

Design of 132 kV Transmission Line Tower with Guy Wire Support and Design Comparison of Self Supporting Tower

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ABSTRACT: This Project deals with the analysis and design of a 132kV single circuit guyed transmission tower and its comparison with a self-supporting transmission tower of equivalent line. For the guyed tower design considered in this project, project costs are approximately 15-20% less than that of a self-supporting equivalent line. The towers are analysed using STAAD Pro v8i and designed in accordance with IS 802 (Part 1/Sec 2) - 1992. The geometries of the towers are arrived in accordance with the Electrical clearances as per IS 5613(Part 2/Sec 1) - 1985. The maximum compression and tension forces on each member are obtained. The compression and tension capacity of the members are calculated. The size of the member is optimized such that the capacity of the member is more than the member force. Both the guyed and self-supporting towers are designed and their weights are obtained. Pedestal foundation is adopted for Guyed tower; pad and chimney type foundation is adopted for self-supporting tower. The member forces, tower weights, support reactions and foundation volumes of both the towers are compared.

KEYWORDS: Transmission Line tower, Guy Wire Support, Self-supporting tower.

I. INTRODUCTION

The main supporting unit of overhead transmission line is transmission tower. Electric power is today playing an important role in the life of the community and development of various sectors of economy. Developing countries like India are therefore giving a high priority to power development programs. In fact, the economy is becoming increasingly dependent on electricity as a basic input. This in turn has led to the increase in power generation and their capacities and consequent increase in power transmission lines from the generating stations to the load centres. With higher power generation required the sub-distribution system's capacity is also increased, 132kV single circuit lines are now majorly used to distribute power over various parts of India. Power transmission can be done either with overhead lines or with underground cables. Transmission of power through cable is uneconomical. Therefore overhead lines are predominantly used. The design of Power Transmission line tower depends on, voltage that needs to be transmitted, location of tower and its environment, wind zone, deviation angle and material specification. These towers are galvanized to protect the steel from corrosion. The galvanizing coating thickness depends on the weather conditions at the location of tower.

II. OBJECTIVE OF THE PROJECT

The objective of this project is to design an economical and safe tower with the given tower specifications. Therefore a guyed transmission tower is compared to that of a self-supporting tower of same specifications.

Guyed towers utilize less steel and has a very small footprint as it relies on guy wires in tension to support the structure and any unbalanced tension load from the conductors. Therefore it saves money in material and installation costs.

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A guyed tower can be structurally advantageous during a catastrophic or major weather event. The guy wires allow the tower to deflect much more than a self-supporting tower, thus reducing stress on the tower and dissipating the energy safely.

III. LOADS ACTING ON TOWER

The loads acting on the structure are calculated in three directions: vertical, transverse, and longitudinal. The transverse loads are perpendicular to the line, caused due to component force of tension in wire due to angle of deviation of tower line and the longitudinal loads act parallel to the line which generally occurs when a wire breaks.

Body wind Load: The wind acting on the tower body can be calculated only when the tower outline diagram is finalized. The tower is divided into number of panels and wind force acting at each height is calculated. The wind acting on tower body depends upon the area of panel exposed to the wind and the height of panel from ground level. The body wind acting on the exposed area of the members is calculated as below.

Step 1: Separation of whole tower into panels

Step 2: Calculation of exposed area of all members

Step 3: Calculation of the C.G of the individual blocks of the tower

Step 4: Calculation of the circumscribed area of block shape

Step 5: Calculation of solidity ratio (Projected area/Circumscribed area)

Step 6: Identify the drag coefficient from Table 5 of IS 802 (Part 1/Sec 1) - 1995

Step 7: Identify the gust response factor from Table 6 of IS 802 (Part 1/Sec 1) - 1995, according to the height of C. G of a block from ground level

Step 8: Calculation of total wind load

Step 9: Separation of Loads at the top and Bottom of block based on the C. G of the block

Factor of safety: The factors of safety adopted in the designs have a great bearing on the cost of structures and they have to be chosen so that the structures prove economical as well as safe and reliable. Rule 76(1)(a) of the Indian Electricity Rules, 1956, specifies the following factors of safety, to be adopted in the design of steel transmission line towers:

- under normal conditions 2.0
- under broken-wire conditions 1.5

IV. REVIEW OF LITERATURE

The majority of failure of transmission line towers shall be avoided by non-linear method of analysis and design. The results of non-linear analysis of towers converged with the experimental results than the linear analysis. The secondary members lead to overall economy of the towers, since they reduce the weight of the tower. The individual member failure of the transmission line towers is more frequent than the entire structures failure due to natural disasters. The guyed masts are more economical than the square and triangular based towers. Installing a GTS will restrict the vertical deflection and settlement.

