Scientific Journal of Impact Factor (SJIF): 4.72
e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 4, Issue 11, November -2017

COMPARATIVE STUDY BETWEEN CONVENTIONAL LATTICE TOWER & TUBULAR POLE FOR 765kV DOUBLE CIRCUIT MEDIUM DEVIATION ANGLE TOWER

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Abstract — *Lattice towers are the most commonly used medium for transferring electricity in the transmission network across our country. Whereas Tubular Poles are the most commonly used medium for transferring electricity in the transmission network in the developing countries. This project is a comparative study between the conventional lattice tower and the tubular pole for 765kV double circuit medium deviation angle tower with the exception of foundation design. The conventional lattice tower and the tubular pole are modelled and analyzed in STAAD PRO software. The maximum deflections and the weight of the towers are compared and conclusions are drawn in order to determine the advantages and disadvantages of both types of transmission towers.*

Keywords- *Lattice Tower, Tubular Pole, Comparison, Medium Deviation Angle Tower, Staad Pro.*

I. INTRODUCTION

Electricity is the most versatile & convenient form of energy. Per Capita consumption of electricity is considered to be the measuring stick for assessing the growth of economy of any state or a country. Power generation, Transmission & Distribution system is therefore growing exponentially all over the world. To meet the ever increasing power demand & for transporting power from very distantly located generating units in areas having concentration of coal or hydro potential, an efficient Transmission Network is required[1]. In many countries like the United States, Germany, France etc. Tubular steel poles are widely used whereas the lattice towers are most commonly used in the transmission system of India. This paper is an attempt to learn the various pros and cons of both types of transmission towers.

II. GENERAL CONSIDERATIONS FOR THE STRUCTURES

The base dimensions of the Lattice tower are determined to be 21.542m x 21.542m (Square base). Whereas the base dimension of the Tubular pole is found to be 7m (Circular base). Basic wind span was taken as 400m. Basic wind speed of 44m/s with open terrain with well scattered obstructions having height generally between 1.5m to 10m and return period of 150 years was considered. The conductor and ground wire properties are given below.

Table 1. Conductor and Ground Wire properties.

Wire Details	Conductor	OPGW
Name	ZEBRA	OPGW
Material	ACSR	GAL.STEEL
Alum. Strands (No/mm)	54/3.18	-
Diameter (mm)	28.62	12.5
Sectional Area (mm^2)	484.5	80.2
Unit weight (kg/m)	1.689	0.46
Ultimate Strength (kg)	13288.84	8555
E Value (kg/mm^2)	7034	13909
Alpha (/^oC)	$1.93E^{-5}$	$1.43E^{-5}$

III. METHODOLOGY

3.1. Lattice Tower.

The height of a lattice tower is proportioned considering the vertical and horizontal clearances of the Top conductor, Middle conductor and Bottom conductor as well as the sag and ground clearance. Preliminary design of the lattice tower namely base width and thickness of the pole are considered as per IS 802 Part 2. The conductor tensions as per sag tension calculations are considered for assessing tower loadings. The tower main members along with redundants are modelled as a 3d structure using beam elements. All the redundant members are treated as truss members and the primary members as beam elements. As the magnitude of the bending moments in primary members are insignificant, all the members are designed for axial forces as per the industry practices.

The tower loadings corresponding to 765 kV line with Zebra conductor configuration and associated insulators with wind zone 3 are calculated as per IS 802 & CBIP manual and the same is applied to appropriate points on the lattice tower. The lattice tower is then analysed for the Reliability condition, Security condition, Safety condition & Anti-Cascading condition. The tower body wind load calculations for wind incidence 0^o, 30^o & 45^o are calculated. Loading trees are calculated and drawn for the above loading conditions. All the loadings are applied as nodal loads (ex: peak, cross-arm tips) and tower body wind loads at peak, top cross-arms, middle cross-arms, bottom cross-arms and basic belt levels. The vertical loads corresponding to IS: 802 for maximum for compression and minimum for uplift. All the primary member sections (legs, bracings, cross-arms, peak, and belts) as per design are assigned for the 3D tower model. The design forces for primary members are designed for compression considering the appropriate effective lengths and uplift considering the net area of the section. Accordingly the bolts are designed considering the bearing, shear (single/double) and tension values.

3.2. Tubular Pole.

The height of a transmission line pole is proportioned considering the vertical and horizontal clearances of the Top conductor, Middle conductor and Bottom conductor as well as the sag and ground clearance. Preliminary design of the pole namely diameter and thickness of the pole are considered as per ASCE-52.The pole is modelled as '3d' tubular cantilever structure visualizing as triangular plate models using STAAD Pro software. As per the preliminary design, the pole is considered to be consisting of six sections along its height. The thickness of pole at these sections is considered as 16mm, 14mm, 12mm, 10mm, 8mm and 6mm along its height. The length of the tubular segments is considered as about 10m for ease of handling. Conventional cross arms are fitted to tubular pole. High Tension steel of f_y= 350N/m^2 material is adopted to the pole.

