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# TORSIONAL ANALYSIS AND DESIGN OF TRANSMISSION LINE STEEL TOWER

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**Abstract -** Transmission line towers carry heavy electrical transmission conductors at a sufficient and safe height from ground. In addition to their self-weight they have to withstand all forces of nature like strong wind, earthquake and snow load. Therefore transmission line towers should be designed considering both structural and electrical requirements for a safe and economical design. This study focuses Estimation of a feasible transmission line tower for different wind speed by designing transmission line tower with hot rolled sections and compare three types of bracings. Finally, the optimal design of transmission tower using hot-rolled steel is compared for wind speed.

**Key Words:** Transmission tower, wind speed, analysis, design, staad-pro.

## I. INTRODUCTION

Transmission tower lines are one of most important life-line structures. Transmission towers are necessary for the purpose of supplying electricity to various regions of the nation .This has led to the increase in the building of power stations and consequent increase in power transmission lines from the generating stations to the different corners where it"s needed. Transmission line should be stable and carefully designed so that they do not fail during natural disaster. It should also conform to the national and international standard. In the planning and design of a transmission line, a number of requirements have to be met from both structural and electrical point of view. From the electrical point of view, the most important requirement is insulation and safe clearances of the power carrying conductors from the ground. The cross-section of conductors, the spacing between conductors, and the location of ground wires with respect to the conductors will decide the design of towers and foundations. The major components of a transmission line consist of the conductors, ground wires, insulation, towers and foundations. Most of the time transmission lines are designed for wind and ice in the transverse direction. However, the Indian Sub-continent is prone to moderate to severe earthquakes seismic loads may be important because the transmission line towers and the cables may be subjected to higher force and stressed during ground motion. However, the major concern of the transmission line during high earthquakes may be that the large displacements do not causes the cables to touch each other or any surrounding objects, causing power failure and accidents. Therefore, earthquake forces may be important in design in high earthquake zones of the country.

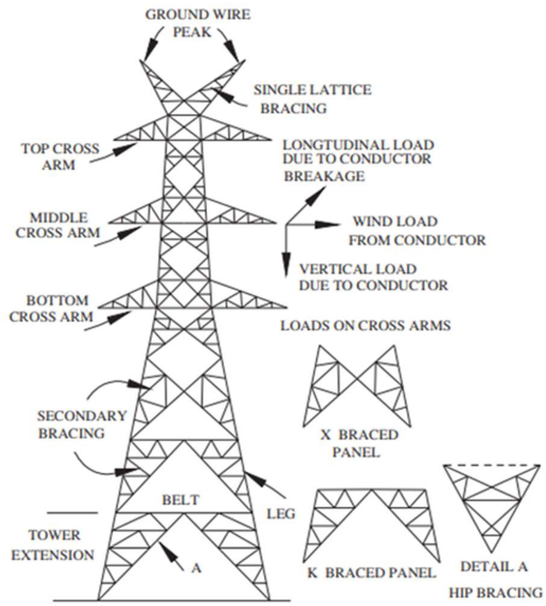


Fig 1. Double Circuit Transmission Line Tower (Typical).

The advancement in electrical engineering shows need for supporting heavy conductors which led to existence of towers. Towers are tall structures, their height being much more than their lateral dimensions. These are space frames built with steel sections having generally an independent foundation under each leg. The height of tower is fixed by the user and the structural designer has the task of designing the general configuration, member and the joint details (John D Holmes). A high voltage transmission line structure is a complex structure in that its design is characterized by the special requirements to be met from both electrical and structural points of view, the former decides the general shape of the tower in respect of its height and the length of its cross arms that carry electrical conductors (Visweswara Rao, G 1995).

## II. INDIAN SCENARIO

India has a large population residing all over the country and the electricity supply need of this population creates requirement of a large transmission and distribution system. Also, the disposition of the primary resources for electrical power generation viz., coal, hydro potential is quite uneven, thus again adding to the transmission requirements. Transmission line is an integrated system consisting of conductor subsystem, ground wire subsystem and one subsystem for each category of support structure. Mechanical supports of transmission line represent a significant portion of the cost of the line and they play an important role in the reliable power transmission [1]. They are designed and constructed in wide variety of shapes, types, sizes, configurations and materials. The supporting structure types used in transmission lines generally fall into one of the three categories: lattice, pole and guyed. The supports of EHV transmission lines are normally steel lattice towers. The cost of towers constitutes about quarter to half of the cost of transmission line and hence optimum tower design will bring in substantial savings. The selection of an optimum outline together with right type of bracing system contributes to a large extent in developing an economical design of transmission line tower. The height of tower is fixed by the user and the structural designer has the task of designing the general configuration and member and joint details. The goal of every designer is to design the best (optimum) systems. But, because of the practical restrictions this has been achieved through intuition, experience and repeated trials, a process that has worked well. Power Grid Corporations of India Limited has prescribed [2].

## III. DESIGN FACTOR

Design factor of Power Transmission Lines:-

- Selection of clearances.
- Insulator and insulator string design.
- Bundle conductor studies.
- Tower configuration analysis.
- Tower weight estimation.
- Line cost analysis and span optimization.
- Economic evaluation of line.

