A Review on Electrical Transmission Tower Structure and Its Design

Er. Rashi Mathur , Er. Vikas Mathur
Jodhpur (Raj.)

ABSTRACT :

This review provides a comprehensive overview of electrical transmission tower structures and their design principles. It emphasizes the significance of these structures in supplying electricity to various regions and explores both the structural and electrical requirements involved in their planning and construction. The document covers the components and design considerations of transmission towers, including ground clearance, conductor clearances, and insulator string length. It also discusses various types of electrical transmission towers and the importance of structure configuration and material selection. In conclusion, the review underscores the critical role of proper tower type and material selection for cost-effective and safe transmission lines.

INTRODUCTION

Transmission line towers are one of most important life- line structures. Transmission towers are necessary for the purpose of supplying electricity to various regions of the nation. They are designed and constructed in wide, variety of shapes, types, sizes, configuration and materials. Transmission towers of square base self- supporting with different bracing systems are considered in this study. Transmission line should be stable and carefully designed so that they do not fail during natural disaster. 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. From Structural point of view, Steel angle sections of different grades are generally used for towers.

Transmission Tower:

The transmission lines are connecting links between generating station to Distribution system.

A transmission tower (also known as a power transmission tower, power tower, or electricity pylon) is a tall structure (usually a steel lattice tower) used to support an overhead power line. In electrical grids, they are used to carry high voltage transmission lines that transport bulk electric power from generating stations to electrical substation utility poles are used to support lower-voltage sub-transmission and distribution lines that transport power from substations to electric customers.

Transmission towers have to carry the heavy transmission conductors at a sufficient safe height from the ground. In addition to that, all towers have to sustain all kinds of natural calamities. So transmission tower design is an important engineering job where civil, mechanical, and electrical engineering concepts are equally applicable.

Different Parts of Transmission Tower:

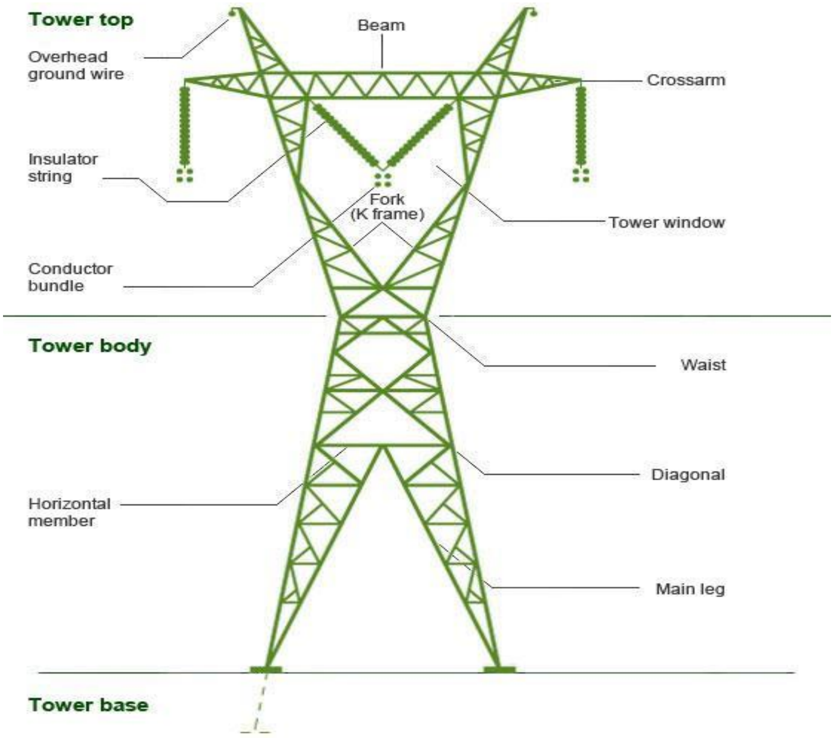

Fig 1- Different Parts of Transmission Tower

Power transmission tower consists of the following parts:

1. The peak of the transmission tower
2. The cross arm of the transmission tower
3. The boom of transmission tower
4. Cage of transmission tower
5. Transmission Tower Body
6. Leg of transmission tower
7. Stub/Anchor Bolt and Baseplate assembly of the transmission tower.

Peak of Transmission Tower

The portion above the top cross arm is called peak of transmission tower. Generally earth shield wire connected to the tip of this peak.

