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Analysis and Design of Transmission Tower Using Staad Pro for Indian Condition

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***Abstract:** The structural planning and design process includes not only creativity and logic, but also a solid understanding of structural engineering science, as well as practical knowledge of modern design codes and bye laws, as well as a wealth of experience, intuition, and judgement. The purpose of standards is to ensure and improve people's and the environment's safety. A steel structure created by striking a fine balance between cost and security. The transmission tower, in particular, must consider safety first in order to provide a comfortable environment. For the benefit of those who live nearby as a result, the transmission tower needs to be properly constructed and maintained. As a result, the transmission tower must be built and maintained with care. Normal tower design and analysis takes more time, thus we use various tools to get the findings. "STAAD Pro V8i" is used to analyze and design transmission towers.*
***Keywords:** Transmission Line Tower, Analysis, Design, STAAD Pro.*

I. INTRODUCTION

A tall skeleton structure with a narrow cross-section and a large height-to-maximum-width ratio is referred to as a tower. A tower is a self-supporting, free-standing structure that is supported by a foundation or base. A transmission tower, also known as a power tower or an electrical pylon, is a tall structure that supports an overhead power line and is usually composed of steel lattice. They're employed in high-voltage AC and DC systems. They come in a wide range of forms and sizes. The average height ranges from 15 to 55 meters, with the tallest peak standing at 370 meters. In addition to steel, other materials like as concrete and wood can be used.

II. PROBLEM STATEMENT

A 220 kV single circuit transmission line towers which is situated in wind zone II is selected for the study. Modelling, design and analysis is carried out on STAAD Pro. Software.

III. OBJECTIVES

1) To analyze and design of self-supporting transmission line tower with different types of cross section like Angle, Channel, Square Hollow Section, Circular Hollow Section, Tube section.
2) To validate software results with manual calculations.
3) To compare design of transmission tower with different cross sections with respect to Displacement, Reactions, Axial forces, Weight.

IV. LITERATURE REVIEW

Gopi Sudam Punse [4] (Analysis and Design of Transmission Tower) In this thesis, the analysis and design of a narrow-based Transmission Tower (using Multi Voltage Multi Circuit) is carried out in India, with the goal of maximizing the use of electrical supply with limited ROW and an increasing population. Transmission Line Towers contribute to 28 to 42 percent of the total cable cost. The increased demand for power is frequently handled more cost-effectively by designing various light-weight transmission tower layouts. In this project, a battle has been waged to make the cable more cost-effective while keeping in mind the goal of providing the best possible electric supply for the defined area by identifying a unique transmission tower structure. The goal of this study is to increase the current geometry by using a 220KV and 110KV Multi Voltage Multi Circuit with narrow based Self Supporting Lattice Towers. STAAD PRO v8i was used to accomplish the analysis and design.

Vikas Gahlawat [5] (Analysis and Design of a 25-Metre-Tall Steel Transmission Tower) The analysis and design of a steel lattice tower used for electricity transmission systems is done in this paper under various categories of gravity and lateral loads. The tower is analysed under a variety of load conditions before being designed according to IS 800:1984. In order to plan the design process most correctly, proper site research data as well as environmental impact assessment data are collected prior to the design process using appropriate electronic and paper media.

During the design, relevant safety design aspects are considered, taking into account the hilly slope terrain of the location (Shimla). During the design process, non-linear imperfections in both the surroundings and the structural material are taken into account. The steel angles that were riveted together were chosen for their various purposes and load impacts. The geotechnical investigation data is used to determine the foundation details. STAAD.Pro 2008 was the software tool utilised in the process. The load calculations were performed manually, however STAAD.Pro 2008 was used to acquire the analysis and design outputs. At all times, the goal is to create the most safe design possible while keeping cost in mind.

N. Mahesh [9] (Design & Estimation of Electric Steel Tower) The main analysis and design of a convergent based Electrical Steel Tower utilising STAAD are presented in this study. This is done with the goal of giving the maximum amount of electric supply with the available ROW while keeping the expanding population in the area in mind. Electrical Steel tower lines cost roughly 30-48 percent of the overall cost of the lines to build.

