IJNRD.ORG ISSN : 2456-4184

INTERNATIONAL JOURNAL OF NOVEL RESEARCH AND DEVELOPMENT (IJNRD) | IJNRD.ORG

An International Open Access, Peer-reviewed, Refereed Journal

Comparative Study of Three-Legged Lattice Transmission Tower Having Angle Section and Closed Hollow Section

[1]Siddharth Shah, [2]Paresh Mistry, [3]Subhrata Biswal,

[1]Assistant Professor, [2] Assistant Professor, [3] Assistant Professor

[1]Civil Engineering Department, School of Engineering,

[1] P P Savani University, Surat, India

Abstract: Performing dynamic analysis is essential for the safe and cost-effective design of transmission line towers due to their critical importance. This analysis must include both structural and electrical considerations to ensure optimal performance. Achieving economic efficiency in transmission towers involves utilizing various configurations and bracing types. This study focuses on the analysis and design of a standard 400kV double-circuit transmission line tower with a three-legged configuration, considering dynamic loads such as wind, earthquakes, and snow. The analysis and design are conducted using STAAD.PRO software. The transmission tower in question is a suspension tower with two deviations, located in a flat landscape with minimal obstructions. The primary load combination that results in the maximum deflection of the member involves the scenario of a broken wire in conjunction with the anti-cascading condition. In this context, the impact of wind load is more significant than that of earthquake load, while the influence of snow on the tower is negligible.

***Key words*: ** Transmission line tower, Close hollow section, Deflection

INTRODUCTION

The escalating demand for electrical power worldwide underscores the imperative of efficiently distributing electricity across all sectors of society. Transmission line towers emerge as indispensable infrastructural elements facilitating this vital transfer of electricity. Consequently, there has been a surge in power station construction and the subsequent expansion of power transmission lines from generating stations to various destinations. It is imperative that transmission lines are stable and meticulously engineered to withstand natural disasters without failure, adhering to both national and international standards. Factors such as conductor cross-sections, conductor spacing, and the positioning of ground wires relative to conductors dictate the design of towers and foundations. While transmission lines are typically engineered to withstand wind and ice loads in the transverse direction, seismic loads also merit attention due to the potential for heightened forces and stress on transmission line towers and cables during ground motion. The primary concern during severe earthquakes is ensuring that large displacements do not cause cables to come into contact with each other or their surroundings. Hence, robust design and adherence to stringent safety protocols are paramount to safeguarding transmission line infrastructure and ensuring uninterrupted electricity supply, particularly in regions prone to seismic activity.

Benefits of Three-Legged Lattice Transmission Towers with Angle Section and Closed Hollow Design

1. **Strength and Stability**:
   The combination of three legs, angle sections, and closed hollow design results in a tower structure with high strength and stability, capable of withstanding various external forces.
2. **Cost-effectiveness**:
   By optimizing the design with angle sections and closed hollow members, the overall material usage and manufacturing costs are reduced without compromising structural integrity.
3. **Durability**:
   The closed hollow design of the tower members offers protection against corrosion and environmental degradation, prolonging the lifespan of the transmission tower.

4. **Easy Maintenance**:
   The design simplifies maintenance activities as closed hollow sections are less prone to debris accumulation and require minimal cleaning.

STRUCTURAL ANALYSIS AND DESIGN CONSIDERATIONS FOR THREE-LEGGED LATTICE TRANSMISSION TOWERS WITH DIFFERENT SECTIONS

Three-legged lattice transmission towers are a common sight in the field of electrical transmission and distribution. These towers play a critical role in supporting overhead power lines, ensuring the efficient and reliable supply of electricity to various regions. When designing these structures, engineers need to carefully consider various factors to ensure the towers can withstand environmental loads, such as wind and ice, as well as sustain the weight of the power lines.

Design Considerations: Material Selection: The choice of material for constructing three-legged lattice transmission towers is crucial for ensuring structural integrity. Common materials used include steel and aluminium. The material selection is based on factors such as strength, corrosion resistance, and cost.

Tower Configuration: The design of three-legged lattice transmission towers involves selecting appropriate tower configurations based on factors like the terrain, span length, and expected loads. Engineers need to carefully consider whether a self-supporting or guyed tower configuration is more suitable for the specific project requirements.

Section Selection: One of the key design considerations for three-legged lattice transmission towers is the selection of tower sections. Engineers must decide between using angle sections or closed hollow sections based on factors such as structural strength, wind resistance, weight-bearing capacity, and ease of construction.

Spacing and Bracing: The spacing between tower elements and the design of bracing systems are critical for ensuring the overall stability and load-bearing capacity of three-legged lattice transmission towers. Proper spacing and bracing help distribute loads effectively and prevent structural failures.