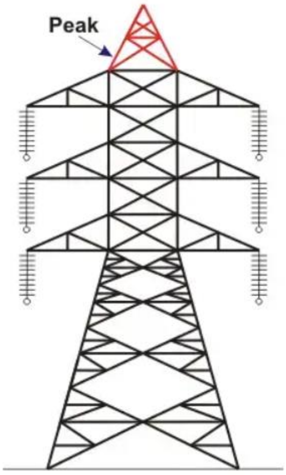

Fig 2- Peak of Transmission Tower

Cross Arm of Transmission Tower

Cross arms of transmission tower hold the transmission conductor. The dimension of cross arm depends on the level of transmission voltage, configuration and minimum forming angle for stress distribution.

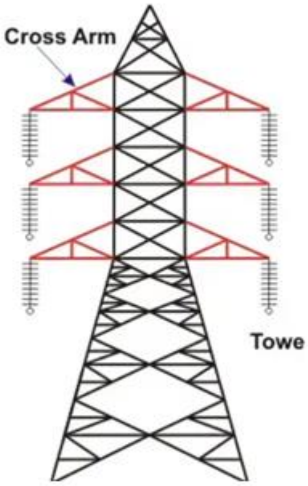

Fig 3- Cross Arm of Transmission Tower

Cage of Transmission Tower

The portion between tower body and peak is known as cage of transmission tower. This portion of the tower holds the cross arms.

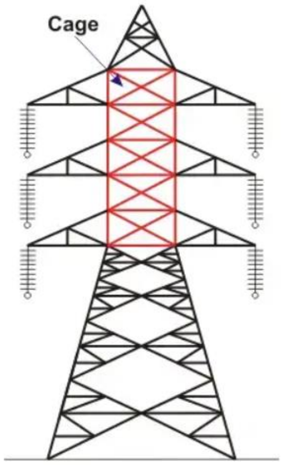

Fig 4- Cage of Transmission Tower

Transmission Tower Body

The portion from the bottom cross arms up to the ground level is called the transmission tower body. This portion of the tower plays a vital role in maintaining the required ground clearance of the bottom conductor of the transmission line.

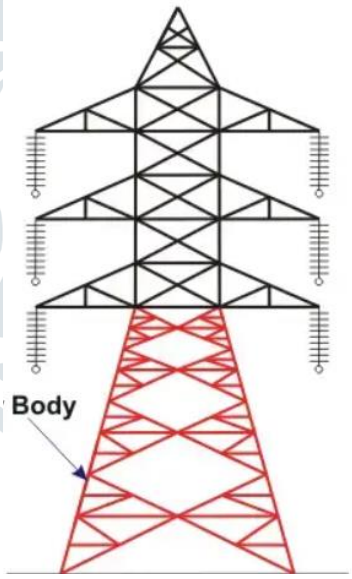

Fig 5- Transmission Tower Body

Transmission Tower Design

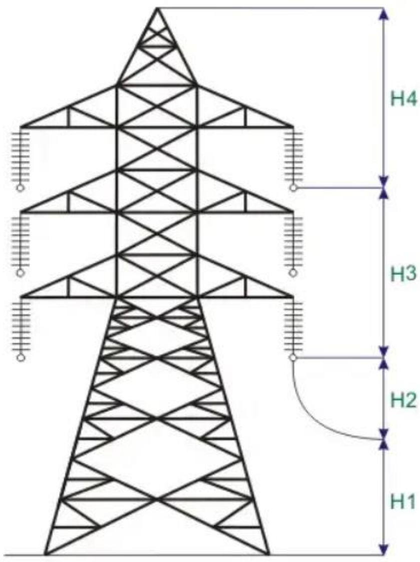

Fig 6:- Transmission Tower Design

During design of transmission tower the following points to be considered in mind:

- The minimum ground clearance of the lowest conductor point above the ground level.
- The length of the insulator string.
- The minimum clearance to be maintained between conductors and between conductor and tower.
- The location of a ground wire with respect to outermost conductors.
- The midspan clearance required from considerations of the dynamic behavior of the conductor and lightning protection of the power line.

