iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 **Issue:** VII **Month of publication:** July 2019

DOI: http://doi.org/10.22214/ijraset.2019.7211

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 7 Issue VII, July 2019- Available at www.ijraset.com

Structural Analysis of Steel Transmission Tower for different Risk Coefficients-A Case Study

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Abstract: The present study deals with the analysis of the steel transmission tower for different risk coefficients located in Pune and Delhi. The analysis of the steel transmission towers has been done by using SAP2000 Integrated Solution for Structural Analysis and Design Software version 20.

A study has been done of both the models subjected to wind and seismic forces as per IS codes and the results so obtained were compared for DIFFERENT RISK COEFFICIENTS with the same configuration. A comparative analysis has been carried out for various parameters like axial force, bending moment, base reaction, torsion, shear force etc. and critical load conditions for both the Pune and DELHI location.

***Keywords: SAP2000, risk coefficient, steel transmission tower, wind force, seismic* forces**

I. INTRODUCTION

This document A case study is done to check whether the same structure along with its same configurations can be safe when they are located at different locations and subjected to wind and seismic forces as per IS codes with different risk coefficient or probability factor (k_1). Analysis is been carried out as per the IS 800:2007(LSM) and IS 1893:2002 codes. The load calculations are done manually but the results obtained are from SAP2000 analysis software v.20.

The study of Analysis and Design of Three and Four Legged 400KV Steel Transmission Line Towers: Comparative Study has been done by Y.M.Ghugal et.al.

The conclusions drawn out were that axial forces and moments are increased in 3 leg transmission tower as compared to 4 leg transmission tower on the contraverse there is less steel consumption and area required for 3 leg transmission towers as compared to 4 leg transmission tower. [1]

A study on Structural Analysis and Design of Steel Transmission Tower in Wind Zones II and IV using
STAAD.ProV8i by S.Panwar et.al is done. In this paper it is found that the axial forces and bending moments have changed for the two different locations. [2]

A study on Static and Dynamic Analysis of Transmission Line Towers under Seismic Loads is done by S.Karthik C S et.al. The paper introduces different types of transmission tower and its configuration as per Indian Standard IS-802. A typical type of transmission line tower carrying 220kV single circuit conductors is modelled and analysed using SAP2000 considering forces like wind load, dead load of the structure, breaking load of the conductors and earthquake load as per Indian Standard IS1893: 2000 (part
The conclusion drawn out from this paper is that Study of different load cases on structure is very important to recognize the case that will cause larger deflection in tower model and to say which case will be optimized and Tower structure with least weight is directly proportional in reduction of the cost. [3]

A research study on Seismic Response of Power Transmission Tower-Line System Subjected to Spatially Varying Ground Motions is done by Li Tian, Hongnan Li, and Guohuan Liu. The outcomes prove that the uniform ground motion at all supports of system does not provide the most critical case for the response calculations. [4]

A study about the design of four-legged steel lattice tower for categorization of gravity and lateral loads under various load combinations for Shimla using IS 800:1984 by Bhardwaj H.L. et.al. [5].

A comparative analysis carried out for different heights of towers using different types of bracing system for wind zones I to V and earthquake zones II to V of India by gust factor method is used for wind load analysis, model analysis and response spectrum analysis, used for earthquake loading by Sharma Kr. K. et al. [6].

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II. PROPOSED METHODOLOGY

The following flow process was adopted for analysis of the steel transmission tower for different risk coefficients located in Pune and Delhi.

A. Application of Proposed Methodology

The present problem is solved by using SAP 2000 v.20 by following the procedure as described below: -

The software tool used in the design and analysis of the tower is SAP 2000 v.20

1) Manual calculations are important for the recommendations of IS codes but the validation of these results and study of effects of these loads on the structure is also an important part to do.
2) Analysis of the performed task is the key to success for the safe and durable serviceability of the structure under various load combinations.
3) Now based on the validation of results through SAP 2000 v.20 and the conclusions are drawn out.