Due to the growth in demand, lightweight constructions will be developed, which will have lower loads on the structure due to a reduction in self-weight. In examining the tower's design and estimation, the structure chosen becomes crucial. In order to make the electrical tower more cost effective than the standard ones, a small analysis was conducted. In a single electrical steel tower, the best electric supply for the needed area is also taken into account.

The construction may include 230 KV and 120 KV multi-voltage circuits, as well as self-sustaining towers that are created depending on the geometry. STAAD. Pro is used to assess and design an electric steel tower, which is also known as a steel lattice tower, for any load magnitude or orientation.

It is necessary to construct three-dimensional structures of tower members. The new edition of the code is the design of steel structures based on Indian standard code IS: 800-2007 under limit state design. The foundation design of an electric steel tower is also carried using Hansen's method in this study. In addition, a total cost estimate for the construction of an electric steel tower has been completed.

Patil B.Y.[13] (Design and Analysis of Transmission Line Tower using Staad Pro) This research compares three types of bracings and focuses on estimating a feasible transmission line tower for various wind speeds by developing transmission line towers with hot rolled sections. 220 kV twin circuit self-supporting transmission towers with square bases are employed for this purpose. STAAD PRO is used to analyze this transmission tower, which is subjected to wind loads in Zones II, III, and IV. The load calculation for the analysis is performed in accordance with IS 802:1995. Finally, wind speed is used to compare the best transmission tower design utilizing hot-rolled steel.

Anshu Kumar Pal [11] (Comparative Analysis of Transmission Tower Using XX and XBX Bracing Systems in Different Wind Zones) In this work, Using STAAD Pro. V8i software, an improved steel bracing system is recommended in the construction of transmission line towers.

According to IS 802 (Part-1 / Sec-I):1995, two bracing systems, XX and XBX, are being compared in all six wind zones of India, employing seven different load circumstances. STAAD Pro V8i software is used to model and analyze the structural behavior of the tower for both bracing systems. In all wind zones of India, the XBX – bracing system was determined to be more cost-effective than the XX – bracing system.

Yasaswini [8] (Multi Voltage Multi Circuit Transmission Tower Design to Reduce Right of Way) An novel strategy for reducing the ROW width in MVMCT design is proposed in this research.

A case study on MVMCT with three different voltages (400kV/220kV/33kV) was conducted, and it was shown that the proposed design is both technically superior and cost effective.

When compared to traditional broad base towers, the ROW width is lowered to 40 (from 48) meters, resulting in significant cost savings when a transmission line is considered. MVMCT boosts transmission capacity as well. Within the ROW, the EMFs are also within the permitted limits. All of the stresses are within the acceptable range. When ROW is restricted, cost savings might range from 30 to 50%. As a result, MVMCT with a small basis could be a breakthrough in India, both in terms of economics and the reduction of legal concerns related to land.

V. METHODOLOGY

A. Transmission Tower Configuration

Reliability level	1
Wind zone	II
Terrain category	2
Return period	50 years
Basic Wind speed, Vb	39 m/s
Design wind pressure, Pd	958.69 N/m^2
Ground clearance, h1	12.4
Maximum sag of the lower most conductor wires, h2	0.4 m
Vertical distance between conductor wires, h3	4 m
Vertical distance between conductor and ground wire, h4	5.2 m
Entire height of the tower	22 m
Span length	50 m
Base width of the tower, b	4 m
The geometry of the tower	Square base

Table 1. Tower Configuration

B. Design Parameters

Wind Effects [Refer IS 875 (Part 3) : 2015]
Design Wind Speed Vz = 42.12 m/s
Design Wind Pressure Pd: The design wind pressure which is distributed along the height of the towers, conductors and insulators shall be determined by the following expression:
$Pz = 0.6V_Z^2 = 1065.2148$ N/m^2 ,$Pd = k_d\, k_a\, k_c\, p_z = 958.69$ N/m^2
Wind Load on Tower Fwt = 7333.9785 N
Wind Load on Conductor and Groundwire Fwc = 7221.6201 N
Wind Load on Insulator Strings Fw_i = 2070.7704 N

Sag Tension: Sag tension calculation for conductor and groundwire shall be made in accordance with the relevant provisions of IS 5613 (Part 2/ Sec 1): 1985 for the following combinations:
Max Sag $S = WL^2/8T = (0.372 \times 50^2)/(8 \times 699) = 0.4$ m
Seismic Consideration: The transmission line tower is a pin-jointed light structure comparatively flexible and free to vibrate and max. wind pressure is the chief criterion for the design. Concurrence of earthquake and max. wind condition is unlikely to take place and further seismic stresses are considerably diminished by the flexibility and freedom for vibration of the structure. This assumption is also in line with the recommendation given in cl. no. 3.2 (b) of **IS: 1893-1984**. Seismic considerations, therefore, for tower design are ignored and have not been discussed.