For determining the actual transmission tower height by considering the above points, we have divided the total height of the tower into four parts:

1. Minimum permissible ground clearance (H1)
2. Maximum sag of overhead conductor (H2)
3. Vertical spacing between the top and bottom conductors (H3)
4. Vertical clearance between the ground wire and top conductor (H4)

Selection of Transmission Tower

1. Voltage and Capacity
2. Terrain and Location
3. Tower Types
4. Tower Height and Spacing
5. Load-Bearing Capacity

6. Corrosion Resistance
7. Environmental Impact
8. Regulatory and Safety Requirements

Electrical Transmission Towers –Types:

I) According to the angle of deviation, there are four types of transmission tower–
1. A – type tower – angle of deviation 0^o to 2^o.
2. B – type tower – angle of deviation 2^o to 15^o.
3. C – type tower – angle of deviation 15^o to 30^o.
4. D – type tower – angle of deviation 30^o to 60^o.

As per the force applied by the conductor on the cross arms, the transmission towers can be categorized in another way-

1. Tangent suspension tower and it is generally A – type tower.
2. Angle tower or tension tower or sometime it is called section tower. All B, C and D types of transmission towers come under this category.
3.

II) B
ased on numbers of circuits carried by a transmission tower, it can be classified as-

1. Single circuit tower
2. Double circuit tower
3. Multi circuit tower.

1. Single circuit tower

Single Circuit Transmission Line refers to an arrangement of conductor over the Transmission Tower. In Single Circuit Transmission Line, three conductors corresponding to three distinct phases i.e. R, Y & B phase are run on the Transmission Tower.

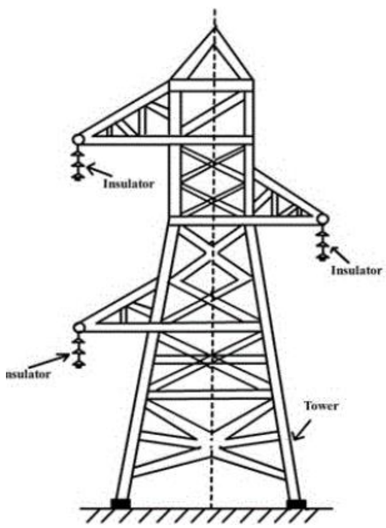

Fig 7:- Single circuit tower

2. Double circuit tower

Double Circuit Transmission Line refers to the arrangement in which a total of six conductors are provided to make two different Transmission Circuit. In Double Circuit Transmission Line, there are two circuits each consisting of three conductors corresponding to three phases. Both the circuits in Double Circuit Transmission Line are mounted or run through the same Transmission Line. In Double Circuit Transmission Line, bundle conductor are mostly used.

A general thumb rule is that, if the number of conductor per bundle is 2 then it will be 220 kV line while if the number of conductor per bundle 4 then it will be 400 kV line. This is general thumb rule and variation is expected.

Tower supply using Double Circuit Transmission Line enables the transfer of more power over a particular distance. However, running two circuits in close proximity to each other will involve inductive coupling between the conductors. This needs to be taken into account when calculating the fault level and while designing the protection schemes. In case of Distance Protection of Double Circuit Line, a compensation for Mutual Coupling between the circuits shall be provided otherwise the distance relay may under reach /over reach.

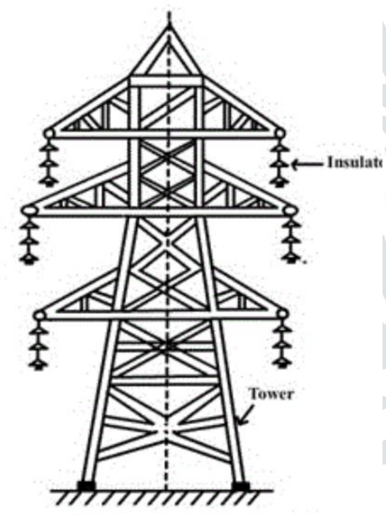

Fig 8:- Double circuit tower

3.Multi circuit tower:

