ANALYSIS AND DESIGN OF TRANSMISSION LINE TOWERS IN COMPARSION WITH WIND ANALYSIS

Mohd Abdul Quddus[1,] Mohd Riyan[2] Dr.Mohd farrukh Anwar[3]

[1] Pg Student, M.tech in Structural engineering, Department of Civil Engineering, Nawab Shah Alam Khan College of Engineering and Technology, Hyderabad, Telangana 500024

[2] Assistant Professor, M.tech in Structural engineering, Department of Civil Engineering, Nawab Shah Alam Khan College of Engineering and Technology, Hyderabad, Telangana 500024

[3]Head of the Department ,(PHD) , M.tech in Structural engineering, Department of Civil Engineering, Nawab Shah Alam Khan College of Engineering and Technology, Hyderabad, Telangana 500024

Abstract: Transmission line towers carry heavy transmission conductors at a sufficient and safe height from ground. In addition to their self-weight they have to withstand all forces of nature like a strong wind, earthquake and snow load. Therefore, transmission line towers should be designed considering both structural and electrical requirements for a safe and economical design. Now-a-days Government of India is planning for Electrification of Semi-Urban and Rural areas. In fact designing of Huge Transmission Tower is the key interest for Power Transmission from Source to utility point. Steel Structures and their behavior are not same as of RCC. All the Transmission Tower is like Skeleton Structures and they have been made in the form of 3-D Truss. Analysis of Space Trusses is not an Easy task when they are subjected to large Wind and Seismic forces. Keeping in view the importance of Wind Forces and Seismic Forces a 3-D Model has been generated in SAP2000. All the Necessary checks has been Performed for safe and stable Design. Parameters such as Lateral

I. INTRODUCTION

India has a large population residing all over the country and the electricity supply need of this population creates requirement of a large transmission and distribution system. Also, the disposition of the primary resources for electrical power generation viz., coal, hydro potential is quite uneven, thus again adding to the transmission requirements. Transmission line is an integrated system consisting of conductor subsystem, ground wire subsystem and one subsystem for each category of support structure. Mechanical supports of transmission line represent a significant portion of the cost of the line and they play an important role in the reliable power transmission. They are designed and constructed in wide variety of shapes, types, sizes, configurations and materials. The supporting structure types used in transmission lines generally fall into one of the three categories: lattice, pole and guyed.

Fastest growing telecommunication market has increased the demand of steel towers. The major loads considered for design of these towers are self-weight, wind load, seismic load, antenna load, platform load, steel ladder load etc. Failure of towers is generally due to high intensity winds. Several studies have been carried out by considering wind and earthquake loads. This study is performed as per the requirement and recommendation of the management for the validation of the results according to the IS codes to check whether the same structure can be safe for both the places without any change in structural configuration and for the different loading conditions for both the places. From the study of literature review, it is reported that the predominant external loads which act on these towers are wind and earthquake loads. For the economical purpose and uniformity in power system, it is an important study to save the cost of designing and maintenance as it is easy and beneficial to have uniform towers. Analysis and design is carried as per the recommendations given in IS: 800-2007(LSM).

OBJECTIVE OF THE STUDY

- The design and analysis transmission tower by using sap 2000 analysis.
- Non- linear dynamic analysis and design of transmission towers.
- The earthquake analysis with comparison of two different zones i.e. zone IV and zone V
- To determine wind analysis and comparison of the wind terrain categories i.e. terrain category III, and terrain category IV.
- Finding the best optimum tower design according to seismic conditions and terrain categories.

SCOPE OF PRESENT WORK

- Continuous demand due to increasing population in all sectors viz. residential, commercial and industrial leads to requirement of efficient, consistent and adequate amount of electric power supply which can only fulfilled by using the Conventional Guyed Transmission Towers.
- It can be substituted between the transmission lines of wide based tower where narrow width is required for certain specified distance.
- Effective static loading on transmission line structure, conductor and ground wire can be replaced with the actual dynamic loading and the results can be compared.
- Attempt in changing the shape of cross arm can lead to wonderful results.
- Rapid urbanization and increasing demand for electric, availability of land leads to involve use of tubular shape pole structure.
- lso restricted area (due to non-availability of land), more supply of electric energy with available resources and for continuous supply without any interruption in the transmission line, will demand the use of high altitude narrow based steel lattice transmission tower