C. Staad Modeling

Limit state design is a one with both strength and serviceability is considered while designing the structure. Coming to steel structures **IS 800-2007** in limit state design by using STAAD. Pro plays an important role in designing huge structures were it having a number of elements like ties and strut members.

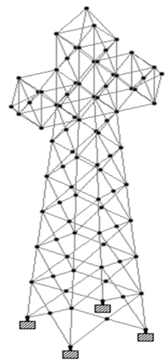

Fig 1. 3D View Of Tower Model

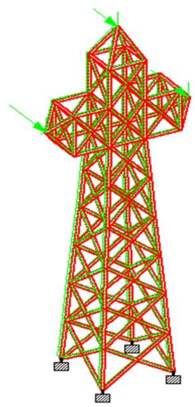

Fig 2. Assigning combination load

VI. DISCUSSIONS AND RESULTS

Analysis of tower is administered by considering all kinds of loading, differing types of Sections. All loads are calculated manually as per IS 802 (part 1 and 2): 1995, IS 5613 (part 2): 1985, IS 875- 2015. The tower is analyzed and designed using STAAD Pro. Maximum axial force, bending moment and maximum deflection values of tower with different configuration are obtained by using STAAD Pro.

A. Maximum Forces

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	40	19 GENERAT	3	**817.740**	3.680	0.956	-0.008	0.937	-3.694
Min Fx	25	19 GENERAT	18	**-721.014**	1.104	3.430	0.008	-4.042	0.388
Max Fy	40	19 GENERAT	3	817.740	**3.680**	0.956	-0.008	0.937	-3.694
Min Fy	25	19 GENERAT	1	-719.744	**-3.425**	-0.960	0.008	-0.942	3.301
Max Fz	113	19 GENERAT	5	13.330	1.939	**16.037**	0.000	-15.670	1.419
Min Fz	110	19 GENERAT	7	-8.613	-0.143	**-16.038**	-0.000	15.667	-0.448
Max Mx	96	19 GENERAT	36	52.855	-0.220	1.899	**0.012**	-2.566	-0.019
Min Mx	107	19 GENERAT	37	52.601	-0.210	-1.899	**-0.012**	2.566	-0.012
Max My	110	19 GENERAT	7	-8.613	-0.143	-16.038	-0.000	**15.667**	-0.448
Min My	113	19 GENERAT	5	13.330	1.939	16.037	0.000	**-15.670**	1.419
Max Mz	25	19 GENERAT	1	-719.744	-3.425	-0.960	0.008	-0.942	**3.301**
Min Mz	39	6 TEMP	32	7.653	-2.018	0.155	-0.000	2.483	**-5.584**

Table 2. Result value of tower with angle section

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	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	40	19 GENERAT	3	**1004.698**	13.620	2.946	-0.049	2.067	-24.143
Min Fx	25	19 GENERAT	18	**-904.805**	-6.701	2.914	0.049	-2.026	-1.621
Max Fy	40	19 GENERAT	3	1004.698	**13.620**	2.946	-0.049	2.067	-24.143
Min Fy	25	19 GENERAT	1	-902.924	**-12.764**	-2.946	0.049	-2.067	22.819
Max Fz	113	19 GENERAT	5	27.621	4.883	**22.409**	-0.002	-17.971	4.908
Min Fz	109	19 GENERAT	6	27.089	4.970	**-22.408**	0.002	17.970	5.050
Max Mx	92	19 GENERAT	37	-8.377	0.903	-4.670	**0.078**	1.972	2.179
Min Mx	91	19 GENERAT	36	-7.000	-0.897	-4.674	**-0.078**	1.978	-2.165
Max My	113	19 GENERAT	42	27.621	2.748	15.416	-0.002	**19.854**	-2.723
Min My	109	19 GENERAT	38	27.089	2.836	-15.415	0.002	**-19.853**	-2.757
Max Mz	25	19 GENERAT	1	-902.924	-12.764	-2.946	0.049	-2.067	**22.819**
Min Mz	40	6 TEMP	3	-13.707	6.821	0.006	0.000	2.147	**-24.304**