For the electrical transmission system, transmission towers are often installed with certain foundations that support the upper tower structure and associated overhead power lines. The transmission tower structures are subjected to various unexpected damages from a wide range of extreme weather events, including hurricanes, tornadoes, snow, and ice storms, and human disasters such as terrorism [1–3]. In particular, as climate change has been an issue in various social and engineering fields, it has become important to prepare a resilient infrastructure system that can guarantee or improve the stability of the energy supply system [4–6]. For the subsurface soil zone where the foundations of transmission towers are embedded, the issue of climate change also needs to be addressed for both design and construction of the structures. Increasing freezing-thawing cycles within the soil zone cause changes in various soil properties such as permeability, volume change behavior, strength, and compressibility [7–9]. Unusual fluctuation of groundwater level due to changes in annual precipitation characteristics causes additional settlements and unexpected reduction in the bearing capability of foundations [10–12]. All these threaten the stability and sustainability of the electrical transmission tower system, highlighting the need for a more robust and resilient structural system with certain reinforcements.

## IV. TOWER FOUNDATION EFFECT IN LOAD BEARING CAPACITY

The types of tower foundation often used are pile, pier, inverted T-type, and mat foundation [13–16]. The inverted T-type foundation is widely used in transmission towers and can be used for small load conditions in good quality soils composed of sand. The pier foundation can be used in steep grade or deep bearing strata. This foundation is effective to support large loads of transmission towers and is frequently used for Ultra High Voltage (UHV) transmission towers. Pile foundation is generally used in weak soils, such as clay and reclaim soil, and often suffers structural damage and geotechnical instability due to insufficient foundation resistance and large differential settlements [1].

The size of transmission towers increases with electricity demand; the foundation size also increases to efficiently support the larger transmission towers. A foundation reinforced with additional structures is often used to improve foundation performance. For example, various researchers proposed setting rock bolt on a pier foundation to reduce settlement and to increase the resistance of the foundation; and setting a protective slab under the tower foundation to reduce the differential settlement of the foundation [5].

All these results were obtained for certain assumed soil and foundation conditions. There were no changes in soil conditions such as strength and compressibility, which were indicating limited condition of the application. As a connected foundation can be more effectively used in soft, clayey soil, it is important to check any possible effect of soil and foundation conditions on variation in mechanical performance. In the present study, the effects of a connected foundation on the performance of transmission tower structures were investigated with consideration of different types of connection beam and various soil conditions. Soft clay conditions with and without a bearing rock layer were assessed as well. For this purpose, a series of finite element analyses were performed and used to analyze the effects of a connected foundation. A large-scale field load test using a prototype model structure was performed and compared with the results from the finite element analyses. Improved performance of transmission tower structures was analyzed in detail for various connection beam stiffness and soil conditions [1].

## V.RESULT AND SIMULATION

### MODELING OF TOWER

The general software STAAD. Pro has been used for modeling. It is more user friendly and versatile program that offers a wide scope of features like static and dynamic analysis, non linear dynamic analysis and non linear static pushover analysis, etc [2].

### SOFTWARE USED STAAD.PRO V8I

The software used for the seismic analysis of multistory building with and without floating column. STAAD.Pro V8i is a comprehensive and integrated finite element analysis and design offering, including a state of the-art user interface, visualization tools, and design codes. It is capable of analyzing any structure exposed to static loading, a dynamic response, wind, earthquake, and moving loads. STAAD.Pro V8i provides FEM analysis and design for any type of project including towers, culverts, plants, bridges, stadiums and marine structures.

### NATURE OF LOADS

Nature of Loads as given by “Transmission Line Manual” is as follows:

1. Transverse loads

This type of load covers

• Wind load on tower structure, conductor, ground wire and insulator strings.
• Component of mechanical tension of conductor and ground wire.

**2. Vertical loads**

This type of load covers

• Loads due to weight of each conductor, ground wire based on appropriate weight span, weight of insulator strings and fittings.

• Self weight of the structure.

• Loads during construction and maintenance.

**3. Longitudinal loads**

This type of load covers

• Unbalanced horizontal loads in longitudinal direction due to mechanical tension of conductor and/or ground wire during broken wire condition.

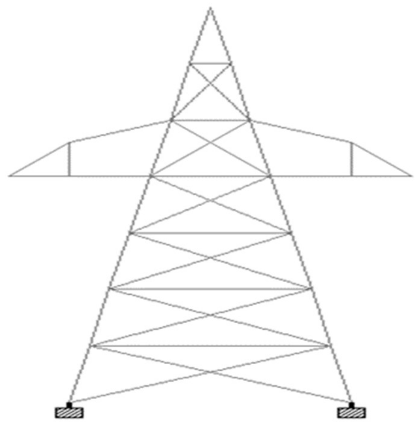

Fig.2 Staad Pro Software Design.