II. STRCUTRAL MOLDELLING

Transmission Tower Dimensions: MODEL 1: SQUARE BASE TOWER

Description	Lengths
Total Height (H)	**30 mts**
Ground clearance (h1)	**7.01 mts**
Maximum sag of the lower most conductors wire (h2)	**7.66 mts**
Vertical distance between conductor wires (h3)	**7.66 mts**
Vertical distance between conductor and ground wire (h4)	**7.66 mts**
Length of cross arm from edge of hamper	**4 mts**
Span between the towers	**200 mts**
Length of wire between two suspension towers	**230 mts**
Basic wind pressure in kg/m2	**50**
Maximum Temperature of conductor	**73°**
Maximum Temperature of Ground wire	**53°**
Every day temperature	**33°**
Minimum Temperature	**12°**
Terrain Type	**plain**
Return Period	**50 years**
Tower Geometry	**Square base**
Peak type	**Square**
Tower type	**Suspension tower**
Angle of line deviation	0 ° -2 °
No. of circuits	Double circuit
Basic wind speed in m/sec	**44**
Minimum Width at Base	4.5 m Square Tower

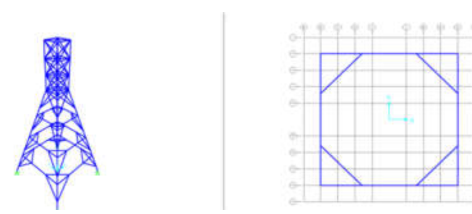
Transmission Tower Dimensions: MODEL 2: trapezoidal Base Tower

Description	Lengths
Total Height (H)	**30**
Ground clearance (h1)	**7.01 mts**
Maximum sag of the lower most conductors wire (h2)	**7.66**
Vertical distance between conductor wires (h3)	**7.66**
Vertical distance between conductor and ground wire (h4)	**7.66**
Length of cross arm from edge of hamper	**5 mts**
Span between the towers	**200 mts**
Length of wire between two suspension towers	**230 mts**
Basic wind pressure in kg/m2	**50**
Maximum Temperature of conductor	**73°**
Maximum Temperature of Ground wire	**53°**
Every day temperature	**33°**
Minimum Temperature	**12°**
Terrain Type	**plain**
Return Period	**50 years**
Tower Geometry	**Square base**
Peak type	**Square**
Tower type	**Suspension tower**
Angle of line deviation	0 ° -2 °
No. of circuits	Double circuit
Basic wind speed in m/sec	**50**
Minimum Width at Base	4.5 m Trapezoidal Tower

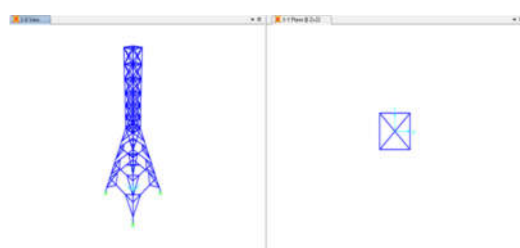
Transmission Tower Dimensions: MODEL 3: Trapezoidal Base Tower:

Description	Lengths
Total Height (H)	**30**
Ground clearance (h1)	**7.01 mts**
Maximum sag of the lower most conductors wire (h2)	**7.66**
Vertical distance between conductor wires (h3)	**7.66**
Vertical distance between conductor and ground wire (h4)	**7.66**
Square base width	**6.0 mts**
Length of cross arm from edge of hamper	**3 mts**
Span between the towers	**200 mts**
Length of wire between two suspension towers	**230 mts**
Basic wind pressure in kg/m2	**50**
Maximum Temperature of conductor	**73°**
Maximum Temperature of Ground wire	**53°**
Every day temperature	**33°**
Minimum Temperature	**12°**
Terrain Type	**plain**
Return Period	**50 years**
Tower Geometry	**Trapezoidal base**
Peak type	**Triangle**
Tower type	**Suspension tower**
Angle of line deviation	**0 ° -2 °**
No. of circuits	**Double circuit**
Basic wind speed in m/sec	**50**
Minimum Width at Base	**6 m Trapezoidal Tower**

