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Review on Analysis of Transmission tower system

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Abstract:-Transmission tower is the main supporting aid for the transmission line, transmission tower should carry heavy electric conductors and safe height from the ground. In addition to this the transmission line should be capable of withstanding all the natural calamities, so transmission tower designing is an important engineering job where it involves all the three basic engineering branches like civil engineering, mechanical engineering and electrical engineering.This report is an attempt to review various works carried out on this topic by various people and study the outcome of those papers

Keywords: - Transmission tower, finite element analysis.

1. INTRODUCTION

Transmission towers are tall structures, their height is much larger when compared with the lateral dimension. These towers generally will have separate foundation for each leg. The electric power generated at power plants will be transmitted through transmission lines supported by transmission towers.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 the forces of nature like seismic load, wind load and snow load, therefore transmission line should be designed considering both structural and electrical requirements.

Transmission tower line system damage often brings the huge direct loss and indirect loss for the national economy, but the causes of destruction of transmission tower line is very complex, and the earthquake is a serious natural disasters, the earthquake under impact loading of transmission tower structure mechanics characteristic is a line of complex characteristic and research hot spot problems of the current domestic and international research hot spot problems.

2. LITERATURE REVIEW

1. **N. Prasad Rao, G. M. Samuel Knight, S. Seetharaman, N. Lakshmanan and Nagesh R. Iyer(2011)** studied different types of premature failures that were observed during full-scale testing of transmission line towers at Tower Testing and Research Station, Structural Engineering Research Centre, Chennai (CSIR-SERC) are studied, and the results are discussed in detail. The failures are modelled using finite-element software, and the analytical results and the test results are compared with various code pro- visions. The nonlinear finite-element analysis program NE-Nastran was used to model the elastoplastic behaviour of towers. Bracing members with slenderness ratios above 170 become ineffective, even though they have to carry insignificant forces. Importance of design assumptions and connection detailing in overall performance of towers were studied. Nonlinear finite-

element analysis is useful in understanding the system behaviour and for prediction of the failure pattern and ultimate load. Based on the test results, the importance of studying these failures is highlighted and significant conclusions were drawn.

Conclusion: -

1. Bracing members with slenderness ratios above 170 become ineffective, even though they carry only small forces.
2. In horizontal configuration towers, the forces in the leg members increased by 5–8%, and the forces in bracing members increased by 10–20% compared with conventional linear static analysis. In the case of multicircuit tower, the nonlinear analysis forces in the bracing members have increased by 10%.

2. **Gopi Sudam Punse (2014)** analysed and designed narrow based transmission tower keeping in view of supplying optimum electric supply with available row and with increasing population in the locality.In this project, an attempt has been made to make the transmission line more cost effective keeping in view providing optimum electric supply for the required area by considering unique transmission line tower structure. The objective of this research is met by choosing a 220KV and 110KV Multi Voltage Multi Circuit with narrow based Self Supporting Lattice Towers with a view to optimize the existing geometry. Using STAAD PRO v8i analysis and design of tower has been carried out as a three dimensional structure. Then, the tower members are designed.

Conclusion: -

1. Narrow based steel lattice transmission tower structure plays a vital role in its performance especially while considering eccentric loading conditions for high altitude as compared to other normal tower.
2. Narrow based steel lattice transmission tower considered in this paper can safely withstand the design wind load and actually load acting on tower. 3. The Geometry parameters of the tower can efficiently be treated as design Variables and considerable weight reduction can often be achieved as a result of geometry changes.
3. The tower with angle section and X-bracing has the greater reduction in weight afteroptimization. Tube section is not economic to use in this type of transmission tower.
4. Total weight of tower considering weight of nut bolts, anchor bolts, hardware etc. works out to 30 to 35 Tonne.

