International Research Journal of Education and Technology
Peer Reviewed Journal
ISSN 2581-7795

Comparative Study of Transmission Line Tower and Mopole Tower

Neel D Sheladiya

Abstract— Nowadays, population is increasing day by day and consequently, the use of electricity has been also increased. It is becoming difficult to cater increasing demand of energy since the use of electrical gadgets is escalating day by day. There are various sources to get energy like transmission of generated electricity to people by transmission tower. Because of this approach, the use of electricity has been increased and hence, the construction of transmission tower is also increasing. The construction of transmission tower requires a lot of space. One energy transmission tower requires approximately 25 m^2 land space and because of this it has become extremely pivotal to find a structure that requires less space. The use of monopole tower has become imperative because it requires less space as compared to transmission tower. While transmission tower is a structure made of one truss, Monople tower is a structure made of tubes. In this comparative study Transmission line tower and Monopole tower has to be compared for minimum space, weight and cost by evaluating axial force, displacement and weight of tower. In this present research a study on 132kv suspension tower with different configuration is compared with monopole tower for same configuration and loadings. Modelling and Analysis of the tower is done using STAAD.Pro V8i software using IS 802 (Part1 / Sec 1): 2015 and CBIP manual.

Index Terms— Comparative Study, Cost Cutting, Energy Supply, Energy Demand, Land Problems, Monopole Tower, Transmission Tower.

1 Introduction

THIS document is to highlight the current scenario for the increase in the energy demand and decreade in the usable land as transmission towers require a much amount of space, due to the polulation density it is very hard for the power grid to transmit sufficient energy through the population density centers effectively.

Addressing this issue may find us a way to supply electricity through dense areas in a comparatively cheaper way also in urban cities transmission lines are non asthetic and could affect the aschetics of the CBD (The central business district) of a urban city**. Monopole** Towers here can provide us the same rang of transmitting the electricity needs with comparatively less space and very much better asthetics.

Developed contries has already opted monopoles for transmission of electricity.

In general steel transmission line towers and monopoles are used to transmit the electric power. Considering of non-availability of sufficient land for installation of conventional steel lattice type tower, To defeat these practical difficulties, a new type of transmission line is being used world-wide, is called monopole.

The construction cost of monopole tower constitutes about quarter to half of the cost of transmission line and hence optimum tower design will bring in essential savings.

2 Scope of study

- To find out and compare the axial forces, deflection and weight of tower for different configuration of tower.
- Analysis can be done with different loading condition like Reliability condition, security condition and safety condition.
- Single circuit, Double Circuit, suspension and tension tower will be study.
- Design of transmission tower is done as per IS 802:2015 and monopole tower is design as per CENTRAL BOARD OF IRRIGATION AND POWER manual publication No.323.
- Analytical study helps to select structure for area where need of right of way is limited due to adequate land.
- Cost comparison for both types of tower.
- The economic tower can be used after comparing the results of the STAAD pro analysis.

3 Tower Loadings

As Tower loading is most vital input for tower design. Any mistake, omission or error in the load assessment will make the tower design erroneous and it will lead to severe financial impact to perform corrections, modification at a later date. Various types of loads are to be calculated accurately depending upon the design parameters. In the load calculation the wind play a vital role. The correct assessment of wind load will lead to proper load assessment and reliable design of tower structures.

Requirement of Loads on Transmission Lines

3.1. Climatic loads related to reliability requirements.
3.2. Failure containment loads related to security requirements.
3.3. Construction and maintenance loads related to safety requirements.

Neel Dineshbhai Sheladiya is currently pursuing masters in technology program in structural engineering in Dr. AJP Abdul Kalam University, Indore, Madhya Pradesh-452016, Email: neelsheladiya15@gmail.com

International Research Journal of Education and Technology
Peer Reviewed Journal
ISSN 2581-7795

3.1 TRANSVERSE LOADS FOR RELIABILITY CONDITION (NORMAL CONDITION)

Wind load on Conductor and Ground wire

The load due to wind on each conductor and ground wire, Fwc in Newton applied at supporting point normal to the line shall be determined by the following expression:

$$Fwc = Pd \times Cdc \times L \times d \times Gc$$

Where,

Pd = design wind pressure, in N/m^2;

Cdc = drag coefficient, taken as 1.0 for Conductor and 1.2 for ground wire;

L = wind span, which is sum of half the span on either side of supporting point, in metres;

D = diameter of cable, in metres; and

Gc = gust response factor, takes into account the turbulence of the wind and the dynamic response of the conductor. Values of Gc are given in Table below for the three terrain categories and the average height of the conductor/ground wire above the ground.