Table 3. Result value of tower with channel section

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	40	19 GENERAT	3	**846.752**	6.408	2.318	-1.771	3.011	-8.466
Min Fx	25	19 GENERAT	18	**-784.460**	-0.781	2.948	1.770	-3.801	-0.659
Max Fy	40	19 GENERAT	3	846.752	**6.408**	2.318	-1.771	3.011	-8.466
Min Fy	25	19 GENERAT	1	-783.417	**-6.171**	-2.320	1.770	-3.012	8.071
Max Fz	113	19 GENERAT	5	14.260	1.093	**13.057**	-0.073	-12.488	0.895
Min Fz	109	19 GENERAT	6	13.751	1.100	**-13.054**	0.073	12.485	0.906
Max Mx	92	19 GENERAT	37	-11.083	0.111	-2.934	**2.904**	1.350	0.355
Min Mx	91	19 GENERAT	36	-9.697	-0.110	-2.942	**-2.906**	1.367	-0.353
Max My	109	19 GENERAT	6	13.751	1.100	-13.054	0.073	**12.485**	0.906
Min My	113	19 GENERAT	5	14.260	1.093	13.057	-0.073	**-12.488**	0.895
Max Mz	25	19 GENERAT	1	-783.417	-6.171	-2.320	1.770	-3.012	**8.071**
Min Mz	40	19 GENERAT	3	846.752	6.408	2.318	-1.771	3.011	**-8.466**

Table 4. Result value of tower with square hollow section

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	40	19 GENERAT	3	**890.317**	8.732	4.550	-2.819	6.736	-12.476
Min Fx	25	19 GENERAT	18	**-832.055**	-2.029	1.863	2.817	-3.363	-1.175
Max Fy	40	19 GENERAT	3	890.317	**8.732**	4.550	-2.819	6.736	-12.476
Min Fy	25	19 GENERAT	1	-830.764	**-8.591**	-4.549	2.817	-6.735	12.158
Max Fz	113	19 GENERAT	5	15.813	0.890	**13.152**	-0.153	-12.133	0.744
Min Fz	109	19 GENERAT	6	15.345	0.894	**-13.150**	0.153	12.131	0.750
Max Mx	3	19 GENERAT	7	-179.939	3.494	-1.394	**5.496**	-1.197	2.005
Min Mx	1	19 GENERAT	8	-184.687	3.504	1.419	**-5.491**	1.179	2.035
Max My	109	19 GENERAT	6	15.345	0.894	-13.150	0.153	**12.131**	0.750
Min My	113	19 GENERAT	5	15.813	0.890	13.152	-0.153	**-12.133**	0.744
Max Mz	25	19 GENERAT	1	-830.764	-8.591	-4.549	2.817	-6.735	**12.158**
Min Mz	40	19 GENERAT	3	890.317	8.732	4.550	-2.819	6.736	**-12.476**

Table 5. Result value of tower with circular hollow section

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	40	19 GENERAT	3	**578.661**	4.112	1.889	-1.065	1.548	-4.460
Min Fx	25	19 GENERAT	18	**-544.202**	0.456	2.501	1.065	-2.316	-0.182
Max Fy	40	19 GENERAT	3	578.661	**4.112**	1.889	-1.065	1.548	-4.460
Min Fy	25	19 GENERAT	1	-543.646	**-4.006**	-1.889	1.065	-1.549	4.276
Max Fz	113	19 GENERAT	5	13.113	0.668	**10.018**	-0.038	-9.013	0.609
Min Fz	109	19 GENERAT	6	12.640	0.671	**-10.017**	0.038	9.012	0.614
Max Mx	3	19 GENERAT	7	-117.567	2.436	-0.804	**3.564**	-1.311	1.338
Min Mx	1	19 GENERAT	8	-122.349	2.446	0.822	**-3.562**	1.298	1.360
Max My	109	19 GENERAT	6	12.640	0.671	-10.017	0.038	**9.012**	0.614
Min My	113	19 GENERAT	5	13.113	0.668	10.018	-0.038	**-9.013**	0.609
Max Mz	25	19 GENERAT	1	-543.646	-4.006	-1.889	1.065	-1.549	**4.276**
Min Mz	39	6 TEMP	32	4.912	-1.674	-0.006	-0.010	2.643	**-4.880**