3. **Wen-QiangJiang, Yao-PengLiu,Siu-Lai Chan, and Zhang-Qi Wang(2017)** In this paper, second-order direct analysis is used and slippages of bolted joints as well as semi rigid connection behaviour are taken into account. Member initial bowing and frame out-of-plumbness imperfections are considered in the present study, which is verified by full-scale test on an ultrahigh-voltage (UHV) lattice transmission tower. The technique of semi rigid design and simulation of joint stiffness for load eccentricity by simple modelling for transmission towers meeting the requirements for direct analysis withverification by a full-scale test is unavailable in literature and proposed in this paper. Furthermore, the influences of joint slippage on the deflection and load behaviour of the studied towers are quantified and reported.

Conclusion:-

1. The proposed second-order direct analysis method with consideration of initial member and frame imperfections, joint slip- page, and semi rigid connections can be used in the practical design of lattice transmission towers in terms of accuracy.
2. The proposed simplified bolted-joint-slippage model is easy to code into nonlinear analysis software such as NIDA with numerical convergence achieved in all cases. Thus, the

proposed analysis and design method can be used for daily design of transmission towers

3. The traditional linear-analysis method without consideration of second-order effects and joint behavior cannot predict the tower's behavior and therefore it is not recommended for use in designing slender structures like lattice transmission towers.

4. **G.Visweswara Rao (1995)**gave a method for the development of optimized tower designs for extra high-voltage transmission lines. The optimization is with reference toboth tower weight and geometry. It is achieved by the control of a chosen set of key design parameters. Fuzziness in the definition of these control variables is also included in the design process. A derivative free method of nonlinear optimization is incorporated in the program, specially developed for the configuration, analysis and design of transmission line towers. A few interesting result of both crisp and fuzzy optimization, relevant to the design of a typical double circuit transmission line tower under multiple loading condition arealso presented.

5. **QianXu, YongxingZhangJiangongchen (2013)**analysed the effect of ruptured wire loads ontransmissiontowers.Towers are themain part to bear loads in transmission lines.Withoutconsidering seis mic loads andwind loads, straight tower (transmission t owers in straight line) mainly bearvertical loads,while t he angle towers did not only bear vertical loads but also transverse loads.
Especially when wires broke, the responses of the differ ent types of towers were also varying under the effect of ruptured wire loads. By the analysis of FEM (Finite Ele ment Methods), it was found that there were much more obliviousdisplacements, to the direction of ruptured wir es,on the straight toweron the contrary, the responses of angle tower were different. However, in current Tower Design Code, the ruptured wire loads were regardedas s tatic ones without considering the dynamic effects of fra gile wire loads.

Conclusions:-

1. Under linear elastic condition, the dynamic res ponses of transmission tower can be simulated much better by FEM.
2. After wires breaking, great displacement appea rs on tower head and cross arms, at the same ti me, there is also considerable relative displace ment emerging incrossarms. The tower may step into geometry nonlinear condition, consequently, it is limited to make analysis by adopting linear elastic theory .
3. In the light of analysis results, both straight to wer and angle tower experience extremely larg e deformation under the effect of ruptured wire loads; moreover, the responses of angle tower are even more intense than those of straight to wer. So it is unreasonable to consider the ruptu red wire loads as static one, but these dynamic effects should be taken into account.

6. **XiaohongLong, Wei Wang, and JianFan (2018)** studied Collapse Analysis of Transmission Tower Subjected toEarthquake Ground Motion. The collapse of transmission towers involves a series of complex problems, including geometric nonlinearity, material nonlinearity, dynamic nonlinearity, and the failure of members. This paper employs the finite particle method (FPM) to simulate the collapse of a transmission steel tower under earthquake ground motions,the three-dimensional (3D) finite particle model using MATLAB and the 3D finite element model using ANSYS of the transmission steel tower are established, respectively. And the static and elastic seismic response analyses indicate that the results of the FPM agree well with those of the FEM. To simulate the collapse of the transmission steel tower, a failure criterion based on the ideal elastic-plastic model and a failure mode are proposed. Finally, the collapse simulation of the

transmission steel towers subjected to unidirectional earthquake ground motion and the collapse seismic fragility analysis can be successfully carried out using the finite particle method. The result indicates that the transmission steel tower has better seismic safety performance and anti-collapse ability.