Terrain Category	Height above Ground, (m)	Values of Ge for Ruling Span of in (m)						
		Up to 200	300	400	500	600	700	800 and above
1	Up to 10	1.70	1.65	1.60	1.56	1.53	1.50	1.47
	20	1.90	1.87	1.83	1.79	1.75	1.70	1.66
	40	2.10	2.04	2.0	1.95	1.90	1.85	1.80
	60	2.24	2.18	2.12	2.07	2.02	1.96	1.90
	80	2.35	2.25	2.18	2.13	2.10	2.06	2.03
2	Up to 10	1.83	1.78	1.73	1.69	1.65	1.60	1.55
	20	2.12	2.04	1.95	1.88	1.84	1.80	1.80
	40	2.34	2.27	2.20	2.13	2.08	2.05	2.02
	60	2.55	2.46	2.37	2.28	2.23	2.20	2.17
	80	2.69	2.56	2.48	2.41	2.36	2.32	2.28
3	Up to 10	2.05	1.98	1.93	1.88	1.83	1.77	1.73
	20	2.44	2.35	2.25	2.15	2.10	2.06	2.03
	40	2.76	2.67	2.58	2.49	2.42	2.38	2.34
	60	2.97	2.87	2.77	2.67	2.60	2.56	2.52
	80	3.19	3.04	2.93	2.85	2.78	2.73	2.69

Wind load on tower

In order to determine the wind load on tower, the tower first of all divided into different panels having a height 'h'. These panels in normal case should be taken between the intersections of the legs and bracings. For a lattice tower composed of square cross- section, the resultant wind load F_{wt} in Newtons, for wind normal to the longitudinal face of tower, on a panel height 'h' applied at the centre of gravity of this panel is:

$$Fwt = Pd \times Cdt \times Ae \times Gt$$

Pd = design wind pressure, in N/m2;

Cdt = drag coefficient for panel under consideration against which the wind force is acting. Values of Cdt for different solidity ratios are given in Table 4.1.

Solidity ratio which is equal to the effective area (projected area of all the individual elements) of a frame normal to the wind direction -divided by the area enclosed by the boundary of the frame normal to the wind direction;

Ae = total net surface area of the legs, bracings, cross arms and secondary members of the panel projected perpendicular to the face in m2. (The projections of the bracing elements of the adjacent faces and of that plan-and-hip bracing sections may be neglected while determining the projected surface of a face)

Gt = gust response factor, peculiar to the ground roughness and depends on the height above ground. Values of GT for the three terrain categories are given in Table.

Height Above Ground (meter)	Values of G_T and G_i for Trerain Categories		
	1	2	3
Up to 10	1.70	1.92	2.55
20	1.85	2.20	2.82
30	1.96	2.30	2.98
40	2.07	2.40	3.12
50	2.13	2.48	3.24
60	2.20	2.55	3.34
70	2.26	2.63	3.46
80	2.31	2.69	3.58

Transverse Load from Mechanical Tension of Conductor and Ground wire due to Wind (Deviation Load)

This load acts on the tower as component of Mechanical tension of conductor or ground wire.

$$Fwd = 2 \times T \times \sin Ø/2$$

Fwd = Load in Newtons

T = Maximum tension of Conductor and ground wire at every day temperature and 100% of full wind pressure or at minimum temperature and 36% of full wind pressure whichever is more stringent.

Ø = Angle of deviation.

International Research Journal of Education and Technology
Peer Reviewed Journal
ISSN 2581-7795

Total transverse load under reliability condition

TR = $Fwc + Fwi + Fwt + Fwd$

Where "Fwc" and "Fwi" and "Fwd" are to be applied on all Conductor/Ground wire points But "Fwt" to be applied on tower at ground wire peak and cross arm levels and at any one convenient level between bottom cross arm and ground level for normal tower In case of Normal tower with extensions, one more application level shall be taken at top end of extension.

3.2 TRANSVERSE LOADS IN SECURITY CONDITION

3.2.1 Suspention Tower

- Transverse loads due to wind action on tower structure, conductor, ground wires and insulators shall be taken as corresponding to 75% of full wind pressure at everyday temperature.
- Transverse loads due to line deviation shall be based on component of mechanical tension of unbroken conductors and ground wires/ OPGW corresponding to everyday temperature and 75% of full wind pressure. For broken conductor, ground wire or OPGW, the component shall be corresponding to 50% of mechanical tension of conductor and 100% of mechanical tension of groundwire at everyday temperature and corresponding to 75% of full wind pressure.

