A Review Study of Transmission Line Tower Structure by FEM

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Abstract: **Transmission line structures are frequently made out of metal lattice structures, due to their ease of assembly and because of their mild weight, which ends up in enormously small foundations. Transmission line towers, though designed in step with code provisions, might also fail in the course of mandatory trying out required in many nations. The present Study interacts with the investigation of static and dynamic analysis of Electric tower structure. Various literature researches study to analyze research work performed on electric tower structure by using FEM analysis.**

Keywords: **Transmission line tower, deformation, types of tower, Design of tower, FEM.**

I. INTRODUCTION

The requirement of electricity uses has continued to grow in every country, the amount of requirement being bigger in the developing countries. The transmission line towers are considered one of maximum important life-line structures that help in transmitting electric powered energy. The Transmission towers are essential for the cause of providing electricity to diverse areas of the nation. In present situation, there may be growth in building of power stations and consequent increase in energy transmission traces from the producing stations to the distinct corners. Interconnections between structures also are growing to enhance reliability and financial system. Transmission line should be solid and punctiliously designed so that they do now not fail all through herbal catastrophe and should agree to the countrywide and global popular. The planning and designing of a transmission line encompass some of requirements of both structural and electric. From the electrical point of view, the most important requirement is insulation and safe clearances of the strength sporting conductors from the ground. The cross-segment of conductors, the spacing between conductors, and the area of ground wires with appreciate to the conductors will decide the design of towers and foundations. Transmission line is an incorporated device inclusive of conductor subsystem, ground cord subsystem and one subsystem for each category of guide structure. Mechanical supports of transmission line represent a considerable portion of the price of the road and that they play a crucial position in the reliable power transmission. They are designed and built in huge form of shapes, types, sizes, configurations and materials. The supporting shape types utilized in transmission lines normally fall into one of the three categories: lattice, pole and guyed. The supports of EHV transmission traces are usually steel lattice towers. The value of towers constitutes approximately sector to half of the fee of transmission line and for this reason ultimate tower design will bring in substantial savings.

II. TRANSMISSION LINE TOWER

Overhead transmission lines play a significant role inside the operation of a dependable electricity equipment. Sustained business throughput and performance of operations of essential sectors of the countrywide economic system rely highly on protection and reliability of energy lines.

Transmission line towers are used to aid the electric electricity conductors on the stipulated clearances from ground and different carrying out media. From the point of electricity transmission, the tower shape is considered as nonproductive. Conductors are considered as efficient and costs 36% of transmission line machine. The tower shape and basis expenses are 33% and 14% respectively. This without a doubt shows that the nonproductive charges are a good deal higher than the productive fees and emphasizes the significance of affecting all possible economies in towers and foundations from design stage to erection. Transmission line towers are erected in large numbers and therefore their designs ought to be commercially competitive. Substantial financial savings in materials can be performed through choice of efficient structural configuration and highest quality designs without compromising at the safety and reliability of towers. The geometry of the tower is mainly governed by means of the practical and structural requirements such as

- The line voltage
- Number of circuits to be carried
- The location of the tower in the line
- Arrangement of conductors and earth wires
- Sag-tension properties of the conductors and ground wires
- Electrical clearance requirements
- Arrangement of insulator strings
- Landscape / terrain

Bracing elements are used to decrease the slenderness ratio of the main contributors thereby growing their sporting ability. The force within the bracing depends on the stiffness of the bracing. The most usually used bracing structures in transmission line towers are Single lattice bracings X or Cross

bracing and K- bracing. A standard transmission line tower, its elements and the loads to which they are subjected are explain in Figure 1.1. The design of transmission line towers, which are heavily produced, is commonly based on minimum weight philosophy. The towers, in fashionable, are of lattice type which include legs, number one, secondary bracings and cross arm individuals. The structural design of the tower is particularly ruled with the aid of the wind hundreds performing at the conductor /tower frame, self-weight of the conductor /tower and different masses due to line deviation, damaged twine condition, cascading, erection, maintenance, and many others. The towers also are checked for other incidental environmental hundreds like icing, wind impact on icing and everyday temperature variations, and many others. The tower is modelled as a pin jointed space truss for the evaluation. For the member layout, quit restraint (both as pinned or as partially restricted) and stop eccentricities within affordable limits are considered. Linear static analysis is carried out to acquire the member forces assuming that each one participants are subjected to best axial forces and the deformations are small. The members are designed based totally on the winning codes of practice. Bearing kind bolted connections are used to connect the tower individuals with nominal bolts.