Foundation Design: The design of foundations for three-legged lattice transmission towers is fundamental to ensuring the stability and longevity of the structure. Engineers must consider factors such as soil conditions, tower height, and expected loads when designing the tower foundations.

Structural Analysis: Load Analysis: Structural engineers conduct load analysis to determine the various types of loads that the three-legged lattice transmission tower will be subjected to, including dead loads (weight of the tower and equipment), live loads (wind, ice, and environmental factors), and dynamic loads (due to vibrations or seismic events).

RESEARCH METHODOLOGY

STAAD.PRO is a structural analysis and design software initially developed by Research Engineers International in Yorba Linda, CA. In late 2005, Bentley Systems acquired Research Engineers International. In this study, STAAD.PRO is used to model a three-legged transmission line tower, incorporating angle and closed hollow sections. Elevations for all dimensions, from tower height to various stages, are created using AutoCAD. Wind loads on the tower body, conductor, ground wire, and insulator are manually computed according to IS 802 Part 1, Section 1, and applied to the STAAD.PRO model. Earthquake loads are applied following IS 1893 Part 4, and snow loads are applied per IS 875 Part 4. Various load combinations, as specified in Indian Standards, are developed, and subsequent analyses are conducted. The study includes calculating deflections for the top node of both three-legged transmission towers.

Fig.1 Three-legged transmission line tower

TOWER CONFIGURATION CALCULATION

Total height of the transmission tower = h1 + h2 + h3 + h4 (m) The minimum ground clearance (h1): For 400 KV = 8.84 (m) Maximum sag of the lowermost conductor (h2):

Max Sag = WL2/8PH

Where,

PH = horizontal component of tension in conductor (kN) W = unit weight of conductor (kN/m)

L = weight span of conductor (m)

T_2^2 [(T_2 – T_1) + {W_1^2 x L^2 x E x A / 24T_1^2} + {(t_2 – t_1) x α x E x A}] = (W^2 x L^2 x E x A) /24 $_2$

Where,

T_1 = Permissible tension in conductor (kN) T_2 = Tension in cable in mid-span (kN)

A = Effective cross sectional area (mm^2) (t_2 - t_1) = Temperature variation (/·C)

E = Modulus of elasticity = 7.036 x 10^6 (Kg/mm^2)

α = Coefficient of linear expansion = 11.3 x 10^{-6} (/·C)

W_1 = Weight of conductor at minimum temperature and wind (kN/m) W_2 = Self weight of conductor (kN/m)

T_2^2 [(T_2 – T_1) + {W^2 x L^2_1 x E x A / 24T^2} + {(t_2 – t_1) x α x E x A}] = (W^2 x L^2 x E x A) /24$_2$

T_2^2 [(T_2 – 161.20) + {0.0268^2 x 400^2 x 7.036 x 10^6 x 597 / 24 x 161.20^2 x 1000} + {(50 – 0) x 11.3 x 10^{-6} x 7.036 x 10^6 x 597}] = (0.02004^2 x 400^2 x 7.036 x 10^6 x 597) /24 x 1000

T_2 = 60.757 KN = P_H

M57ax Sag = $WL^2/8P_H$

$= 0.02004 \times 400^2 / 8 \times 60.757$

$= 7$ m

Vertical spacing between power conductor for 400 m span = 8 m Vertical spacing between ground wire and conductor = 7.8 m

Total height of tower = h1 + h2 + h3 + h4

= 9 + 7.5 + 8 + 7.8

= 42.5m

The base width to total tower height is about 1/3 to 1/6 = 1/5 x 38 m = 8m.

RESULTS AND DISCUSSION

The table and Fig. show the deflection of top node of the transmission line tower for three-legged tower. The deflection due to snow load is very small as compared to wind and earthquake load.

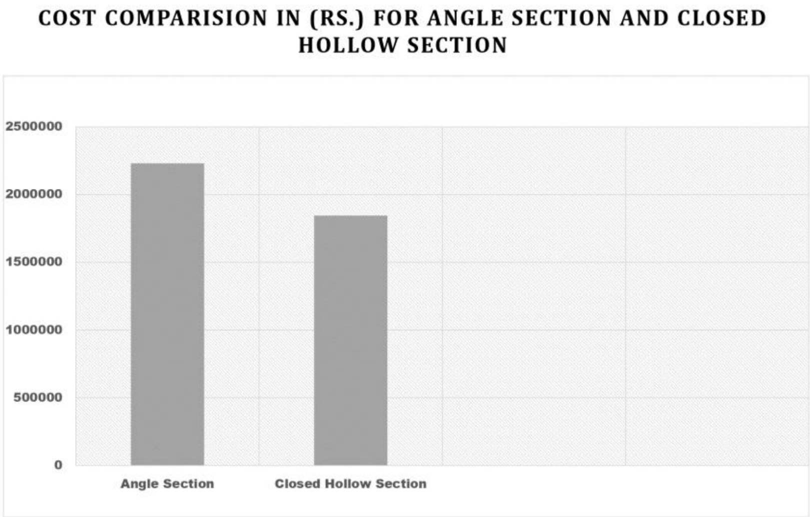
Table.1 Deflection of top node of tower for angle section and closed hollow section