3.2.1 Tension and Dead End Tower

- Transverse loads due to wind action on tower structure, conductors, groudwires and insulators shall be computed as per clause 4.3.1 for 75% of full wind pressure. 60% wind span shall be considered for broken-wire and 100% for intact wire.
- Transverse loads due to line deviation shall be the component of 100% mechanical tension of conductor and groundwire as defined in Clause 4.3.4 for Everyday temperature and 75% of full wind pressure condition.

3.3 TRANSVERSE LOADS IN SAFETY

Condition Normal Condition for Suspension, Tension and dead End Towers

Transverse loads due to wind action on tower structure, conductor, groundwire and insulators shall be taken as nil.

$$Fwd = 2 \times T \times \sin Ø/2$$

Fwd = Load in Newtons
T = Tension of conductor / groundeire at corresponding wind pressure.

Ø = Angle of deviation.

Broken-wire Condition for Suspension, Tension and Dead End towers

Transverse loads due to wind action on tower structure, conductor or groundwire at everyday temperature and nil wind on account of line deviation shall be considered as follows :

$$TM = T1 \times \sin Ø/2$$

Where,

TM = Load in newtons

T1 = 50% of tension in Newtons of conductor and 100% of tension of groundwire at everyday temperature and nil wind for suspension tower and 100% for angle and dead end towers for both conductor and groundwire.

Ø = Angle of deviation of the tower.

Vertical loads for Reliability condition

Vertical loads for Security Condition and safety condition

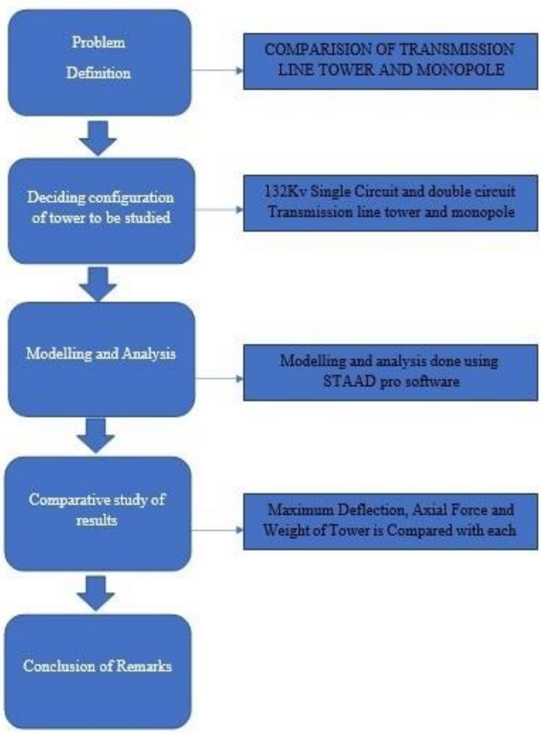
Longitudinal Loads for Reliability condition

Longitudinal Loads for Security Condition

Longitudinal Loads – Safety Condition.

International Research Journal of Education and Technology
Peer Reviewed Journal
ISSN 2581-7795