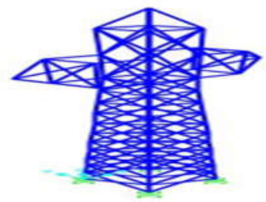
TOWER MODEL 1



TOWER MODEL 2 :



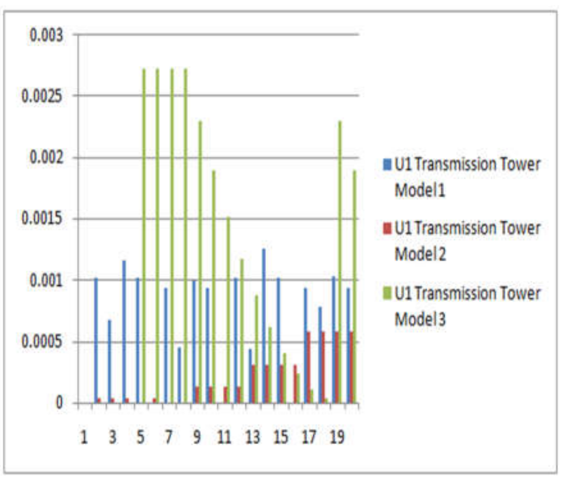
TOWER MODEL 3:



III. RESULTS AND ANALYSIS

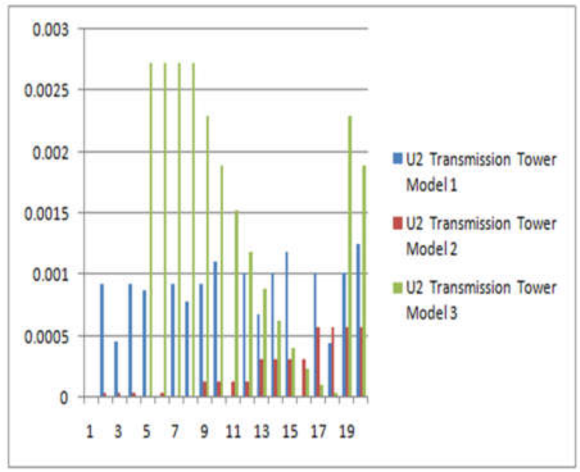
1. RESULTS OF TRAMISSION TOWER COMPARASION OF THE RESULTS (U 1 displacement)

Joint	Output Case	U1 Transmission Tower MODEL1	U1 Transmission Tower MODEL 2	U1 Transmission Tower MODEL3
Text	Text	meters	meters	Meters
1	RSA	0	0	0
2	RSA	0.001012	0.000036	0
3	RSA	0.000671	0.000036	0
4	RSA	0.00116	0.000036	0
5	RSA	0.00101	0	0.002718
6	RSA	0	0.000036	0.002718
7	RSA	0.000934	0	0.002718
8	RSA	0.00045	0	0.002718
9	RSA	0.000996	0.000133	0.002289
10	RSA	0.000932	0.000133	0.001885
11	RSA	0	0.000133	0.001512
12	RSA	0.001012	0.000133	0.001174
13	RSA	0.000442	0.000309	0.000875
14	RSA	0.001251	0.000309	0.000616
15	RSA	0.00101	0.000309	0.000401
16	RSA	0	0.000309	0.000232
17	RSA	0.000934	0.000579	0.000108
18	RSA	0.000783	0.000579	0.000036
19	RSA	0.001023	0.000579	0.002289
20	RSA	0.000932	0.000579	0.001886



