.758
6	59.643	38.376
7	84.27	43.19
8	95.97	54.76
9	124.84	62.28
10	137.50	75.10
11	165.7	82.36
12	178.89	98.19
13	200.36	104.8
14	224.79	108.651



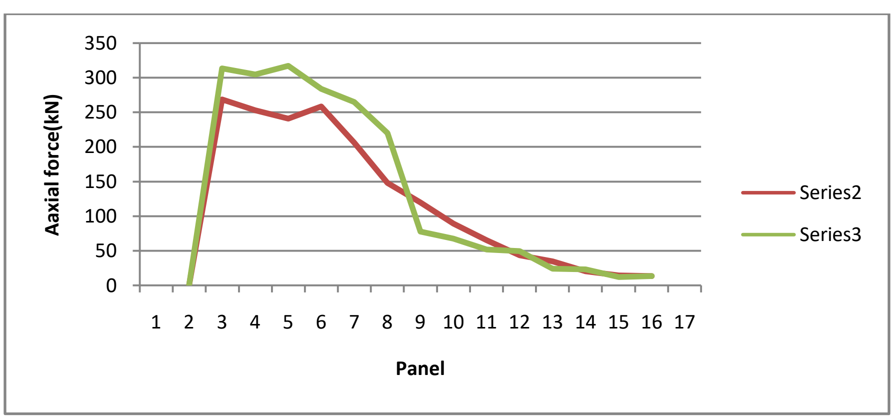
Graph2. Nodal displacement in z direction v/s Panel

4.3 Axial Forces

A sum of internal force whose resultant is a force acting along the longitudinal axis of a structural element or assembly. Table showing at axial forces different panels for X and K type of Bracing**.**

Table 4.Axial forces

Panel no	XKX BARCING (kN)	KXK BRACING (kN)
1	268.56	313.439
2	252.94	304.535
3	240.77	317.13
4	258.19	283.69
5	206.09	265.008
6	148.07	220.104
7	119.67	77.484
8	89.42	127.925
9	65.641	51.804
10	43.461	61.884
11	34.778	23.848
12	20.169	23.18
13	14.44	12.22
14	13.305	13.18



Graph 3. Axial force v/s Panel

4.4 Deflection

Defection is a degree to which a structural element is displaced under a load. Deflection for whole tower for combination of X and K Type of Bracing the results shows that the maximum Deflection is 115.292 mm for XKX type of bracing tower for considering all the load case and for KXK type of bracing tower is 155.540mm for considering all the load case.

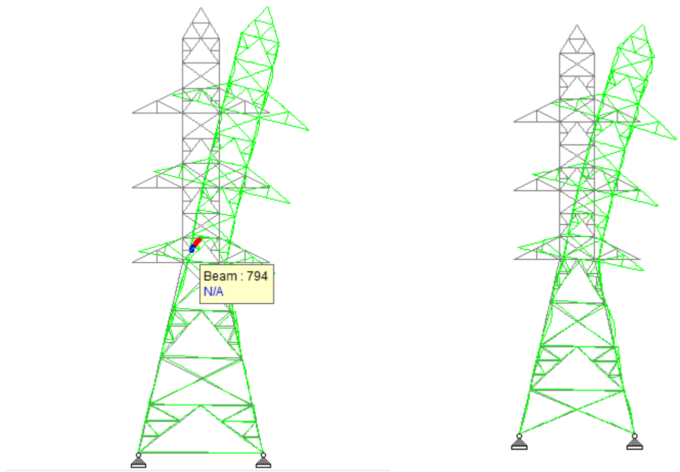
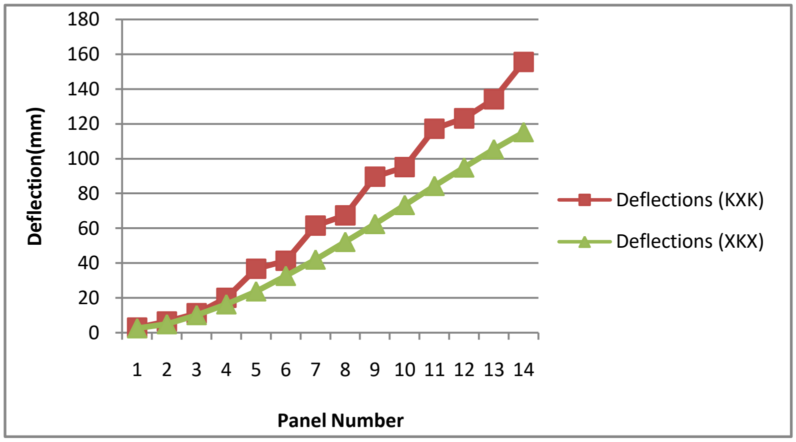