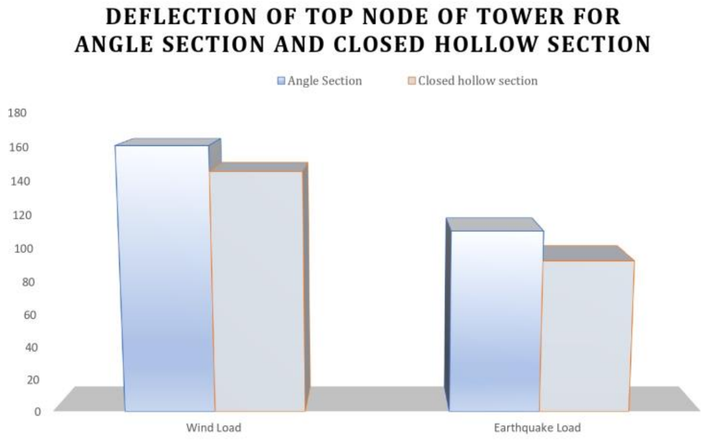
	Deflection for top node (mm)	
	Wind load	**Earthquake load**
Angle section	160.97	110.41
Closed hollow section	145.90	92.62

Table.2 Cost comparison of angle section and closed hollow section

	Weight (kN)	Cost (Rs/Kg)	Total cost (Rs)
Angle section	230.32	95	2231179
Closed hollow section	190.49	95	1845280

Based on the findings of this study, it is evident that the deflection analysis of the upper node of a transmission line tower with a three-legged closed hollow section exhibits a lower value compared to that of an angle section. The allowable deflection for all transmission line towers under wind loading is limited to H/100 or 1% of the total height. For earthquake loading, the maximum allowable deflection is capped at $D_{max} = 0.003 \times h$, where h represents the height of the tower.





CONCLUSION

- The optimizations in terms of deflection at the top and material cost are obtained in the case of three-legged closed hollow section tower as compared to the angle section transmission tower.
- The deflection for top node of the transmission tower during wind load has greater impact than that of earthquake load. So, wind load case governs more for structural design as compared to the earthquake.
- The deflection of the top most nodes come out to be permissible limit for three-legged angle section and closed hollow section but tower having closed hollow section is economical as compared to tower having angle section.
- The deflection of top node under wind load using conventional angle section for three-legged transmission line tower is 20.47 % more than earthquake load and for closed hollow section is 12.65 % more than earthquake load.
- The deflection of top node under earthquake load using angle section is 3.15 % more than closed hollow section and for wind load using angle section is 14.85 % more than closed hollow section.
- The cost of three-legged transmission tower having angle section is 17.15 % more as compared to three-legged tower having closed hollow section.

REFERENCES

[1] Alaa C. Galeb and Ahmed Mohammed Khayoon "Optimum Design of Transmission Towers Subjected to Wind and Earthquake Loading" Jordan Journal of Civil Engineering,Volume 7, No. 1, 2013

[2] Behrouz Asgarian, Soheil Dadras Eslamlou, Arash E. Zaghi, Masoud Mehr "Progressive collapse analysis of power transmission towers" Journal of Constructional Steel Research Volume123 (2016)

[3] C. Preeti and K. Jagan Mohan "Analysis of Transmission Towers with Different Configurations" Jordan Journal of Civil Engineering Volume 7, No. 4, 2013.

[4] Dr. Ramchandra & Virendra Gehlot," Design of Steel Structure – 2" 9th revised and enlarged edition, 2008.

[5] Gopi Sudam Punse "Analysis and Design of Transmission Tower" International Journal Of Modern Engineering Research (IJMER) ISSN: 2249–6645 Vol. 4 Iss. 1 Jan. 2014.

[6] Ileana Calotescu, GiovanniSolari Alongwind load effects on free-standing lattice towers" Journal of Wind Engineering and Industrial Aerodynamics volume 155(2016).

[7] Indian Standards," Use of structural steel in overhead transmission line tower", IS 802 part 1, Sec 1, 1992, (Material and loads) Bureau of Indian Standards, New Delhi.

[8] Indian Standards," Use of structural steel in overhead transmission line tower", IS 802 part 1, Sec 2, 1992, (Permissible stress) Bureau of Indian Standards, New Delhi.

[9] Indian Standard," Criteria for earthquake resistant design of structures", IS 1893 part 4, 2005, (Industrial structures including stack-like structures) Bureau of Indian Standards, New Delhi.