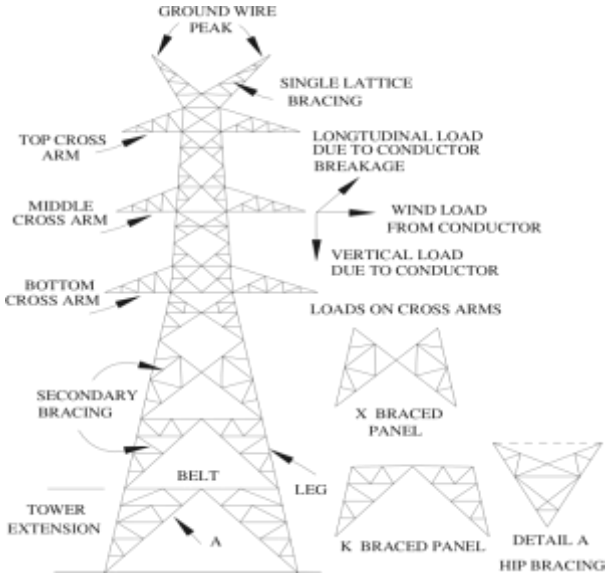

Figure 1.1: Double Circuit Transmission Line Tower

Proof checking out of systems is essential to confirm the engineering components of the layout process. The evidence check demonstrates the efficiency of the evaluation approaches used in calculating the load results from design loads, the adequacy of the electricity and the detailing of the structural additives. Full scale testing of towers provide an insight into the real stress distribution in unique tower configurations, pressure-suit verification, and motion of the structure in deflected positions, adequacy of connections and other detailing. Generally, these tests are made on the prototype towers prior to the producing technique or beneath certain situations, these assessments may also be made as recognition check for a batch of towers. In view of the above, maximum of the energy transmission tower industries everywhere in the global have made evidence testing of transmission line towers obligatory. Study of test outcomes offers a perception into the behavior of the system and it also enables in arriving at suitable remedial measures within the event of premature failure of towers.

III. NEED FOR THE STUDY

Most of the earlier studies have been concentrated on additives along with single attitude behavior, X and K braced panels. Studies on failure of full scale transmission line towers are accomplished by way of very few researchers. Literature to be had at the experimental behavior of complete scale transmission line towers is scant. Hence specified investigations have been conducted on the failure of transmission line towers. Lattice towers include primary contributors like leg and bracing members. The secondary bracing members are supposed to aid the primary participants at their intermediate duration, as a result, reducing their powerful period and increasing their buckling power. The lattice towers are generally analyzed assuming the contributors to be concentrically related using hinged joints so that the forces in the angle contributors are only axial. Under this assumption, the forces within the redundant are negligibly small or zero and subsequently are not covered within the linear evaluation models. However, the main legs and the bracing contributors aren't axially loaded and the redundant forces aren't negligibly small, because of the following reasons:

- The foremost legs are commonly continuous via the joint.
- Usually more than one bolt is used in the connections and subsequently the joints are semi-rigid.
- The angle members are typically bolted through best one in every of their legs and as a result the pressure transfer inside the member is eccentric.
- The joints are flexible because of the local deformation of the leg of the angles beneath the focused bolt forces.
- The towers with high electric rankings have a tendency to be flexible and therefore equilibrium in the deformed configuration has to be considered.
- The compression member deformation increases the bending moments (P- effects).

Therefore, the angle contributors of the tower experience each axial force and bending moments, even properly before the tower fails. This additionally produces forces in the redundant participants because of typical body movement, which isn't always negligible as often assumed in designs. The Indian Standard IS:802 - Use of Structural Steel in overhead Transmission line towers – Part 1 gives six buckling curves for computing the buckling pressure of hot

rolled angles similar to ASCE 10-ninety seven preferred primarily based on slenderness ratio and end conditions. The permissible stress curves are primarily based on Euler formula in the elastic range and Structural Stability Research Council (SSRC) method in the inelastic range for concentrically loaded columns. The influence of stop fixity is believed to have negligible impact. Using the curves, the power of attitude strut is checked for buckling. Local buckling is accounted for by using considering the width to thickness ratio of angle sections and appropriately decreasing the yield strain if the ratio exceeds the prescribed limit. Allowable width to thickness ratio for neighborhood buckling calculation varies with unique codes. The American and Indian Standards specify the flat width after deducting the thickness and root radius of attitude segment. The British Standard considers the entire width of the attitude section for b/t calculations.

