ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 3, Issue 4, April 2018

Analysis and Design of Four Legged 400kv Multi-Circuit Transmission Tower with Different Bracing Systems

[1] Yashodeep N. Borse, [2] Dr. G. R. Gandhe
[1] Student, M.E. Structural Engineering, DIEMS Aurangabad,Aurangabad (M.S), India.
[2] Professor & HOD,Civil Engineering Dept., DIEMS Aurangabad, Aurangabad (M.S), India

***Abstract*— Transmission tower design is very useful because they constructed to carry power lines at safe and sufficient distances from ground level due to high voltage. Transmission tower constitutes 28 to 42% cost of transmission lines. Cost of tower depends upon its configurations and bracing patterns used. Bracing members enhance the stiffness and reduce the slenderness ratio of the tower. In the present study, four-legged multi-circuit 400 kV self-supporting transmission towers having 20 line deviation consisting four different bracing models are considered. Four different bracing patterns i.e. Inverted V bracing, XBX bracing, X-X bracing and W bracing are considered in the lower body. For analysis and design STAAD.Pro software is used as 3D space. For wind, analysis IS 802 (1995) is used. Performance of towers with respect to axial forces and deflections is presented.**

***Index Terms*— Angle sections, axial forces, bracings, deflections, multi-circuit tower, sag, etc.**

I. INTRODUCTION

Transmission line towers are carrying heavy power lines at safe and sufficient distance. Tower is designed as per structural and electrical point of view. Tower configurations, conductors, insulators, bracings, cross arms and foundations are major components of tower. Transmission line towers constitute about 28 to 40% of the cost of the transmission line as stated by Rao G. Visweswara (1995). Cost of tower depends upon tower configurations, cross arm, height and right type of bracing systems as stated by David J.S.(1992) and Tupe D.(2008). The bracing members increases stiffness and reduces slenderness ratio of tower. The present study is regarding bracing pattern and its impact on axial forces, deflections under same loading pattern. Wind analyses are carry out as par IS 802 (1995).The objective of this paper is to find out efficient bracing system for 400kV multi-circuit transmission line tower.

II. TRANSMISSION TOWER CONFIGURATION

The present study, four legged 400 kV multi-circuit self-supporting suspension angular tower having line deviation of 20 with different bracing systems in tower body are considered. A floor plan of 13.5 m x 13.5 m size is considered as shown in figure 1. The bracing patterns are Inverted V bracing, XBX bracing, W bracing and XX bracing in the tower body. The tower configurations are given in Table 1 and figure 2. As per the guidelines of IS 802 and HVPNL[9], Table 2 lists the details of parameters for conductor and ground wire are considered from IS 802 (Part 1/section1)1995 and IS:5613 (Part 3/section1)1989 and Table 3 lists the details of wind parameters required for analysis. The STAAD.Pro software have been used for the analysis. In this study, 3D analysis of tower considering all members of tower as space truss as primary member. The wind load analysis is carried out according to IS 802(1995). The loading is considered for normal condition (NC). The four different models are as shown in Figure 2 and Figure 3 indicates loading criteria considered while analysis of four models of tower in STAAD.Pro software. The different bracing patterns are differed only in tower body however other members of tower remain same in all models of tower.

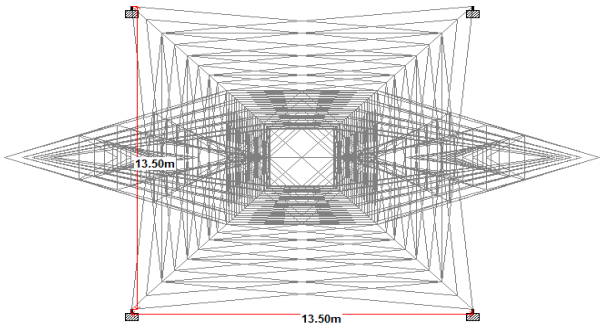

Fig. 1: Plan for four legged transmission tower

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 3, Issue 4, April 2018

Table 1 Configurations of Four Legged transmission towers

Transmission line voltage	400 kV
Tower type	Suspension Tower
No. of circuit	Multi-circuit
Shielding angle	200 permissible
Angle of line deviation	0°- 2°
Cross arm	Pointed
Tower shape	Barrel shaped
Bracing pattern in Cage of Body	X-X Bracing