B. Configuration of the Tower

1) The locations are Pune and Delhi
2) The height of the tower is 27m.
3) The base width of the tower is 5 m.
4) The top width of the tower is 5m.
5) Number of cables supported by tower are 7.

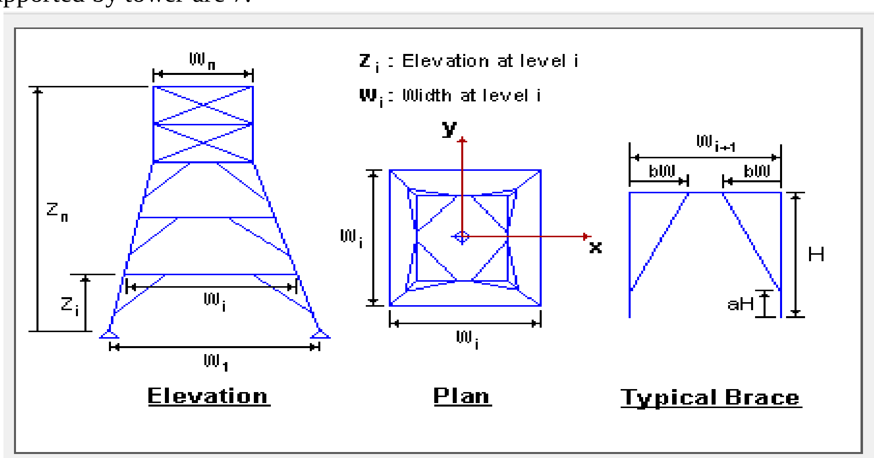

Fig.1 Typical Tower Parameters

Fig.2 Flow process adopted for analysis of the steel transmission tower

C. Design calculations:

1) Area of segment (A_e) =22m^2
2) Cable load=Unit load X c/c distance of one cable from the other cable = 10KN
3) Total Cable Load= 1.5 X cable load+ wt. of man with loads + Weight of earth wire attachment =1.5* 10+1+1 =17KN

Following is the table showing manual calculations of loads to be applied on both the modelsway to comply with and simply type your text into it.

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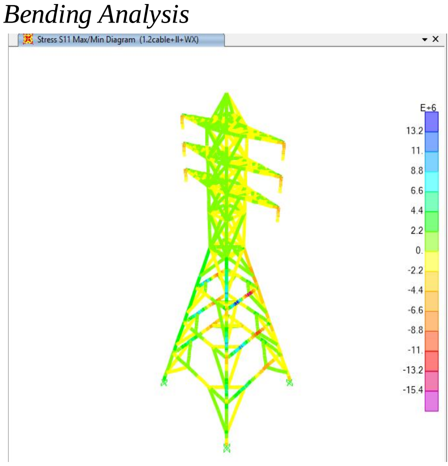
TABLE I
MANUAL CALCULATIONS OF LOADS TO BE APPLIED ON BOTH THE MODELSWAY