IV. ELECTRICAL TRANSMISSION TOWER TYPES AND DESIGN

The primary helping unit of overhead transmission line is transmission tower. Transmission towers must deliver the heavy transmission conductor at a sufficient secure peak from ground. In addition to that all towers should sustain all kinds of herbal calamities. So transmission tower designing is an essential engineering activity where all 3 primary engineering concepts, civil, mechanical and electrical engineering principles are equally applicable.

A power Electric tower includes of the following parts:

- Top of transmission tower
- Cross arm of transmission tower
- Boom of Electric tower
- Cage of Electric tower
- Electric Tower Body
- Leg of Electric tower
- Stub/Anchor Bolt and Base plate assembly of Electric tower.

The main parts among these are shown in the pictures.

- *Peak of Transmission Tower*

  The portion above the top cross arm is known as top of transmission tower. Generally, earth protect twine related to the top of this height.

- *Cross Arm of Transmission Tower*

  Cross fingers of transmission tower maintain the transmission conductor. The dimension of pass arm depends on the level of transmission voltage, configuration and minimal forming attitude for pressure distribution.

- *Cage of Transmission Tower*

  The portion among tower body and height is called cage of transmission tower. This part of the tower holds the cross arms.

- *Transmission Tower Body*

  The element from bottom pass arms as much as the ground degree is called transmission tower body. This part of the tower plays an important role for maintaining required floor clearance of the bottom conductor of the transmission line.

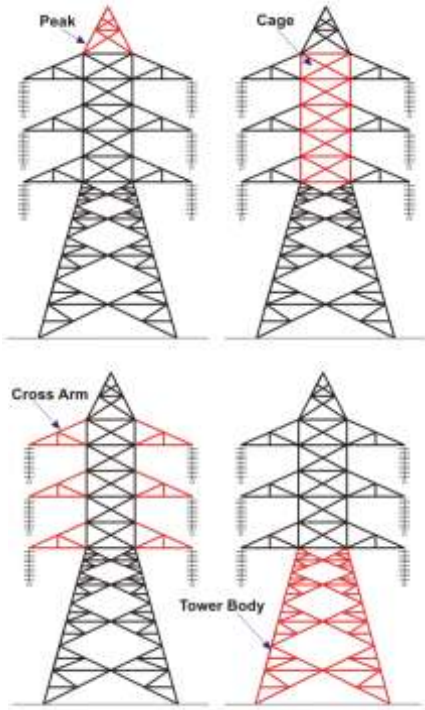

Figure 1.2: Transmission tower body

- *Design of Transmission Tower*

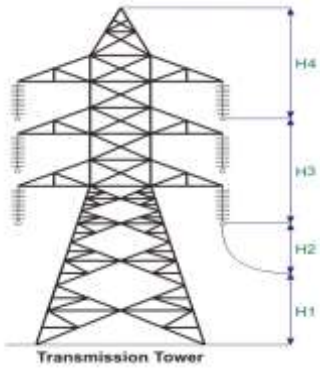

Figure 1.3: Design of Electric Tower Structure

To decide the actual transmission tower height by considering the above factors, we have divided the overall peak of tower in 4 parts,

- Minimum permissible ground clearance (H1)

- Maximum sag of the conductor (H2)
- Vertical spacing between top and bottom conductors (H3)
- Vertical clearance among ground twine and top conductor (H4).

- *Types of Transmission Tower*

According to different considerations, there are exclusive forms of transmission towers. The transmission line is going as in keeping with available corridors. Due to unavailability of shortest distance straight corridor transmission line has to deviate from its directly way while obstruction comes. In overall length of a long transmission line there may be several deviation factors. According to the perspective of deviation there are four styles of transmission tower-

- A – type tower – angle of deviation 0° to 2°.
- B – type tower – angle of deviation 2° to 15°.
- C – type tower – angle of deviation 15° to 30°.
- D – type tower – angle of deviation 30° to 60°.

V. LITERATURE STUDY

Transmission line towers are vital systems, and their design calls for unique strategies and standards. The safety of those structures is crucial with a purpose to provide continuous electricity switch from power flowers to communities. Due to electrical clearances and attachments, transmission line towers frequently have complex geometries. The towers are a lattice type, which includes legs, primary, secondary bracings, and cross-arm members.