V. TOWER MODELLING

The towers are modelled in Staad.Pro. The towers are separated into panels consisting of various members and trial sections for analysis are assigned.

Positioning Of Guy Wires

As we know that the guy tower relies on the guy wires to safely dissipate the forces that are acting on the tower. So the attachment point of guy wire on the tower and the angle in which it is attached to the horizontal plane plays an important role in dissipating the forces on the tower. At critical loading conditions (or during broken wire conditions), a large torsion occurs at the cross arm portion, so it's best to attach guy wire at that portion as shown below Fig. 5.1



Fig 5.1 Guy wire attachment in a guy tower

Next factor is the angle the guy wire makes with respect to the vertical and horizontal plane. This affects both the load flow in the tower and the right of way of the tower. Many trials have been made changing the angles respective with each other and the optimized angle is chosen as 50° with horizontal and 50° with vertical. The towers are modelled based on outline diagram. The STAAD.Pro models are in the following figures, Fig. 5.2.

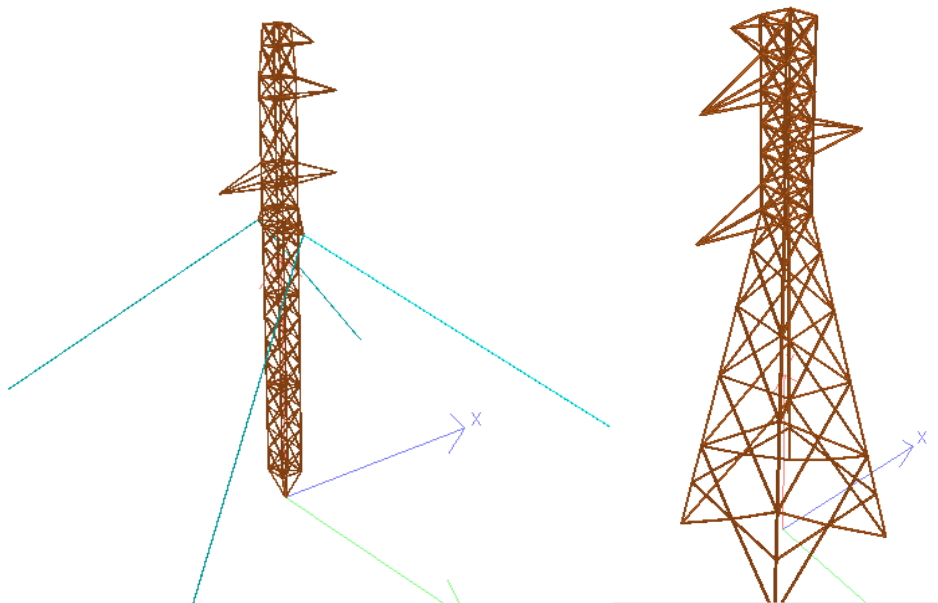


Fig. 5.2 (a) Guy supported Tower Model 5.2(b) Self-supporting Tower Model

5.3 Loading on the Model

The loads on conductor, insulator, and ground wire are applied in their attachment points as nodal loads based on the loading tree diagrams. The loads are applied on the associated nodal points on the tower model in transverse, vertical, and longitudinal directions (F_x , F_y , and F_z). The combination of load cases are generated based on the broken wire conditions and min/max spans.

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Table4.2 Loading Combinations as per IS 802(part1/sec2)

S.no	Load Combinations based on IS 802 (part 1/ section 2)
1	1.1 DL + 2 BWT/BWL + 2 RC (max/min)
2	1.1 DL + 1.5 BWC (C1/C2/C3) (max/min)
3	1.1 DL+ 1.5 BWC (E1/E2) (max/min)
4	1.1 DL + 1.5 SC (max/min)

The Body wind loads and the Loads on wire acting on the tower model is shown below **Fig 5.3 and Fig 5.4.**