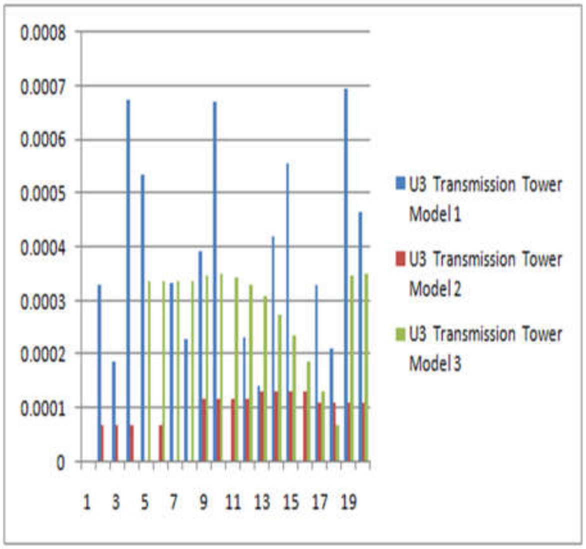
U 2 Displacements

Joint	Output Case	U2 Transmission Tower Model 1	U2 Transmission Tower Model 2	U2 Transmission Tower Model 3
Text	Text	meters	meters	Meters
1	RSA	0	0	0
2	RSA	0.000932	0.000036	0
3	RSA	0.000452	0.000036	0
4	RSA	0.00093	0.000036	0
5	RSA	0.000877	0	0.002724
6	RSA	0	0.000036	0.002721
7	RSA	0.000932	0	0.002724
8	RSA	0.000783	0	0.002721
9	RSA	0.00093	0.000133	0.002298
10	RSA	0.001115	0.000133	0.001896
11	RSA	0	0.000133	0.001523
12	RSA	0.001013	0.000133	0.001185
13	RSA	0.000675	0.000309	0.000884
14	RSA	0.001011	0.000309	0.000624
15	RSA	0.001189	0.000309	0.000408
16	RSA	0	0.000309	0.000236
17	RSA	0.001013	0.000579	0.00011
18	RSA	0.000438	0.000579	0.000036
19	RSA	0.001011	0.000579	0.002298
20	RSA	0.001249	0.000579	0.001896



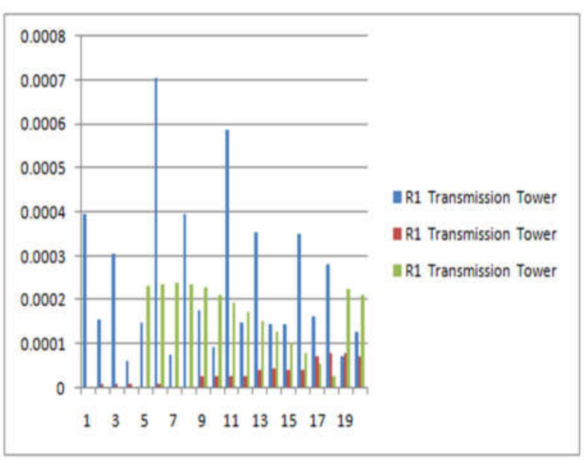
U 3 Displacements

Joint	Output Case	U3 Transmission Tower Model 1	U3 Transmission Tower Model 2	U3 Transmission Tower Model 3
Text	Text	meters	meters	meters
1	RSA	0	0	0
2	RSA	0.00033	0.000069	0
3	RSA	0.000189	0.000069	0
4	RSA	0.000676	0.000069	0
5	RSA	0.000536	0	0.000336
6	RSA	0	0.000069	0.000337
7	RSA	0.000335	0	0.000336
8	RSA	0.00023	0	0.000337
9	RSA	0.000393	0.000118	0.000348
10	RSA	0.000672	0.000118	0.000351
11	RSA	0	0.000118	0.000346
12	RSA	0.000233	0.000118	0.000331
13	RSA	0.000143	0.000133	0.000308
14	RSA	0.00042	0.000133	0.000276
15	RSA	0.000556	0.000133	0.000236
16	RSA	0	0.000133	0.000188
17	RSA	0.000331	0.00011	0.000133
18	RSA	0.000213	0.00011	0.000068
19	RSA	0.000694	0.00011	0.000349
20	RSA	0.000466	0.00011	0.000351