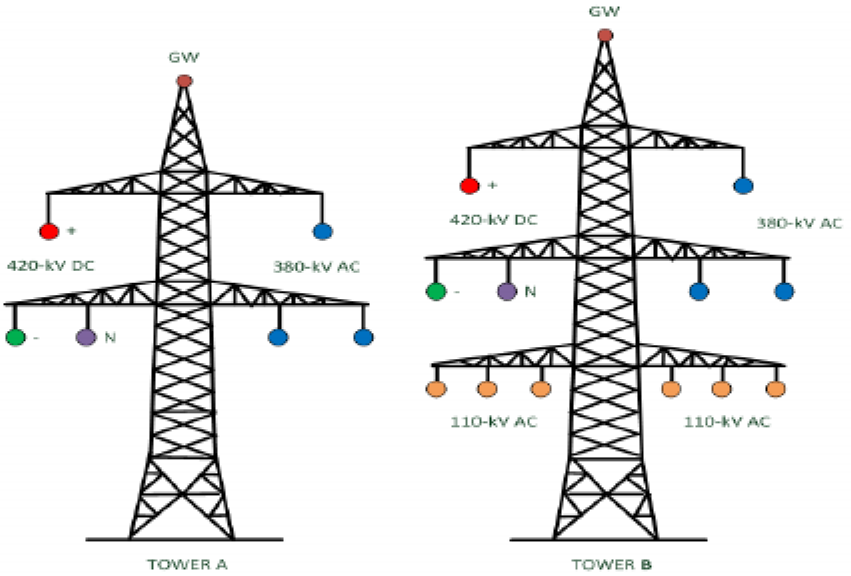

Fig 9- Multi circuit tower

III) Based on Structure types by a transmission tower, it can be classified as-

a) Lattice Structure
b) Hybrid Structure
c) Tubular Pole Structure

IV) Classification based on material used, it can be classified as-

a) Steel Structure
b) Wooden Material
c) RCC Pole

V) On the basis of current types of towers

a) HVAC transmission tower
b) HVDC transmission tower
c) Railway traction line tower

Structure Configuration and Material

Structure cost usually accounts for 30 to 40% of the total cost of a transmission line. Therefore, selecting an optimum structure becomes an integral part of a cost- effective transmission line design.

A structure study usually is performed to determine the most suitable structure configuration and

material based on cost, construction, and maintenance considerations and electric and magnetic field effects. Some key factors to consider when evaluating the structure configuration are:

- A horizontal phase configuration usually results in the lowest structure cost.
- If right-of-way costs are high, or the width of the right-of-way is restricted or the line closely parallels other lines, a vertical configuration may be lower in total cost.
- In addition to a wider right-of-way, horizontal configurations generally require more tree clearing than vertical configurations.
- Although vertical configurations are narrower than horizontal configurations, they are also taller, which may be objectionable from an aesthetic point of view.

In general, vertical configurations will have lower field strengths at the edge of the right-of-way than horizontal configurations, and delta configurations will have the lowest single-circuit field strengths and a double-circuit with reverse or low-reactance phasing will have the lowest possible field strength. Selection of the structure type and material depends on the design loads.

For a single circuit 230-kV line, costs were estimated for single-pole and H-frame structures in wood, steel, and concrete over a range of design span lengths. For this example, wood H-frames were found to have the lowest installed cost, and a design span of 1000 ft resulted in the lowest cost per mile. As design loads and other parameters change, the relative costs of the various structure types and materials change.

Conclusion

In conclusion, this review paper provides a comprehensive overview of electrical transmission towers and their design principles. It addresses the structural, electrical, and material aspects involved in the construction of these essential infrastructure components. The selection of the right tower type and material is crucial for ensuring cost-effective, safe, and efficient transmission lines. Understanding these factors is essential for engineers and professionals working in the field of power transmission and distribution.

References:

1. IS 802 Part 1 Sec 1 1995 Codeof practice for use of structural steel in overhead transmission line towers, Part 1

2. Yoganantham.C Helen Santhi.M (2013), “Dynamic Analysis of Transmission Towers International Journal of Advanced Information Science and Technology (IJAIST)”Vol.20, No.20.

3. Yoganantham.C Helen Santhi.M (2013), “Dynamic Analysis of Transmission Towers International Journal of Advanced Information Science and Technology (IJAIST)”Vol.20, No.20.

4. Rao NP, Knight GS, Mohan SJ, and Lakshmanan N (2012). Studies on failure of transmission line towers in testing. Engineering Structures.

5.] Rao NP and Kalyanaraman V (2001). Non-linear behaviour of lattice panel of angle towers. Journal of Constructional Steel Research.

6. McClure G and Lapointe M (2003). Modeling the structural dynamic response of overhead transmission lines. Computers and Structures.

7. Pearson KJ, Baur JA, Lewis KN, Peshkin L, Price NL, Labinskyy N, Swindell WR, Kamara D, Minor RK, Perez E, Jamieson HA. Resveratrol delays age-related deterioration and mimicstranscriptional aspects of dietary restriction without extending life span. Cell metabolism. 2008.

8. Yoganatham and C Helen Santhi M, 'Dynamic Analysis of Transmission Tower' International journal of Advanced Information Science and Technology, Vol 20,No.20,2013.