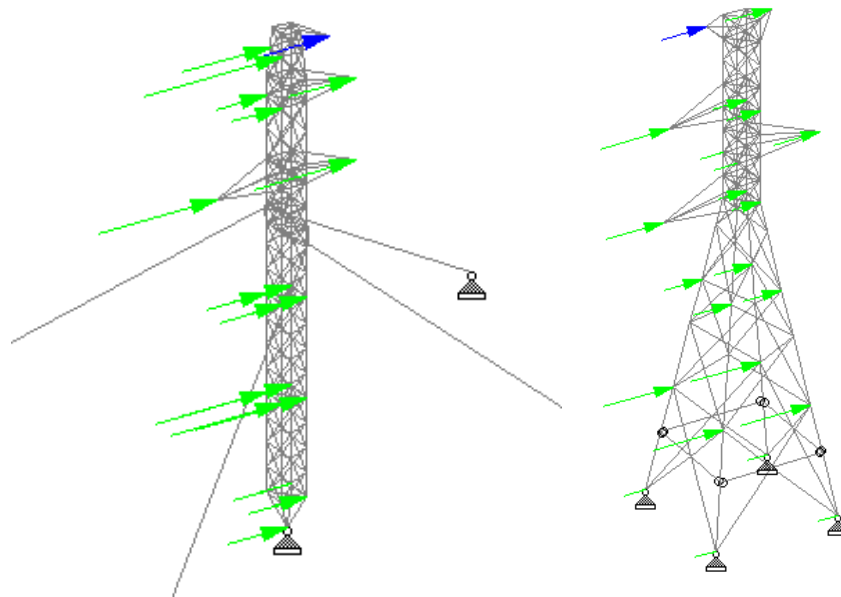


Fig. 5.3 Body Wind on Guy supported and Self-supporting Tower

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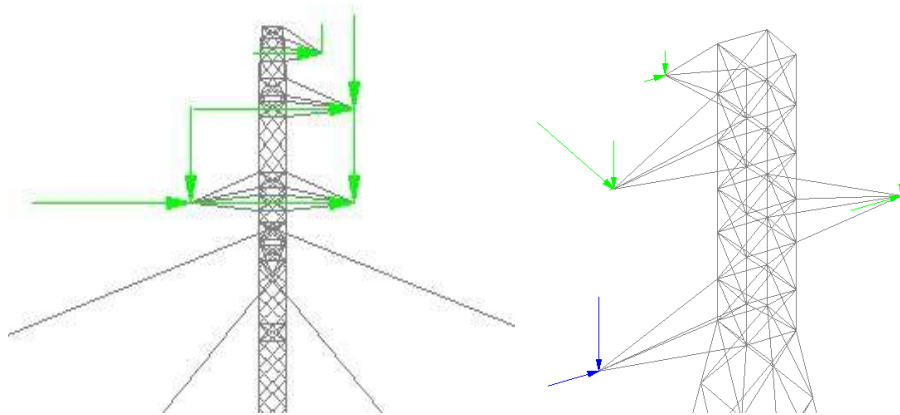


Fig. 5.3 Vertical, Transverse and Longitudinal loads on tower

VI. ANALYSIS AND DESIGN OF TOWERS

- ▶ Finding Axial forces in each member
- ▶ Choosing a section (ISA-equal angles)
- ▶ Checking the adequacy of the section
- ▶ Choosing trial sections for economic design
- ▶ Design of Bolts
- ▶ Design of redundant members

VII. CONCLUSION

The guy supported tower is an alternative to self-supporting tower when adequate right of way is not available. The overall weight of the guy supported tower is more; the cost of the guy supported tower with its foundation will be high. Hence, the 132 kV guy supported tower provides a right alternative when the available right of way is less than the required right of way of 27 m. The geometry of the tower is fixed, and trial and error method of analysis is performed. Then the design of the tower is done based on IS 802. The approximate weight of the guy supported tower is 4217 kg and the approximate weight of the self-supporting tower is 6459 kg. The support reactions for the guy supported tower is more than the self-supporting tower; since heavy angle sections are used as leg members for guy supported tower. Since the support reactions for guy supported tower raft foundation is adopted, and individual pad and chimney type foundation is used for self-supporting tower.

REFERENCES

- [1] Alam M. J. and Santhakumar, A. R. 'Reliability Analysis and Full Scale Testing of Transmission Tower', Journal of Structural Engineering © ASCE., Vol. 122, No. 3, pp. 338-344,1996
- [2] Albermani F., Chan R. W. K., and Kitipornchai S. 'Failure analysis of transmission towers', 'Engineering Failure Analysis', © ELSEVIER., Vol. 16, pp. 1922-1928,2008
- [3] Alian Peyrot and Brian McDonald 'Sag-Tension Calculation Valid for any Line Geometry', Journal of Structural Engineering © ASCE., Vol. 116, No. 9, pp. 2374-2387,1990.
- [4] Andre Laneville., Frederic Legeron., Minch Khue Tran., and Simon Prud'homme. 'Wind Force on Single and Shielded Members in Lattice Structures', Journal of Wind Engineering and Industrial Aerodynamics © Elsevier., Vol. 124, pp. 20-28,October, 2013.
- [5] CBIP – Central Board of Irrigation and Power manual, 1998.
- [6] Davidson A., David V. Rosowsky M., Haibin Liu., Isaac Sarpong K. S. M., and Peter Sparks M. 'Electrical Power Distribution System Performance in Carolina Hurricanes', Natural Hazards Review © ASCE., Vol. 4, No. 1, pp. 36-45,2013.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