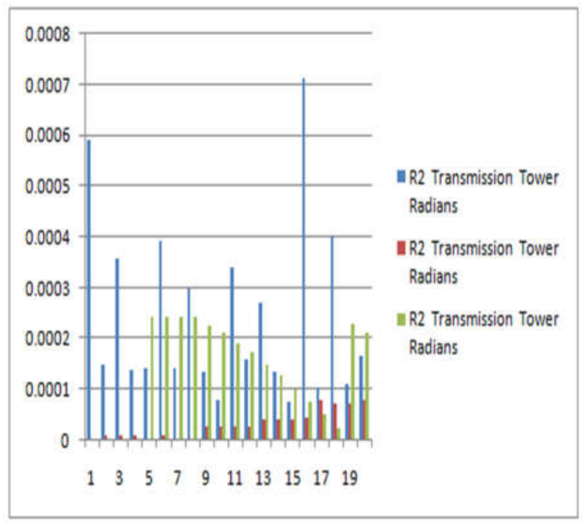
Displacements in radians (R1)

Joint	Output Case	R1 Transmission Tower Model 1	R1 Transmission Tower Model 2	R1 Transmission Tower Model 3
Text	Text	Radians	Radians	Radians
1	RSA	0.000397	0.000003146	0
2	RSA	0.000156	0.00001	0
3	RSA	0.000305	0.000011	0
4	RSA	0.000062	0.000011	0
5	RSA	0.000148	0.000003405	0.000234
6	RSA	0.000707	0.00001	0.000235
7	RSA	0.000078	0.000003308	0.000239
8	RSA	0.000395	0.000003128	0.000237
9	RSA	0.000177	0.000026	0.000228
10	RSA	0.000093	0.000027	0.000213
11	RSA	0.000588	0.000026	0.000194
12	RSA	0.00015	0.000026	0.000175
13	RSA	0.000356	0.000042	0.000153
14	RSA	0.000145	0.000044	0.00013
15	RSA	0.000145	0.000043	0.000104
16	RSA	0.000352	0.000042	0.000079
17	RSA	0.000162	0.000072	0.000054
18	RSA	0.00028	0.000079	0.000027
19	RSA	0.000074	0.000078	0.000227
20	RSA	0.000129	0.000071	0.000213



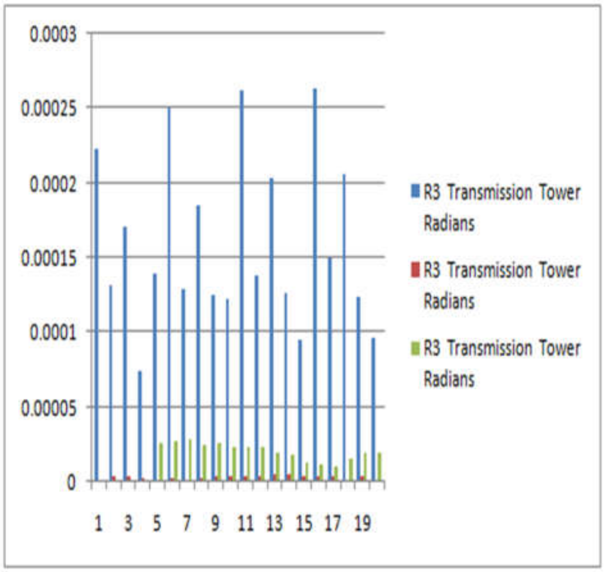
Displacements in radians (R2)

Joint	Output Case	R2 Transmission Tower Model 1	R2 Transmission Tower Model 2	R2 Transmission Tower Model 3
Text	Text	Radians	Radians	Radians
1	RSA	0.00059	0.000003433	0
2	RSA	0.000151	0.000011	0
3	RSA	0.000357	0.00001	0
4	RSA	0.000139	0.00001	0
5	RSA	0.000143	0.000003188	0.000245
6	RSA	0.000394	0.000011	0.000243
7	RSA	0.000143	0.000003097	0.000244
8	RSA	0.000298	0.000003356	0.000244
9	RSA	0.000136	0.000026	0.000227
10	RSA	0.000081	0.000026	0.000212
11	RSA	0.000341	0.000026	0.000192
12	RSA	0.000159	0.000026	0.000173
13	RSA	0.00027	0.000043	0.00015
14	RSA	0.000135	0.000042	0.000127
15	RSA	0.000076	0.000042	0.000102
16	RSA	0.000714	0.000044	0.000077
17	RSA	0.000104	0.000078	0.000052
18	RSA	0.000405	0.000072	0.000023
19	RSA	0.000111	0.000071	0.000228
20	RSA	0.000168	0.000079	0.000212