4 METHODOLOGY FLOWCHART



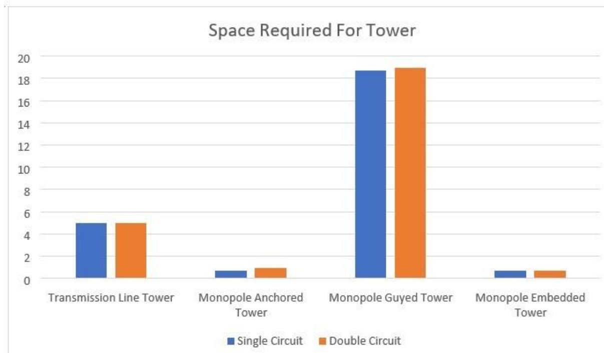
5 COMPARATIVE STUDY

5.1 Space Comparison For Transmission line tower and Monopole Tower

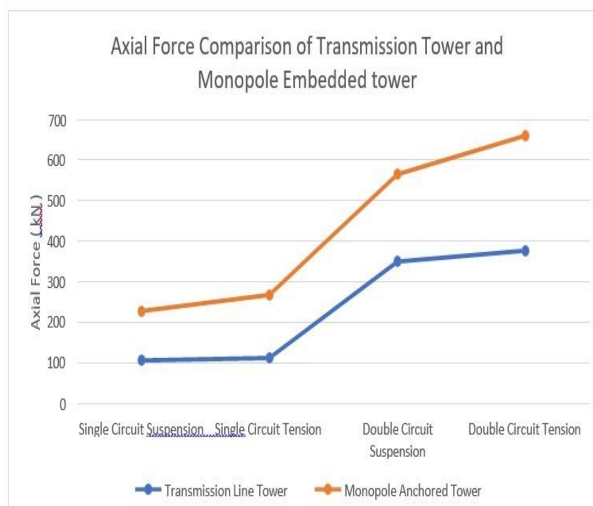
Dimension Comparison For Transmission line tower and Monopole Tower

	Transmission Line Tower Base Width (Meters)	Monopole Tower Embedded Base Width (Meters)
Single Circuit Suspension	5	0.7
Single Circuit Tension	5	0.7
Double Circuit Suspension	5	0.9
Double Circuit Tension	5	0.9

Space Comparison Chart

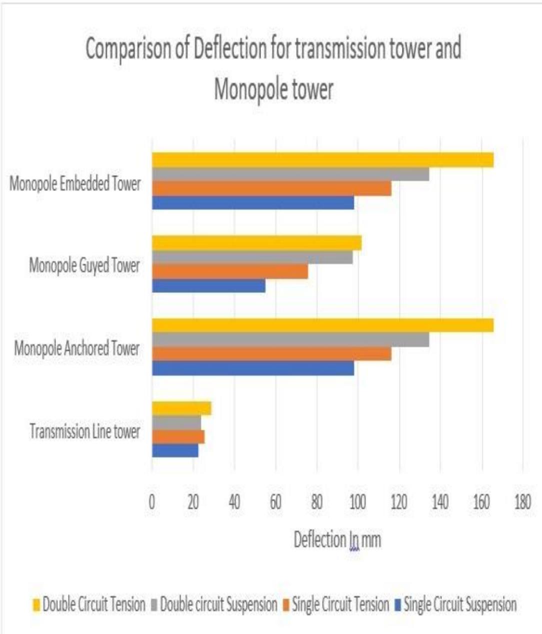


5.2 Axial Force Comparison of Transmission Line Tower and Monopole Tower.

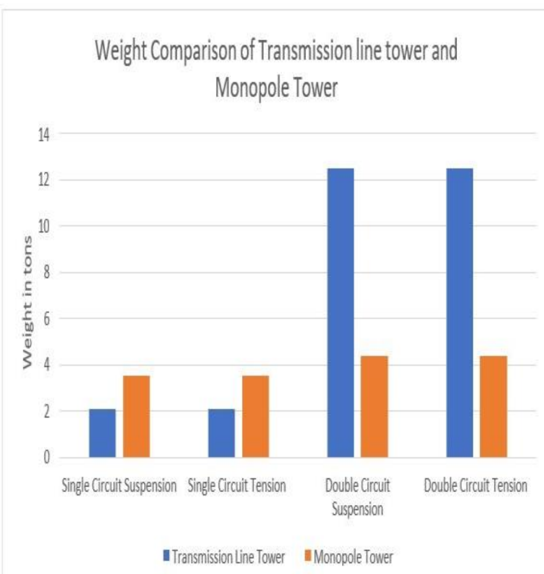


International Research Journal of Education and Technology
Peer Reviewed Journal
ISSN 2581-7795

5.3 Comparison of Deflection for transmission line tower and Monopole tower.



5.3 Weight Comparison of transmission line tower and Monopole tower.



6 CONCLUSION

- From this Comparative study, It Conclude that Monopole tower required less right of way, Space requirement is less than a transmission line tower, It gives Better visual appearance, Usage of Less Compo- nents gives benefits in Faster installation, and less installation cost.
- From study, It conclude that Transmission line tower required 25 square metre area when Monopole required only one square meter area, Monopole tower occupies 96% less area than a Transmission line tower.
- Monopole tower can be constructed where space availability is less in compared with the transmission line towers.
- It can be also conclude that maximum deflection of monopole tower is 165mm and maximum deflection of transmission tower is 28mm, Monopole tower deflection is more than the transmission tower, It is specified in " CENTRAL BOARD OF IRRIGATION AND POWER" maximum 1.5% of the pole height deflection is allowa- ble in Monopole tower.
- It conclude that broken conductor case, bigger deflec- tion of the steel pole reduces tension in intact span and induces smaller bending moment at base. Round profileinduces less wind.
- The monopole towers show 18.7% lesser weight compared to transmission line tower,
- In case of cost estimation Monopole Tower is 4 to 5 times cheaper than transmission line tower, monopole tower erection cost is lesser than transmission line tower because of less components. Monopole tower can be installed within 3 days.