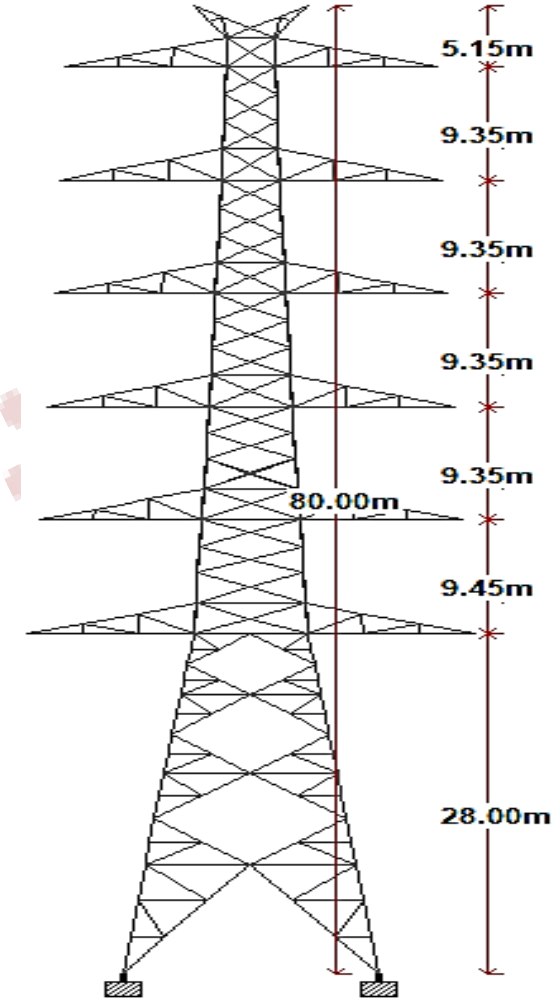

Fig. 2 (a): Elevation of four legged tower in XBX bracing

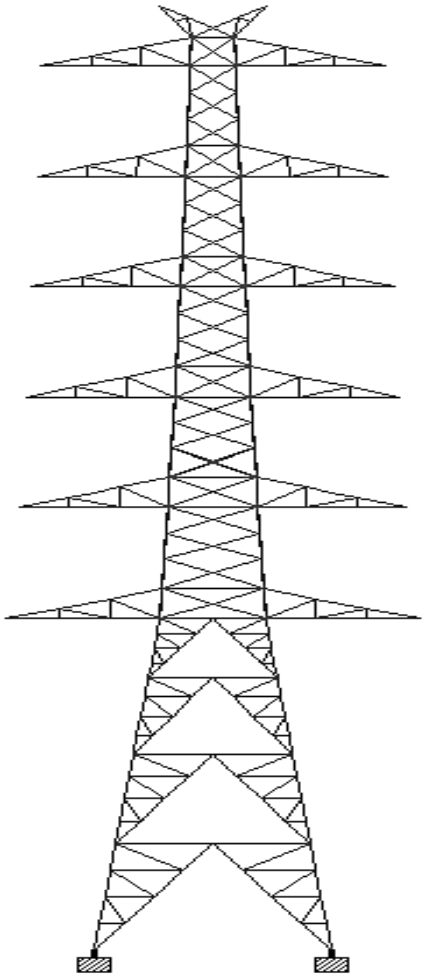

Fig. 2 (b): Elevation of four legged tower in inverted V bracing

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 3, Issue 4, April 2018

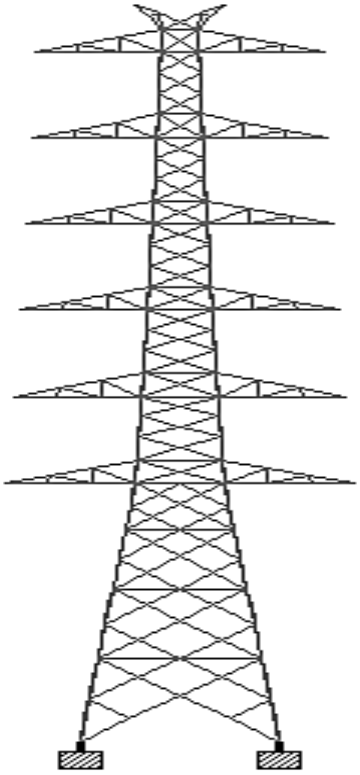

Fig. 2 (c): Elevation of four legged tower in W bracing

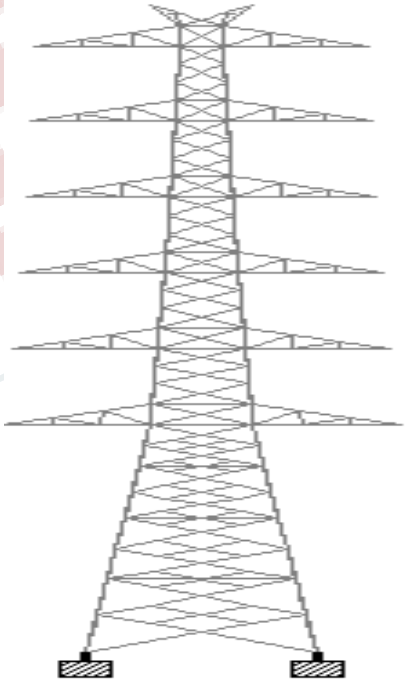

Fig. 2 (d): Elevation of four legged tower in XX bracing

Table 2 Parameters for the Conductor and Ground Wire and insulator

Conductor data	
Conductor material	ACSR (Aluminum Conductor Steel Reinforcement)
Conductor size	54/3.53
Overall diameter of the Conductor	31.77mm
Area of the conductor	5.97cm2
Weight of the conductor	2.004 kg/m
Breaking strength of the conductor	16438.00 Kg
Coefficient of linear expansion (α)	0.193 X10-4/0C
Modulus of Elasticity	0.704X106 kg/cm2
Ground wire	
No. of Ground Wire	2
G.W. type and material	Galvanized steel Earth wire
G.W. size	7/3.66
Diameter	10.98 mm
Area of cross section	0.73646 cm2
Unit Weight	0.583 Kg/m
Breaking Capacity	7848 Kg
Coefficient of linear expansion (α)	0.115X10-4/0C
Modulus of Elasticity	0.1933X107 Kg/cm2
Insulator	
Insulator type	Suspension type
Size of insulator disc	280 mm x170 mm