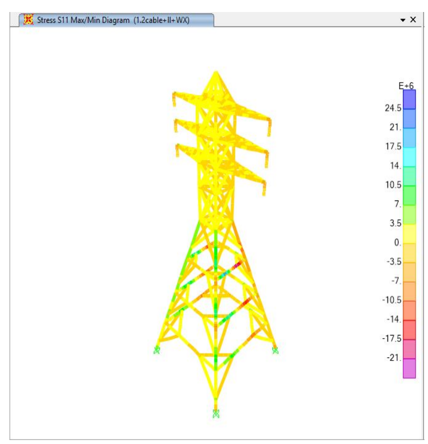
For Pune	For Delhi
Basic Wind Speed = 39 m/sec	Basic Wind Speed = 47 m/sec
k_1 = Probability factor or risk coefficient = 1.06	k_1 = Probability factor or risk coefficient = 1.07
Seismic Zone = III [8]	Seismic Zone = IV [8]
The terrain, height and structure size factor k2 is varying at different levels of the tower and is taken from IS Code 875:1987 Part 3[9]	
k_2 at 16m height = 1.026; k_2 at 19m height = 1.044 k_2 at 21m height = 1.055; k_2 at 23m height = 1.065 k_2 at 25m height = 1.075; k_2 at 27m height = 1.085	
The Topography factor k_3 is assumed to be 1 for plain terrain of Pune.	The Topography factor k_3 is assumed to be 1 for plain terrain of Delhi.
Calculation of wind load The design wind speed is calculated as: $V_z= V_b×k_1×k_2×k_3$ V_z at 16m = 39×1.06×1.026 ×1 = 42.414 m/sec V_z at 19m = 39× 1.06 × 1.044 ×1= 43.159m/sec V_z at 21m = 39 × 1.06 × 1.055×1 = 43.613m/sec V_z at 23m = 39×1.06 × 1.065 ×1= 44.027m/sec V_z at 25m = 39×1.06 × 1.075 ×1= 44.441m/sec V_z at 27m = 39×1.06 × 1.085 ×1= 44.85m/sec	Calculation of wind load The design wind speed is calculated as: $V_z= V_b×k_1×k_2×k_3$ V_z at 16m = 47×1.07×1.026 ×1 = 51.598 m/sec V_z at 19m = 47× 1.07 × 1.044 ×1= 52.503m/sec V_z at 21m = 47 × 1.07 × 1.055×1 = 53.056m/sec V_z at 23m = 47×1.07 × 1.065 ×1= 53.559m/sec V_z at 25m = 47×1.07 × 1.075 ×1= 54.062m/sec V_z at 27m = 47×1.07 × 1.085 ×1= 54.56m/sec
Calculation of Design Wind Pressure $p_z= 0.6\ V_z^2$ p_z at 16 m =0.6×(42.414)^2=1079.36 N/m^2 p_z at 19 m= 0.6 ×(43.159)^2 = 1117.62 N/m^2 p_z at 21 m = 0.6 ×(43.613)^2 = 1141.256N/m^2 p_z at 23 m= 0.6 ×(44.027)^2 = 1163.026N/m^2 p_z at 25 m= 0.6 ×(44.441)^2 = 1185.001 N/m^2 p_z at 27 m= 0.6 ×(44.85)^2 = 1206.91 N/m^2	Calculation of Design Wind Pressure $p_z= 0.6\ V_z^2$ p_z at 16 m =0.6×(51.598)^2=1597.41 N/m^2 p_z at 19 m= 0.6 ×(52.503)^2 = 1653.94 N/m^2 p_z at 21 m = 0.6 ×(53.056)^2 = 1688.96N/m^2 p_z at 23 m= 0.6 ×(53.559)^2 = 1721.14N/m^2 p_z at 25 m= 0.6 ×(54.062)^2 = 1753.62 /m^2 p_z at 27 m= 0.6 ×(54.56)^2 = 1786.07 N/m^2
Design wind force $F= C_f×A_e×p_z×φ$ F at 16m=3.15×44×1079.36×0.23 = 34.41 KN F at 19m=3.15×44×1117.62×0.23=35.63 KN F at 21m=3.15×44×1141.256×0.23=36.38KN F at 23m=3.15×44×1163.026×0.23=37.07 KN F at 25m=3.15×44×1185.001×0.23=37.78 KN F at 27m=3.15×44×1206.91×0.23=38.47 KN	Design wind force $F= C_f×A_e×p_z×φ$ F at 16m=3.15×44×1597.41×0.23 = 50.92 KN F at 19m=3.15×44×1653.94×0.23=52.72 KN F at 21m=3.15×44×1688.96×0.23=53.84KN F at 23m=3.15×44×1721.14×0.23=54.86 KN F at 25m=3.15×44×1753.62×0.23=55.9 KN F at 27m=3.15×44×1786.07×0.23=56.93 KN

III.RESULTS AND DISCUSSIONS

A. Beam Stress, Bending Analysis



Beam Stresses for Pune



Beam Stresses for Delhi

Fig.3 Stresses generated in the steel tower for Pune and Delhi location

Above figure 3 shows the stresses generated in the steel tower for Pune and Delhi location on application of wind load, cable load and live load. The total beam stress due to bending at critical loading combination is shown on the tower.