Displacements in radians (R3)

Joint	Output Case	R3 Transmission Tower Model 1	R3 Transmission Tower Model 2	R3 Transmission Tower Model 3
Text	Text	Radians	Radians	Radians
1	RSA	0.000223	0.000001388	0
2	RSA	0.000132	0.000002984	0
3	RSA	0.000171	0.00000317	0
4	RSA	0.000074	0.000002382	0
5	RSA	0.00014	7.991E-07	0.000026
6	RSA	0.00025	0.000002626	0.000028
7	RSA	0.000129	0.000001427	0.000029
8	RSA	0.000185	0.000001475	0.000025
9	RSA	0.000125	0.000003315	0.000026
10	RSA	0.000123	0.000003201	0.000023
11	RSA	0.000262	0.000003261	0.000023
12	RSA	0.000138	0.000003187	0.000023
13	RSA	0.000203	0.000004482	0.00002
14	RSA	0.000126	0.000004538	0.000018
15	RSA	0.000095	0.000002823	0.000013
16	RSA	0.000264	0.00000377	0.000012
17	RSA	0.00015	0.000003011	0.00001
18	RSA	0.000206	0.000001137	0.000015
19	RSA	0.000124	0.000003503	0.000019
20	RSA	0.000097	0.000001034	0.000019



IV .CONCLUSIONS

- The difference between modeling the forces on foundations of a transmission tower using industry standard static point loads and more advanced dynamic loading techniques appears to be relatively significant.

- This indicates that it is important to model the conductors dynamically although this was not within the scope of this thesis. Maximum compression forces are also reduced by a similar amount, although this is generally a less critical design factor.

- It was observed the displacement of the model 2 transmission tower having the least values in the joint displacements and overturning moments

- The Base reactions are of the model 2 of the transmission line tower is having least values as compared to the other transmission line towers.

- The percentage of the steel used in the transmission line towers are the used less steel with best suitable structure to the transmission 220 KV line towers.

- Maximum displacement along X direction 0.653 m and maximum displacement along Y direction is 0.0653 m as compared to X the direction of Y is quite more less in the model 2 of the transmission line tower

- The seismic load and wind load are within the expectable limits as per the codal provisions as per Indian standards.

- The less seismic loads are observed in the model 2 transmission line tower as it was showing least displacements in joints as well as the base reactions of all the transmission towers (i.e. model 1, model 3)

- The wind loads calculations are calculated, and the wind load was seen a major effect on the transmission line tower.

- Considering all the above the considerations in the all three towers the best suitable structure is the square based transmission tower of model 2 is best suitable structure.

REFERENCES

[1] Albermani, F., Kitipornchai, S. and Chan, R. (2009). Failure analysis of transmission towers. Engineering Failure Analysis, 16(6), pp.1922-1928.

[2] Ambrosini, R., Riera, J. and Danesi, R. (2002). Analysis of structures subjected to random wind loading by simulation in the frequency domain. Probabilistic Engineering Mechanics, 17(3), pp.233-239.

[3] Battista, R., Rodrigues, R. and Pfeil, M. (2003). Dynamic behavior and stability of transmission line towers under wind forces. Journal of Wind Engineering and Industrial Aerodynamics, 91(8), pp.1051-1067.

[4] Belu, R. and Koracin, D. (2013). Statistical and Spectral Analysis of Wind Characteristics Relevant to Wind Energy Assessment Using Tower Measurements in Complex Terrain. Journal of Wind Energy, [online] 2013, pp.1-12. Available at: http://dx.doi.org/10.1155/2013/739162 [Accessed 27 Apr. 2016].

[5] Bessason, B. (2010). Structural Analysis 2. C03.apogee.net. (2017). Fundamentals of Electricity - Towers.

[6] Jordan Journal of Civil Engineering, Volume 7, No. 4, 2013

[7] IS 802 Part 1 Sec 1 1995 Code of practice for use of structural steel in overhead transmission line towers, Part 1