Conclusions:-

1. The model of the transmission tower is established using FEM and FPM, respectively. The correctness of the transmission tower model and the reliability of linear seismic response analysis are verified by comparing the analytical results of the FPM with those of the FEM.
2. The material nonlinearity, geometric nonlinearity and fracture of the truss structure can be well considered in FPM. The collapse processes of the transmission tower are discussed under different PGAs, and the corresponding collapse modes are obtained. The collapse modes will provide a reference to the anticollapse design of the transmission tower subjected to earthquake ground motions.
3. The collapse seismic fragility analysis indicates that the parametric method agrees well with the nonparametric method, and seismic collapse probability of the transmission steel tower can meet the demand of Chinese seismic code.

7. **Faruq M. A. Siddiqui and J. F. Fleming (1984)** in their study gave a general procedure is for computing the dynamic response of electric transmission line systems when one or more wires suddenly break. A computer program for performing a time history analysis for the nonlinear system has been developed. The program will compute the wire tensions, the arm loads and the ground line moments at the base of the support structures. A comparison is made between the computed results and the experimental results for a small scale laboratory model. Analysis of a full scale transmission line system shows that the impact factor as high as 4.5 can be expected due to the dynamic effects.

8. **Ehasz, F. L (1936)** in their report presents the results of a study of the distribution of shear and torque in steel transmission towers. In compliance with the request of officials of fabricated steel construction, Bethlehem steel company, an analytical study of the problem was made and checked experimentally at the Fritz Engineering Laboratory ofLehigh University.Four preliminaryframes, four feet high, and a twenty one foot full sized model tower were investigated. Primary stresses obtained by various methods from the experimental results were compared with the analyticalstresses.

9. **Zhuoqun Zhang, Hongnan Li, Gang Li, Wenming Wang and Li Tian (2013)** gave the finite element models for single tower and transmission tower-line system were established to simulate wind-induced progressive collapse by birth-to-death element technique in ABAQUS/Explicit. The wind field based on the Kaimal fluctuating wind power spectrum and harmonic superposition method, was constructed by MATLAB commercial software. The current research focuses on the dynamic behaviour and the mechanism of a typical transmission tower-line system progressive collapse under wind action with clear step-by-step description. The numerical simulation results demonstrated that transmission tower-line system collapse mechanism depended on the number, position and last deformation of damage elements. Since the gallop effect of conductor and ground lines were ignored in the single tower model, the transmission tower-line system model, which has higher computational precision than the single tower model, is relatively accurate and recommended strongly in the design.

Conclusions:-

1. A nonlinear response analysis associated with wind- induced progressive collapse process of transmission tower-line system by the birth-to-death element technique in ABAQUS/Explicit is carried out. The simulation technique is important for analysis of transmission tower-line system dynamical behaviour and advances the structural ability in resisting progressive collapse.
2. Comparing the numerical results, the three-tower and four-line finite element model is more accurate and dependable than the single tower model with the same load condition and technique for analysing structural nonlinear dynamic and progressive collapse behaviour. Ignoring conductor and ground line gallop response, the transmission tower-line system modelisrecommendedforprogressivecollapse simulation and analysis.

10. **L. Tian, H. Li, and G. Liu(2010)**studied the behaviour of power transmission tower-line system subjected to spatially varying base excitations .The transmission towers are modelled by beam elements while the transmission lines are modelled by cable elements that account for the nonlinear geometry of the cables. The real multistation data from SMART-1 are used to analyse the system response subjected to spatially varying ground motions. The seismic input waves for vertical and horizontal ground motions are also generated based on the Code for design of Seismic of Electrical Installations. Both the incoherency of seismic waves and wave travel effects are accounted for. The nonlinear time history analytical method is used in the analysis. The effects of boundary conditions, ground motion spatial variations, the incident angle of the seismic wave, coherency loss, and wave travel on the system are investigated. The results show that the uniform ground motion at all supports of system does not provide the most critical case for the response calculations.