Fig2 Deflection of KXK and XKX type of bracing tower**.**

Table 5. Deflection of KXK and XKX type of bracing tower**.**

Panel no	Deflections(mm) (KXK)	Deflections(mm) (XKX)
1	2.968	2.7289
2	6.389	5.062
3	11.087	10.290
4	20.026	16.474
5	36.793	23.924
6	41.375	32.797
7	61.475	42.158
8	67.445	52.290
9	89.64	62.557
10	95.126	73.467
11	117.215	84.417
12	123.152	95.004
13	234.155	105.469
14	155.540	115.292



Graph 4. Defection v/s Panel

4.5 Steel Take Off

After finalizing the angle section for the tower member, Following table provides the information about the angle section, its length and its weight for the economical execution of transmission tower erection

Table 17.Steel take off for XKX bracing of tower

STEEL TAKE-OFF

PROFILE	LENGTH(METE)	WEIGHT(KN)
ST ISA70X70X8	16.00	1.303
ST ISA40X40X6	1013.29	34.795
ST ISA60X60X8	16.00	1.101
ST ISA90X90X8	47.87	5.075
ST ISA80X80X8	15.96	1.495
	TOTAL =	43.769

Table 18. Steel take off for XKK bracing of tower

ST ISA75X75X8	8.00	0.701
ST ISA40X40X6	557.27	19.136
ST ISA55X55X8	8.00	0.503
ST ISA80X80X8	31.91	2.991
	TOTAL =	23.330

5 CONCLUSION

1. Deflection value is quite higher i.e, 155.540 mm in case of transmission tower modeled with the combination of KXK bracing when compared with XKX bracing i.e., 115.292mm.
2. The permissible value of the deflection at the top of the tower that is at the height of 35.670 m is 390mm, hence it proves that the deflection of the tower with combination of bracing are well within the permissible value.
3. There is huge reduction in deflection in case of transmission tower modeled with the combination of bracing when compared with X (513.17mm) and K (585.7mm) bracing.
4. The transmission tower modeled with KXK bracing found to required lesser percentage of steel i.e.,46.6%, of XKX bracing Hence tower modeled with KXK type of bracing proves more economic.
5. Comparing the axial forces for the whole tower modeled with the combination of bracing proves that KXK bracing carries maximum axial load (313.439kN) as its consumes little amount of steel (23.3kN).
6. The XKX bracing carries axial force of 268.56kN with a steel take off of 43.769 kN because of higher sections of steel it distributes the forces among the elements. Comparing these results we can conclude that tower with KXK bracing is more stable and economic.

6 FUTURE-SCOPE

1. For the same Geometrical configuration, Transmission Tower can be analyzed for eccentric bracing.

2. For the same Geometrical configuration, Transmission Tower can be analyzed for different Wind and Earth Quake

3. For the same Geometrical configuration, Transmission Tower can be analyzed for combination of Bracing.

4. For the same Geometrical configuration, Transmission Tower can be analyzed for Tubular section.

5. Transmission Tower can be analyzed for different Base width.

6. Transmission Tower can be analyzed by taking unequal length of Conductor on both sides.

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