7 ACKNOWLEDGEMENT

I would like to express my gratitude to my guide Ms. Priyanka Dubey (Head Civil Department Dr. A. P. J. Abdul Kalam University, College of Engineering Indore, MP, India) who had been instrumental in guiding me through each and every phase of my Project Report, she has been a sense of inspiration enthusiasm without which the successful completion of project would have been an impossible dream. I would also like to appreciate enthusiastic cooperation of our University Staff without whose help, knowing the information would have been a

te
dious job. Last but not least, I would like to especially

thank my family members, friends who have tremendously boosted me and who have been my driving force throughout my Major Report. Their support and blessing helped me to reach this stage.

8 REFERENCES

- Stress state and failure path of a tension tower in a transmission line under multiple loading conditions, Xing Fu , Wen-Long Du, Hong-Nan Li , Gang Li, Zhi-Qian Dong, Li-Dong Yang (2020) Elsevier(Thin-Walled Structures 157 (2020) 107012).
- Full-scale test and numerical failure analysis of a latticed steel tubular transmission tower, Li Tiana, Haiyang Pana,Ruisheng Maa, Lijuan Zhangb, Zhengwei Liub, Elsevier Journal of Engineering Structures 208 (2020) 109919.
- Experimental and numerical researches on a new type of tower for steep mountainous areas, Yide Gana , Hongzhou Denga, Huafeng Liub , Qingbin Zhaob, Elsevier Engineering Structures 214 (2020) 110654.
- In-situ retrofit strategy for transmission tower structure members using lightweight steel casings, Li Suna, Marco Trovatob , Bozidar Stojadinovic, Elsevier Engineering Structures 206 (2020) 110171.
- Failure analysis of transmission tower subjected to strong wind load, Jian Zhang a , Qiang Xie, Jian Zhang a , Qiang Xie, Elsevier Journal of Constructional Steel Research 160 (2019) 271–279.
- Failure analysis of a lattice transmission tower collapse due to the super typhoon Rammasun in July 2014 in Hainan Province, China. Liqiang An , Jiong Wu , Zhiqiang Zhang , Ronglun Zhang, Elsevier Journal of Wind Engineering & Industrial Aerodynamics 182 (2018) 295–307.
- Uncertainty analysis of the strength capacity and failure path for a transmission tower under a wind load, Xing Fu a, Hong-Nan Li Elsevier,Journal of Wind Engineering & Industrial Aerodynamics 173 (2018) 147–155.
- Probabilistic capacity assessment of single circuit transmission tower-windsline system subjected to strong, Xuan Lia , Wei Zhanga, Huawei Niub , Zheng Yi Wuc, Elsevier Engineering Structures 175 (2018) 517-530.
- Comparative studies between Indian Standard codes IS 802 (Part 1/ Sec 1):2015 & IS 802 (Part 1/ Sec 1):1995 used for overhead transmission line towers, Vikki K. Shah,
- V.R. Panchal and Bipin B. Shah, Journal of Structural Engineering Vol. 45, No. 2, June, July 2018.
- The behavior of the power transmission tower subjected to horizontal support's movements, Qianjin Shu a , Guanglin Yuan , Zhaohui Huang , , Sheng Ye , Elsevier Engineering Structures 123 (2016) 166–180.
- Studies on failure of transmission line towers in testing, N. Prasad Rao G.M. Samuel Knight , S.J. Mohan , N. Lakshmanan b, Elsevier,Engineering Structures 35 (2012) 55–70.
- Indian Standard Code 802 (Part 1/ Sec 1): 2015, for 'Use of Structural Steel in Overhead Transmission Line Towers'- code of practice (Fourth Revision), section 1: Material and Loads.
- Indian Standard Code 802 (Part 1 / sec 2): 1992 for "Use of structural steel in overhead transmission line towers – code of practice - (Permissible stresses)".
- Indian Standard Code 5613 (Part1/ Sec1): 1985 for Design, Installation and Maintenance of Overhead Power Lines (Part 1 Lines up to and including 11kv Sec 1 Design).