B. Comparison Of The Critical Beams In Both Locations For Axial And Shear Forces And Bending Moment

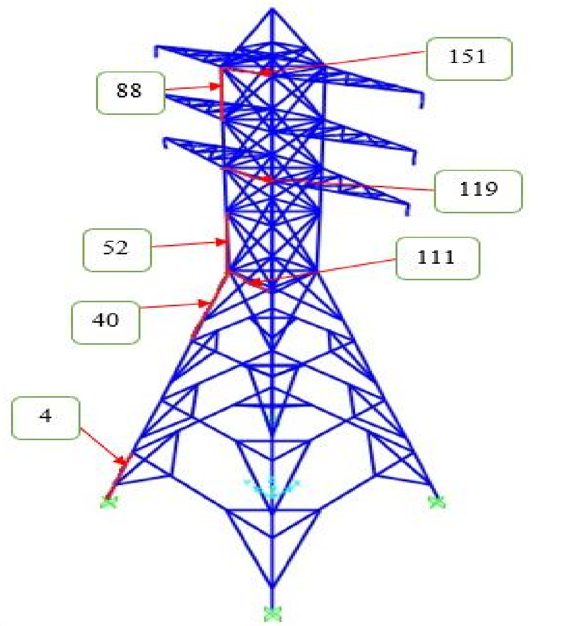


Fig.4 Locations of critical beams

Table III
Comparison Of The Critical Beams In Both Locations For Axial And Shear Forces And Bending Moment

Location	Object No. i.e. beam	Axial Force kN	Shear Force V2 kN	Bending Moment M3 kN-m
Pune	4	1209.719	19.256	23.7937
	40	1410.661	33.991	-30.4489
	52	663.086	-2.115	-4.5243
	88	62.467	-0.846	1.0861
	111	105.913	-0.778	0.8388
	119	-98.383	0.267	-1.49
	151	5.534	0.024	-0.8343
Delhi	4	1718.422	26.819	33.1477
	40	1998.173	47.3	-42.3925
	52	939.961	-2.957	-6.2942
	88	95.457	-0.798	1.045
	111	149.304	-1.09	1.1714
	119	-153.492	0.315	-1.5484
	151	-4.724	0.032	-0.8484

Above table shows the values of axial force, shear force and bending moment for effective beams and the variation of forces and moments between Pune and Delhi.