Length of insulator string	3850 mm
Length of ground wire	2000 mm
Weight of Insulator Disk	3.5 kN
Minimum Wind Load on insulator	1.0 kN
Minimum Ground Clearances	8840 mm
Mid Span Clearance	9000 mm

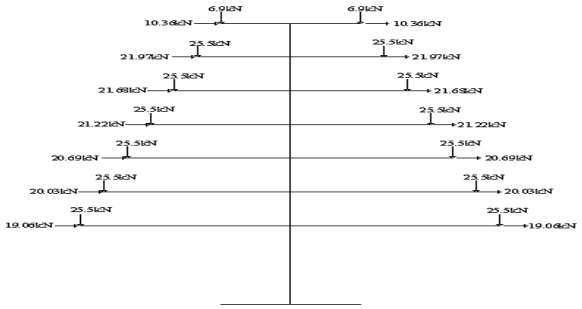

Fig. 3: Wind load on conductors and insulators

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 3, Issue 4, April 2018

Table 3 Parameters for Wind Load

Terrain Category	Category 1
Return period	150 years
Minimum wind load on insulators	1.0 kN
Wind span 400m	400m
Basic wind speed	39 m/s
Basic wind pressure	681 N/m2

III. RESULTS AND DISCUSSIONS

The wind analysis results for all four models are presented here in terms of axial forces and deflection.

Axial Forces

Maximum axial forces in the members of towers are as shown in figure 4. It is observed that W type bracing patterns has minimum axial forces in normal wire condition. Axial forces in XBX bracing are about 4.75% more than W type bracing. Axial forces in inverted V bracing are about 6.43% more than W type bracing where-as forces in XX bracing is about 10.36% more than that of W bracing system. Configurations of cross arm with different bracing system in towers are similar. So axial forces in cross arm member is near about same.