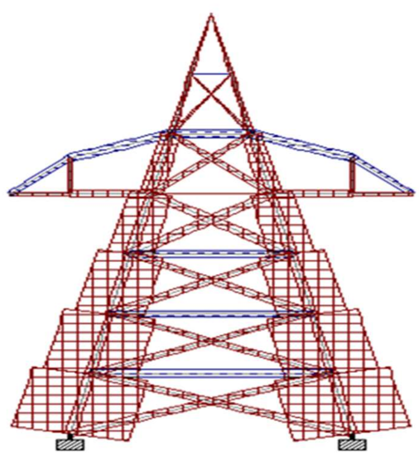

Fig.3 X axis Bending.

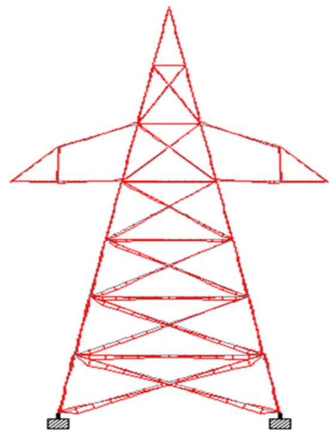

Fig.4 Bending in Y direction.

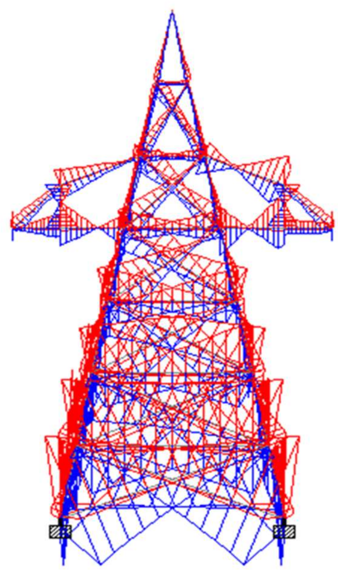

Fig.5 Deformation.

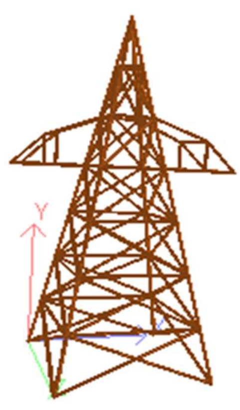


Fig.6 3D view.

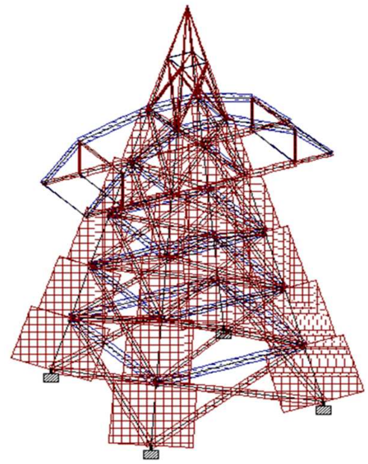

Fig.7 Higher share bending.

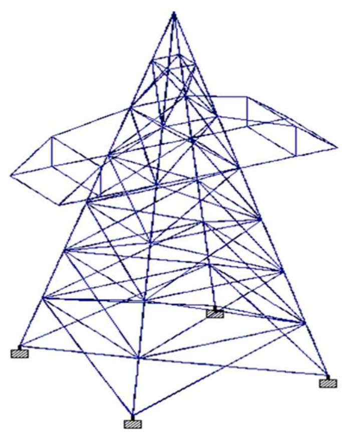

Fig.8 Torsion level.

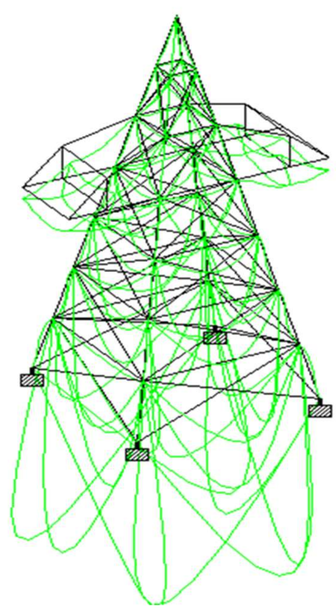

Fig.9 Displacement.

## V. CONCLUSION

Full structure including the foundation can be drawn in STAAD Pro and STAAD foundation software. Total load is found accordingly from the STAAD Pro V8i software and foundation size is determined from the software STAAD Foundation respectively. The maximum load under each tower leg was obtained as 645kN from STAAD Pro V8i. All the individual tower members were found to be stable and safe. The size of isolated footing was found to be from the STAAD FOUNDATION software. The maximum deformation value of transmission tower under wind loading was obtained as 3mm in STAAD Pro accordingly and was within the limits also.

## FUTURE SCOPE

1) Continuous demand due to increasing population in all sectors viz. residential, commercial and industrial leads to prerequisite of efficient, consistent and suitable amount of electric power supply which can only make happen by using the Conventional Guyed Transmission Towers.
2) Effective static loading on transmission line structure, conductor and ground wire can be supplanted with the actual dynamic loading and the results can be competed.
3) Attempt in changing the shape of cross arm can lead to ideal results.
4) Rapid urbanization and increasing demand for electric, availability of land leads to take in use of tubular shape pole structure.

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