Table 6. Result value of tower with Tube section

1) *Maximum Deflection:* It is observed that, maximum resultant displacement obtained from analysis of tower with different sections is due to the load combination 19 which is created with command of define combinations. i.e. (1.5xDead load and 1.5x Wind load +ZD). The maximum resultant displacement of tower with tube sections was found to be 92 mm which is higher than others. The maximum resultant displacement obtained from analysis of Tower with channel sections was found to be 56 mm which is less than others.

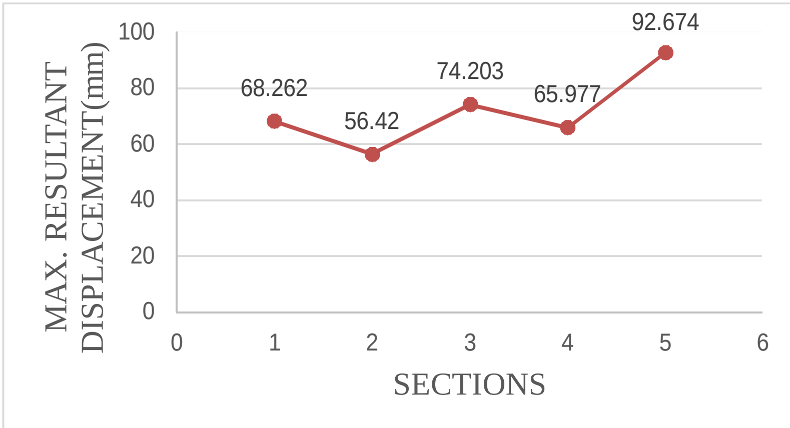

Fig 3. Comparison with respect to displacement [1- Angle, 2- Channel, 3- Square hollow, 4- Circular hollow, 5- Tube]

B. Steel Take Off

As weight of structure is proportional to the cost of the structure, optimizing weight of structure will be become essential while designing any structure. From the results obtained, the steel weight of tower with tube section is less as compare to tower with angle, channel, hollow section.

Sr no.	Tower configuration	Steel Weight (kN)
1.	Angle Section	133.063
2.	Channel Section	138.114
3.	Square Hollow Section	84.146
4.	Circular Hollow Section	77.837
5.	Tube Section	45.288

Table 7. Weight of Tower With Different Sections

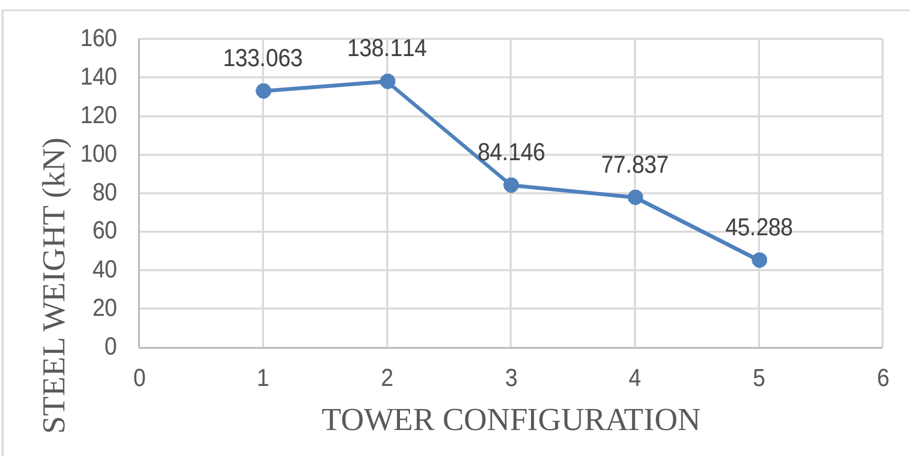

Fig 4. Comparison with respect to weight [1- Angle, 2- Channel, 3- Square hollow, 4- Circular hollow, 5- Tube]

VII. CONCLUSION

A. The axial forces developed in tower with tube section reduced by 41% compared with channel section and 29% compared with angle section.