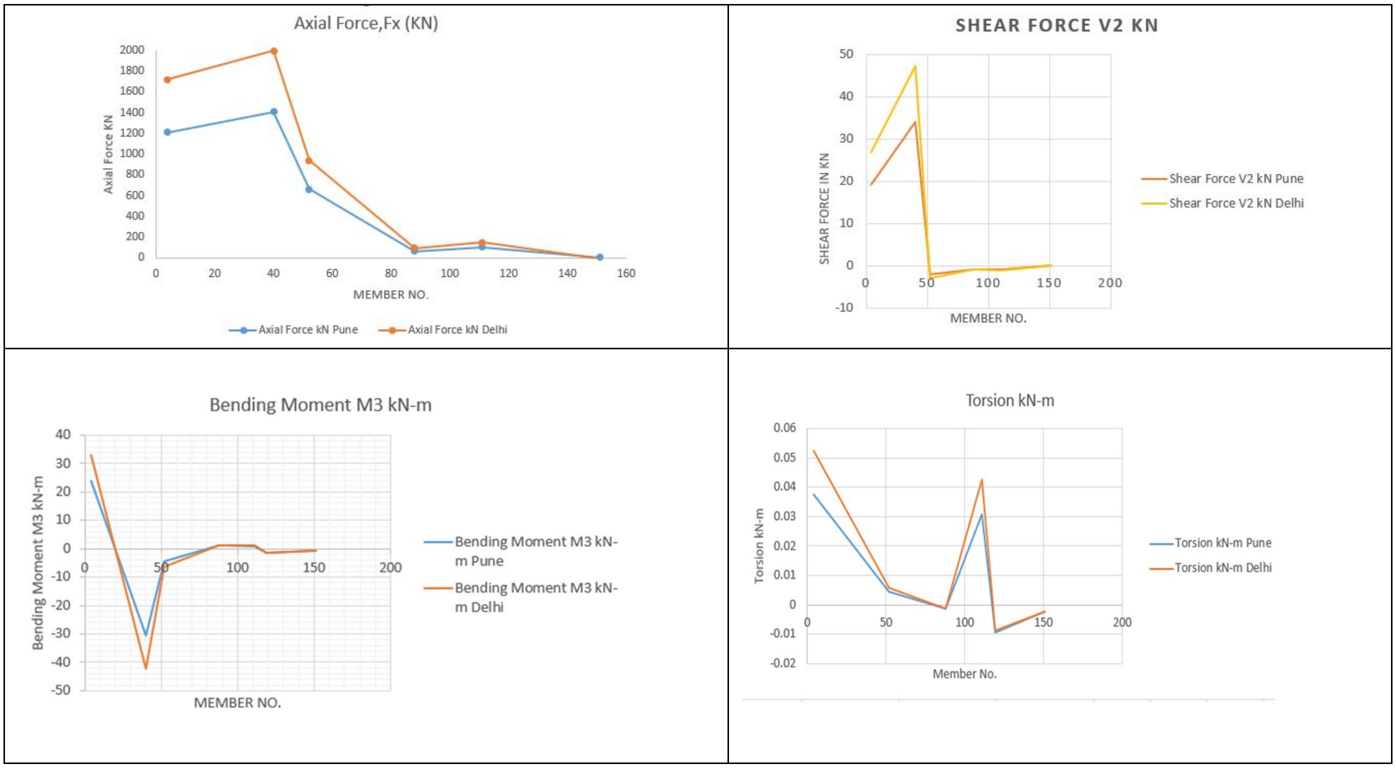


Fig.5 Plotting of graph for the Locations of critical beams in both locations

C. Variation Of Axial Force, Shear Force And Bending Moment Of A Typical Beam

Location : Pune

Location : Delhi

Fig.6 Variation of axial force, shear force and bending moment of a typical beam

D. Base Reaction

TABLE IIIII
BASE REACTION

Location	Global FX KN	Global MY KN-m
Pune	-1038.66	-22124.604
Delhi	-1478.268	-31447.668

IV. CONCLUSIONS

In this paper study of the steel transmission tower for different risk coefficients with same bracing system located in Pune and Delhi is made for seismic zones III and IV. The analysis of the steel transmission towers has been done by using SAP2000 Integrated Solution for Structural Analysis and Design Software version 20.

The following conclusions are drawn on the basis of the research and analysis done using SAP2000 Integrated Solution for Structural Analysis and Design Software version 20 and conforming the safety of same tower at both the mentioned places.

1) There is large difference in the bending moment forces on the members on the two specified locations with the slight change of the wind pressure force but is in safe limits and it is maximum on member no. 4.
2) There is huge change in the axial force in the members of the transmission tower in these two locations for which maximum axial force is shown on member no. 4 and 40.
3) There is slight change in shear force.
4) Base reaction is more in the Delhi steel transmission tower as compared to Pune steel transmission tower.

Further studies can be made for different seismic zones, different bracing of the tower and different risk coefficients. paragraphs

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