Falguni Patel et. al. (2017) Performed assessment take a look at on Buckling Analysis of Lattice Transmission Tower. Different sorts of premature failures that were determined at some point of full-scale trying out of transmission line towers at Tower Testing and Research Station, Structural Engineering Research Centre, Chennai (CSIR-SERC) are studied, and the results are mentioned in detail. Due to the complex load conditions and the nonlinear interplay some of the large quantity of structural additives, correct structural analysis of the LTT systems has been a challenging subject matter for many years. Still nowadays there are a few gaps between studies and commercial practice. This study provides a precis of studies outcomes from current literature.

Hadimani et. al. (2017) Performed static and dynamic evaluation of transmission line tower (X form of bracing machine). The analysis and modeling of tower is executed the use of FE based totally ANSYS software program. The model is created in CATIA and then imported to ANSYS workbench. The masses performing on the tower taken into consideration are useless load, live load and dynamic hundreds (Seismic and wind). The current tower has height of 40m, which includes ground clearance, maximum sag of the conductor, vertical spacing among conductor cord. Static and dynamic evaluation is finished in detail the usage of FE based totally ANSYS software. Static, modal, reaction spectrum and wind analysis is achieved. The maximum deformation, combined stresses, herbal frequencies and direct strain are acquired and plotted graphically.

Vinotha Jenifer et. al. (2017) Studied the green member move segment appropriate for the telecommunication tower with the aid of sporting out a comparative evaluation of telecommunication towers with distinctive member pass section for specific heights. The towers are modelled and modal analysis has been done for diverse member cross sections of telecommunication towers for four distinctive heights the use of FEA package ANSYS Workbench. As a result, frequencies are in comparison for different member cross phase for the corresponding mode shapes. The outcomes of this comparative analysis show the performance of a specific member go section of tower which can be followed for conversation functions.

Harshil Patel et. al. (2017) Performed comparative analysis of round monopole towers between two extensively used configurations straight and tapered. For this look at, the authors have additionally carried out the latest finite element answer capability of general motive software program ANSYS Workbench with incorporated more than one simulation schematic surroundings to carry out static structural evaluation along with modal evaluation and linear buckling evaluation. At the remaining, the comparative benefits of tapered configuration over straight are drawn. It could be said that tapered round section is more beneficial as compared with straight round phase. For the tapered section there is a much less general deformation as well as lesser quantity of Normal Stress and Von-misses Stress.

Emil veg et. al. (2017) Describes a technique for transmission tower 3-D modelling. The task changed into to increase a digital three-D model, similar to the real shape, with the intention to be subjected to structural analysis in ANSYS software. The process of 3-D modelling is critical for this kind of pc analysis. It calls for precise key factor coordinates defining. Not simplest the essential factors of the shape, however also the points of interest for the future structural analysis need to be described. This means that version developer need to be acquainted with the structural evaluation so he ought to form good enough key points in advance.

Zarina Itam et. al. (2016) A static analysis using STAAD Pro was performed to suggest the joint with the most stress. This joint will then be explicitly analyzed in ANSYS the use of the Finite Element Method. Three tactics had been used in the software which might be the simple plate model, bonded touch without a bolts, and beam detail bolts. Results from the joint analysis display that strain values increased with joint details consideration. This proves that joints and connections play an essential position inside the distribution of stress inside the transmission tower. As end, the attention of joint detailing in the analysis of transmission tower is effective, and can dramatically growth the strain produced on the members.

Shivam Panwar et. al. (2016) Design and evaluation of the considered energy machine has been finished the use of STAAD.ProV8i. Under the layout and analysis of the machine, the effect of wind and earthquake masses were studied and the consequences so obtained had been in comparison for wind zones II and IV (seismic region IV) for the equal configuration of tower. Delhi and Panjim have equal seismic region however there is a lot of difference within the basic wind pace as Panjim is a coastal vicinity, so this study performs a very crucial in phrases of wind loading. The evaluation effects had been provided to the management of the taken into consideration machine for taking appropriate selections concerning the development of electricity device layout. The comparative evaluation is carried out with appreciate to axial pressure, deflections maximum sectional residences and important load situation for both the locations.

Murahari Krishna (2016) Determined the static reaction and corresponding strain resultants of transmission tower structure because of wind load at one static instantaneous time on vertical and transversely position of transmission tower the usage of ANSYS. Also studied loose vibrational or modal analysis characteristics of the transmission tower by way of determine the frequencies and mode shapes of transmission tower the usage of ANSYS and validating the finite element based results with closed form solution. At last tricky have a look at the brief dynamic analysis of transmission tower the use of ANSYS with emphasis at the evaluation of dynamic response of transmission tower due to time various wind load with diverse wind speed like displacement and axial force.