B. In terms of reliability, security, and safety, the lightest tower leads to the most cost-effective transmission line. The weight of transmission with tube section is reduced by 65% compared with angle section and 41% compared with circular hollow section.

C. From the result obtained, transmission tower with tube section is concluded as optimum structure configuration.

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REFERENCES

[1] G.Visweswara Rao " Optimum Designs For Transmission Line Towers" Computer & Structures vol.57.No.1.pp.81-92, 1995

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

[3] M.Selvaraj, S.M.Kulkarni, R.Ramesh Babu "Behavioral Analysis of built up transmission line tower from FRP pultruded sections" ISSN 2250-2459, Volume 2, Issue 9, september (2012)

[4] Gopi Sundam Punse. "ANALYSIS AND DESIGN OF TRANSMISSION TOWER". International Journal of Modern Engineering Research (IJMER), ISSN: 2249–6645, Volume 4, Issue 1, Jan. 2014

[5] Vikas Gahlawat, Er. Sumit Kumar, & Yogesh Kaushik. (2015). Analysis and Design of a 25-Metre-Tall Steel Transmission Tower. *International Journal of Engineering Technology, Management and Applied Sciences*, 32-35

[6] Heera Lal Bhardwaj, Ajit, & Yogesh Kaushik. (2015). Analysis and Design of Four Leg Steel Transmission Tower using Staad.Pro. *International Journal of Advanced Engineering, Management and Science (IJAEMS)* , 7-13

[7] B. Bharath Kumar Reddy, K. Rasagnya, & V. Sanjay Gokul. (2016). A Study on Analysis of Transmission Line Tower and Design of Foundation. *International Journal of Engineering Development and Research* , 2214-2224

[8] Yasaswini, S. V. N. L. Lalitha, & Shefali Talati. (2016). Multi Voltage Multi Circuit Transmission Tower Design to Reduce Right Of Way. *Indian Journal of Science and Technology*, 1-7.

[9] N. Mahesh, & V. Ranga Rao. (2017). DESIGN & ESTIMATION OF ELECTRIC STEEL TOWER. *International Journal of Civil Engineering and Technology (IJCIET)*, 646-652.

[10] Trishit Chandra, & Sanjay Sengupta. (2019). Dynamic Analysis of Telecommunication Tower for Optimum Model Combination and Elemental Discretization. *International Journal of Engineering and Advanced Technology (IJEAT)*, 2229-2237

[11] Anshu Kumar Pal, M. Suneel, & P V Rambabu. (2019). Comparative Analysis of Transmission Tower using XX and XBX Bracing Systems in Different Wind Zones. *International Journal of Recent Technology and Engineering (IJRTE)*, 56-61.

[12] Arya, S., & Er. Sindhu, A. R. (2020). Analysis and Design of Transmission Tower with Isolated Footing. *Journal of Science and Technology*, 35-42.

[13] Patil B.Y, Prof. Upase K.S., & Prof. Hamne A. A. (2020). Design and Analysis of Transmission Line Tower using Staad-Pro. *International Journal for Scientific Research & Development*, 11-13.

[14] CH. Prasad Babu, & N. Vikram. (2020). DESIGN OF TRANSMISSION TOWER AND ITS FOUNDATION. *IJARIIE*, 364-375.

[15] Julius O Onyeka, & Ochonogor Hycent Ifechukwudeni. (n.d.). Towards Sustainability in Infrastructure developementStructural Design of a 330kV Transmission Line Tower in Warri, Nigeria.(2020)

[16] N, B. B., & Banavekar, S. M. (2020). ANALYSIS AND DESIGN OF TRANSMISSION. *JETIR December 2020, Volume 7, Issue 12*, 8.

[17] Sujeeth M Banavekar, & Bhavyashree B N. (2020). ANALYSIS AND DESIGN OF TRANSMISSION TOWER USING STAAD.Pro V8i. *Journal of Emerging Technologies and Innovative Research (JETIR)*, 572-579.

[18] IS 875 (part-3):2015 code of practice for design loads (other than earthquake) for buildings and structures. Part-3: wind loads.

[19] IS 802(part 1/sec 1) code of practice for use of structural steel in overhead transmission line towers, part 1 materials, loads and permissible stresses, section 1: materials and loads