The body wind load is calculated as per IS 802 Part 2 and the same is applied to appropriate points on the pole. The pole is then analysed for the Reliability condition, Security condition, Safety condition & Anti-Cascading condition. After calculating the loadings as per the above conditions, the stresses in the peak of the tower, top conductors. Middle conductors, bottom conductors & base of the pole are calculated.

Figure 1. Process Flow Chart

IV. RESULTS & DISCUSSIONS

4.1. Sag Tension Calculations.

As explained earlier Sag Tension calculations for conductor & ground wire are the first step to be done during the tower design. The following are the sag tension calculations for conductor and ground wire.

Table 2. Sag Tension calculations for Conductor

Conductor								
Sl.no.	**Temp (^{o}C)**	**Wind Factor**	**Ice Thickness (cm)**	**Wind Pressure**	**Tension (kg)**	**Sag (m)**	**FOS Avail**	**Remarks**
1	0	0.36	0	57.60	4385	7.393	3.031	*
2	0	0	0	0.00	3355	9.663	3.961	
3	32	1	0	160.00	6975	4.648	1.905	
4	32	0	0	0.00	2925	11.084	4.543	
5	32	0.75	0	120.00	5774	5.615	2.302	
6	32	0.51742	0	82.79	4636	6.993	2.866	
7	85	0	0	0.00	2446	13.254	5.433	

* Indicates initial condition (22% of UTS)

Table 3. Sag Tension calculations for Ground Wire

Ground Wire								
Sl.no.	**Temp (^oC)**	**Wind Factor**	**Ice Thickness (cm)**	**Wind Pressure**	**Tension (kg)**	**Sag (m)**	**FOS Avail**	**Remarks**
1	0	0	0	0.00	1007	9.136	8.496	#
2	32	0.76	0	152.00	2738	3.360	3.125	
3	32	0.517	0	103.40	2105	4.371	4.064	
4	32	1	0	200.00	3317	2.774	2.579	
5	32	0.75	0	150.00	2713	3.391	3.153	
6	32	0	0	0.00	898	10.245	9.527	
7	53	0	0	0.00	840	10.952	10.185	

#Indicates initial condition (20% of UTS)

4.2. Deflection of Lattice Tower.

The deflected shape of lattice tower modelled in Staad Pro is given below.

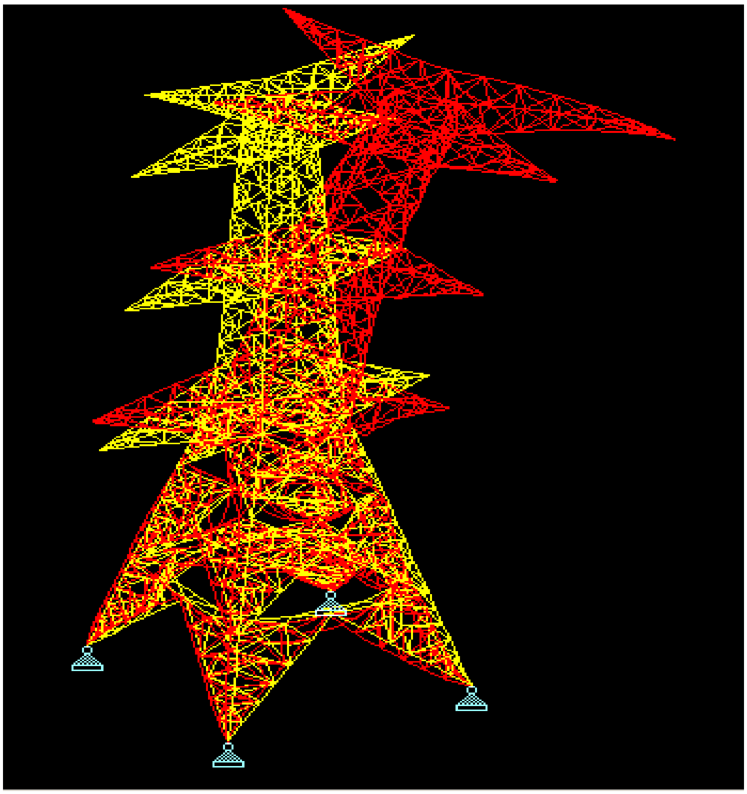

Figure 2. Deflected shape of Lattice Tower

The peak deflection values of the Lattice Tower are as follows:

Table 4. Peak Deflection values of Lattice Tower

Lattice tower					
Node	L/C	X-Trans mm	Y-Trans mm	Z-Trans mm	Absolute mm
39	20	7.926	3.611	13.168	15.787
39	19	7.723	3.165	13.169	15.591
41	31	7.632	-4.267	12.55	15.295
41	32	7.612	-3.9	12.548	15.186

4.3. Deflection of Tubular Pole.

The deflected shape of the tubular pole modelled in Staad Pro is given below.