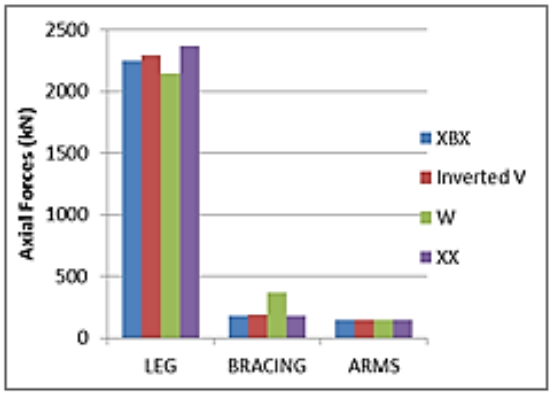

Fig. 4 : Maximum axial forces in towers

Lateral Deflections

Maximum deflections in towers with different bracing systems at different height of towers are as shown in figure 5. It shows that W bracing system has minimum deflection as compare to other bracing systems. Deflection in XBX bracing are about 2.88% more than W type bracing. Deflection in inverted V bracing are about 4.53% more than W type bracing. Deflection in XX bracing are about 3.2% more than W type bracing. Permissible deflectin limit is H/ 100, where H is height in mm. All deflections are within permissible limit.

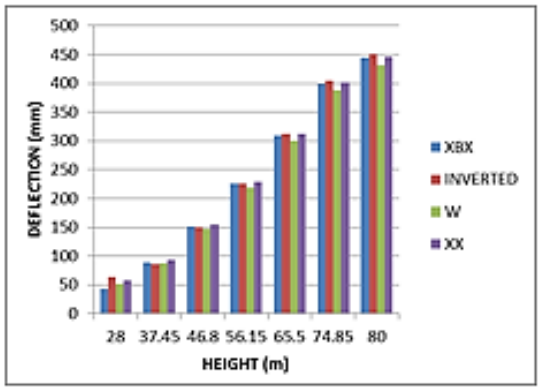

Fig. 5: Maximum deflection in towers with different bracing

IV. CONCLUSIONS

In this paper, comparative analysis and design of four legged 400 kV multi-circuit self-supporting suspension angular tower with different bracing systems. A floor plan of 13.5 m x 13.5 m size is considered.

1. Minimum axial forces are observed in W bracing as compare other bracings.
2. Maximum axial forces are observed in XX bracing i.e. 10.36% more as compare to W bracing system.
3. Axial forces in all cross arm members with different bracing patterns are almost same.
4. Maximum deflection at the top of tower in inverted V bracing is 4.53 % more than deflection of W type bracing.

REFERENCES

1. "Analysis and Design of Three and Four Legged 400KV Steel Transmission Line Towers: Comparative Study", by Y. M. Ghugal et al, International Journal of Earth Sciences and Engineering ISSN 0974-5904, Volume 04, No 06 SPL, October 2011, pp 691-694.

2. "Dynamic Response of Power Transmission Towers under Wind Load" by Li Pengyun, Lin Jiedong, Nie Ming, ZhongWanli, Huang Auguo - SciVerse Energy Procedia 17 (2012) 1124 1131.

3. "Optimum Designs for Transmission Line Towers", by G. Visweswara Rao, Computer & Structures vol.57.No.1.pp.81-92, 1995 Elsevier Science Ltd.

4. I.S. 802 (Part -1/Sec 1)1995, "Use of Structural Steel in

Overhead Transmission Line Towers - Code of Practice".

5. I.S. 5613 (Part-1/Sec 2):1985, "Code of Practice for Design, Installation and Maintenance of Overhead Power Lines".

6. I.S. 802(Part1/Sec2):1995, "Use of Structural Steel in Overhead Transmission Line Towers – Code of Practice".

7. Central Board of Irrigation and Power (CBIP), "Transmission Line Manual", Publication No. 268.

8. "Transmission line Structure" Text Book on Transmission line Structure by Murthy and Santhakumar A.R.

9. "Transmission line Structure" Text Book on Transmission line Structure by Dayaratnam.