11. **Li Tian, Ruisheng Ma, Wenming Wang and Lei Wang (2013)** studied collapse process of a power transmission tower under earthquake excitation. Using international finite element software ABAQUS, the three-dimensional finite element model of the power transmission tower is created based on a practical engineering. Three typical seismic records are selected. The progress collapse processes of the power transmission tower under different seismic excitations are simulated using the nonlinear time history method. The collapse paths and failure positions of the power transmission tower are obtained under different seismic excitations. The results can provide reference for seismic design of power transmission tower which can prevent the collapse of the power transmission tower.

Conclusions:-

1. The method used in the paper is an efficient method of the collapse analysis.
2. According to the collapse analysis, the failure position and collapse routine of the tower under seismic waves can be obtained.
3. The longitudinal or transverse collapse paths are different under various seismic waves. Three or more seismic waves should be used for longitudinal or transverse col- lapse analysis.
4. The result of collapse analysis can be used for the seismic design of power transmission tower and the reinforcement of current structures.

12. **Renju Chandran, Linda Ann Mathew (2013)** studied about the best steel section for stable microwave tower amongI, Cand circular section. In this study the structural strength of microwave tower with different section is analysed under seismic loading condition using ANSYS and best steel section was found out. Maximum deformation and maximum stress obtained for circular section was less, therefore it was concluded that circular section is the most stable steel section .The

second stable section observed was channel section.Finally, concluded that circular section is the most stable section and channel section is the stable section.

Conclusions:-

1. I section, channel section and circular section for stable microwave tower were analysed using ANSYS software.
2. From model analysis frequency and deformation for different sections (I, Circular and C) were obtained and further seismic analysis was based on these results.
3. From seismic analysis the displacement diagram and stress distribution diagram of microwave tower were obtained.
4. Maximum deformation and maximum stress obtained for circular section was less Therefore it was concluded that circular section is the most stable steel section
5. The second stable section observed was channel section.
6. Finally, concluded that circular section is the most stable section and channel section is the stable section.

13. **Bo Chen, Wei-huaGuo, Peng-yun Li, and Wen-ping Xie(2014)**presented an overview on the dynamic analysis and control of the transmission tower-line system in the past forty years. And also reviewed the analytical models and approaches of the transmission tower, transmission lines, and transmission tower-line systems, respectively, which contain the theoretical model, finite element (FE) model and the equivalent model, shows the advances in wind responses of the transmission tower-line system, which contains the dynamic effects under common wind loading, tornado, downburst, and typhoon; and discusses the dynamic responses under earthquake and ice loads, respectively. The vibration control of the transmission tower-line system is also reviewed, which includes the magneto rheological dampers, friction dampers, tuned mass dampers, and pounding tuned mass dampers.

Conclusions:-

An overview is presented in this study on research advances intheanalysisoftransmissiontower-linesystemswithspecialEmphasislaid upon the response assessment and vibration control. The research activity going on around the world in terms of wind-induced responses, seismic responses, ice effects, and vibration control is reviewed, respectively. It is addressed in this review that analytical approaches based on the transmission tower-line system are promising in comparison with traditional techniques. The approaches based on the tower-line system not only provide reasonable observations, but also have the distinguished superiority in exploring the dynamic interaction between the tower and lines when subjected to dynamic excitations.

3. CONCLUSION

The failure of transmission tower may cause direct and indirect effect to a country's economy and it also causes many disasters .From these previous studies it is understood that transmission towers should be properly designed and analysed for various aspects like seismic, wind and also breaking or rupture loads. Transmission towers can also fail during testing also, so special care and interest should be taken while designing and analysing the towers. Transmission towers should also be designed for carrying optimum electricity for increasing population in the locality without varying any geometrical aspects of tower

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