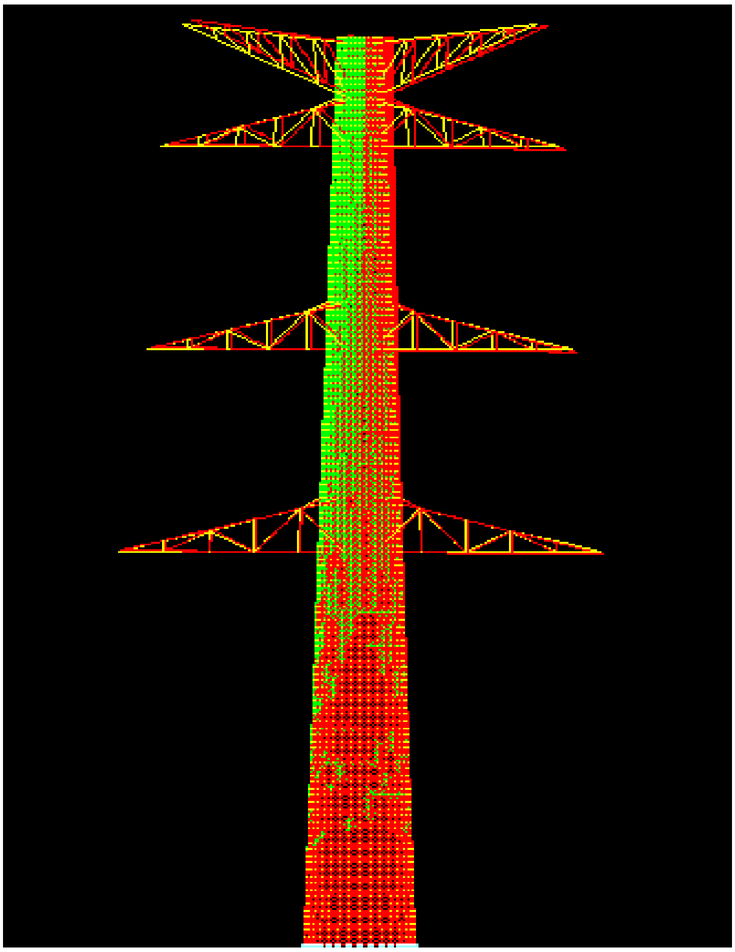

Figure 3. Deflected shape of Tubular Pole

Table 5. Peak Deflection values of Tubular Pole

Tubular Pole					
Node	L/C	X-Trans mm	Y-Trans mm	Z-Trans mm	Absolute mm
4322	20	659.7	239.7	939.0	1172.3
4376	31	644.7	-248.5	939.0	1165.8
4322	19	653.8	217.0	939.0	1164.5

V. CONCLUSIONS

For identical configuration (765 kV Double circuit 15^{o}-30^{o} transmission line deviation tower) and loadings (Wind Zone 3) as per Indian standards, the comparative study between conventional Lattice tower and Tubular pole was carried out and the following conclusions were drawn:

- The base dimensions of the Lattice tower are determined to be 21.542m x 21.542m (Square base).
- Whereas the base dimension of the Tubular pole is found to be 7m (Circular base) which is approximately one third the space occupied by the lattice tower.
- Hence Tubular poles are more preferable than lattice towers from the perspective of Right of Way constraints.
- Tubular Pole is elegantly designed and hence more aesthetically better than lattice towers.
- Wind load acting on the lattice tower body is 34.9 Tonnes which is more than that of tubular tower.
- The weight of the conventional lattice tower is 39 Tonnes and that of tubular pole is 98 Tonnes.
- Hence tubular pole is more expensive than lattice tower.

- The erection of the lattice tower is easier than tubular pole which requires large capacity cranes, more skilled man power and resources.
- Lattice tower is versatile for adoption in cross country area where as tubular pole is mainly suitable for areas with good accessibility for heavy machinery
- The deflection of lattice tower (15.787mm) is less when compared to that of tubular pole (1172.3mm).
- During heavy storms, cyclones lattice towers are more prone to failure than tubular poles due to large number of joints and members whereas tubular pole is a continuous structure with a minimum number of joints.
- Generally foundation costs for lattice towers are cheaper than that of tubular poles.

Tubular poles are preferred in many of the advanced countries where there is constraint for space and less Right of Way issues due to their compact design in spite of higher cost.

V. FUTURE SCOPE

- Independent India has witnessed a phenomenal rise in Power Generation, Transmission & Distribution over the years. The pre-independent generation was 1362 MW.

- By the end of the XI Plan (March 2012), the power generation capacity of India was 1,99,877 MW.

- The generation capacity addition planned for 12^{th} and 13^{th} plan periods are 1,18,537 MW and 1,16,900 MW respectively.

- India is a developing country. With the growth in population and technology the demand for electricity is ever increasing.

- No matter the source of energy generation, the electricity generated will always need the transmission network to transfer that energy to commercial and domestic uses. Hence this is an ever green industry and thus it has an endless potential.

- Hence this project has been developed to compare the conventional lattice towers which are mostly used in our country with the tubular poles which are used in many developed countries to develop a more reliable and economical Transmission Network.

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