Varakavi et. al. (2016) Studied transmission line towers must be designed considering each structural and electrical requirements for a safe and affordable layout. Modeling of transmission tower through the usage of finite detail method. Further determine the static reaction and corresponding pressure resultants of transmission tower shape because of wind load at one static on the spot time on vertically and transversely role of transmission tower the use of ANSYS. Also studied loose vibrational or modal analysis characteristics of the transmission tower by determining the frequencies and mode shapes of transmission tower the usage of ANSYS and validating the finite detail based totally effects with closed shape answer. At last complex have a look at the brief dynamic evaluation of transmission tower the use of ANSYS with emphasis at the assessment of dynamic response of transmission tower because of time various wind load with various wind velocity.

Wang et. al. (2016) A structural optimization model for wind turbine towers has been developed based on a mixed parametric FEA (finite element evaluation) and GA (genetic algorithm) version. The pinnacle diameter, backside diameter and thickness distributions of the tower are taken as design variables. The optimization version minimizes the tower mass with six constraint situations, i.e. Deformation, final pressure, fatigue, buckling, vibration and design variable constraints. After validation, the model has been carried out to the structural optimization of a 5MW wind turbine tower. The results demonstrate that the proposed structural optimization model is capable of correctly and efficaciously accomplishing an optimum structural layout of wind turbine towers, which appreciably improves the efficiency of structural optimization of wind turbine towers. The evolved framework is time-honored in nature and can be hired for a sequence of related troubles, when superior numerical models are required to predict structural responses and to optimize the structure.

Boshra Eltaly et. al. (2014) Two FE fashions have been evolved within the present day research to observe the nonlinear conduct of electrical transmission towers below static load. The tower was modeled with the aid of the two-node three-dimensional L-phase beam finite factors and each of the geometrical and fabric nonlinearities were considered within the modern FE simulations. Model 1 did no longer remember the eccentricity of connections for the tower members and the joint slippage. In version 2, each of the eccentricity of connections for the tower individuals and the joint slippage have been modeled. The FE simulations consequences had been as compared with the preceding published effects of the entire-scale experimental tests and the numerical answers that were achieved on distinctive towers

Li-Jeng et. al. (2014) Studied dynamic evaluation of self-helping power transmission tower using ANSYS. Based on the finite element method (FEM), we appoint Beam-4 element to construct the numerical model of the tower. Then typical numerical example is taken into consideration and the primary leading six fundamental frequencies and durations of the tower crane acquired by using ANSYS are acquired and checked by way of using SAP2000. The associated mode shapes acquired from those two software's also are offered and compared. Furthermore, the time histories of transmission tower frame subjected to 1940 El Centro and 1995 Kobe earthquake are carried out, respectively. Maximal displacements, velocities and accelerations are explained.

Magalhaes Junior et. al. (2016) Studied the self-assisting truss towers used to aid large wind generators. The intention is to assess and validate numerically through finite element method the structural evaluation while the lattice systems of the towers of wind mills are subjected to static loads and these from common usage. The results obtained for freestanding lattice tower are in comparison with the statistics of a tubular one designed to support the generator with the identical traits. At the end of this paintings it changed into possible to look at the feasibility of the usage of lattice towers that proved better as its structural overall performance however with caveats about its dynamic overall performance considering the advent of numerous other modes natural frequency for that reason reducing the durations among them in low frequency and theoretically growth the risk of resonance.

VI. CONCLUSION

Various literature studies investigated and concluded that various Experiments have been performed on numerous steel

single identical angles. Even though transmission line towers are designed based totally on codal provisions, they fail for the duration of checking out. Different kinds of screw-ups found all through complete scale testing of Transmission line towers are studied and the reasons have been discussed in detail. Many disasters due to the redundant member were found at some stage in testing. Importance of the layout assumptions and the connection detailing in the standard overall performance of towers had been additionally studied. Different codes recommend specific provisions for the layout of secondary bracings. No precise guiding principle is available for redundant and hip bracing pattern to be followed in the towers. Importance of secondary member design and connection info inside the general performance of the tower changed into also studied. The effect of a non-triangulated hip bracing sample and the remoted hip bracings inside the 'K' and 'X' braced panels, on tower behavior were studied.

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