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- [7] Edwin H., Gaylord., and Gene M. Wilhoite. 'Transmission Towers: Design of Cold-Formed Angles', Journal of Structural Engineering © ASCE., Vol. 111, No. 8, pp. 1810-1825,1985.
- [8] Fengli Yang., Junke Han., Jingbo Yang., and Zheng Li. 'Some Advances in the Applications of Weathering and Cold-Formed Steel in Transmission Tower', Journal of Electromagnetic Analysis and Applications © Scientific Research Publishing., Vol. 1, pp. 24-30,2009.
- [9] Gopi Sudam Punse. 'Analysis and Design of Transmission Tower', International Journal of Modern Engineering Research (IJMER)., Vol. 4, No. 1, pp. 116-138,2014.
- [10] Holmes J. D. 'Recent Developments in the Specification of Wind Loads of Transmission Lines', Journal of Wind and Engineering., Vol. 5, No. 1, pp. 8-18,2008.
- [11] IS: 802 (Part1/Sec1): – Use of structural steel in overhead transmission line towers – Code of practice. Part 1 – Materials, Loads and Permissible Stresses. Section 1 – Materials and Loads,1995.
- [12] IS: 802 (Part1/Sec2):– Use of structural steel in overhead transmission line towers – Code of practice. Part 1 – Materials, Loads and Permissible Stresses. Section 2 – Permissible Stresses,1992.
- [13] IS: 808: – Dimensions for Hot Rolled Steel Beam, Column, Channel and Angle Sections,1989.
- [14] IS: 2062: – Steel for General Structural Purposes – Specification,1999.
- [15] Knight G. M. S and Santhakumar A. R. 'Joint Effects on Behaviour of Transmission Towers', Journal of Structural Engineering © ASCE., Vol. 119, No. 3, pp. 698-712,1993.
- [16] Kok-Kwang Phoon M.ASCE., Kulhawy Fred H. F.ASCE., and Mircea Grigoriu D. F.ASCE. 'Development of a Reliability-Based Design Framework for Transmission Line Structure Foundations', Journal of Geotechnical and Geoenvironmental Engineering © ASCE., Vol. 129, No. 9, pp. 798-806,2003.
- [17] Li Sun and Qiang Xie 'Experimental Study on the Mechanical Behaviour and Failure Mechanism of a Latticed Steel Transmission Tower', Journal of Structural Engineering © ASCE., Vol. 139, No. 6, pp. 1009-1018,2013.
- [18] Mohan S. J., Rahima Shabeen S., and Samuel Knight G. M. 'Behaviour of Cold Formed Lipped Angles in Transmission Line Towers', Thin-Walled Structures © ELSEVIER., Vol. 44, pp. 1017-1030,2006.
- [19] Napa Prasad Rao., Samuel Knight G. M., Lakshmanan N., and Nagesh Iyer R. 'Effect of Bolt Slip on Tower Deformation', Practice Periodical on Structural Design and Construction © ASCE., Vol. 17, No. 2, pp. 65-73,2012.
- [20] Peng Zhang., Gangbing Song., Hong-Nam Li M., You-Xin Lin. 'Seismic Control of Power Transmission Tower Using Pounding TMD', Journal of Engineering Mechanics © ASCE., Vol. 139, No. 10, pp. 1395-1406, 2013.
- [21] Prasad Rao N., Kalyanaraman V. 'Non-linear Behaviour of Lattice Panel of Angle Towers', Journal of Constructional Steel Research © Elsevier., Vol. 57, pp. 1337-1357,2001.
- [22] Prasad Rao N., Samuel Knight G. M., Seetharaman S., Lakshmanan N., and Nagesh Iyer R. 'Failure Analysis of Transmission Line Towers', Journal of Performance of Constructed Facilities © ASCE., Vol. 25, No. 3, pp. 231-240,2011.
- [23] Santhakumar A. R. and Murthy S. S. 'Transmission Line Structures', McGraw-Hill Book Co,2011.
- [24] SP: 6 (1): – Handbook for Structural Engineers. 1. Structural Steel Sections,1964.
- [25] SP: 16 – Design Aids for Reinforced Concrete to IS: 456 – 2000.