ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 3, Issue 1, January 2018

Comparison of Wind Codes for Transmission Tower

[1] Rangoli K. Jiwankar
Rashtrasant Tukdogi Maharaj University , Nagpur

***Abstract:* -- The transmission line is an integrated system consisting of conductor subsystem, ground wire subsystem and one subsystem for each category of the 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 the wide variety of shapes, types, sizes, configurations, and materials. In general, most towers may be idealized as statically determinate and analyzed for wind forces as per IS 875 part 3:1987. Revised code IS 875 is introduced in 2015. In revised code IS 875: Part 3-2015, loading and design parameters are changed. In this paper, the comparison of code IS 875: Part 2-1987 and EN 1991-1-4:2005 will be carried out.**

***Keywords*: - Transmission line, Mechanical supports, Design Parameters, Loading.**

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.Transmission line is an integrated system consisting of conductor subsystem, ground wire subsystem and one subsystem for each category of support structure. Conventional process of data generation in describing the topology, geometry, load and support conditions are very tedious, time consuming and susceptible to error. 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. In general, most towers may be idealized as statically determinate and analyzed for wind forces as per IS 875 part 3:1987. Revised code IS 875 is introduced in 2015. In revised code IS 875: Part 3-2015,some loading and design parameters are changed. In this study the analysis and design for various heights of suspension and angle transmission tower by using code IS 875: Part 2-1987 and EN 1991-1-4:2005 will be carried out.

II. LITERATURE REVIEW

V.Lakshmi, A. RajagopalaRao (Jul-Aug 2012) "Effect of Medium Wind Intensity on 21m 132kv Transmission Tower" International Journal of Engineering Science & Advanced Technology Volume-2, Issue-4, Jul-Aug 2012 pp 820 – 824

The performance of 21M high 132kV tower with medium wind intensity is observed. The Recommendations of IS 875-1987, Basic wind speeds, Influence of height above ground and terrain, Design wind speed, Design wind pressure, Design wind force is explained in detailed. An analysis is carried out for the tower and the performance of the tower and the member forces in all the vertical, horizontal and diagonal members are evaluated. The critical elements among each of three groups are identified. In subsequent chapters the performance of tower under abnormal conditions such as localized failures are evaluated. The details of load calculation, modeling and analysis are discussed. The wind intensity converted into point loads and loads are applied at panel joints.

P. Gopi Sudam (Jan 2014) “Analysis and Design of Transmission Tower.” International Journal of Modern Engineering Research (IJMER) Vol.4, Issue 1, Jan 2014, pp 116-138

Analysis and Design of narrow based Transmission Tower (using Multi Voltage Multi Circuit) is carried out keeping in view to supply optimum utilization of electric supply with available ROW and increasing population in the locality, in India. Transmission Line Towers constitute about 28 to 42 percent of the total cost of the Transmission Lines. The increasing demand for electrical energy can be met more economical by developing different light weight configurations of transmission line towers.In this project, an attempt has been made to make the transmission line more cost effective keeping in view to provide optimum electric supply for the required area by considering unique transmission line tower structure. The objective of this research is met by choosing a 220KV and 110KV Multi Voltage Multi Circuit with narrow based Self Supporting Lattice Towers with a view to optimize the existing geometry. Using STAAD PRO v8i analysis and design of tower has been carried out as a three dimensional structure. Then, the tower members are designed.

D.B. Sonowal , J.D. Bharali, M. K. Agarwalla, N. Sarma, P. Hazarika"Analysis and Design of 220 kV Transmission Line Tower (A conventional method of analysis and Indian Code based Design)"IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) NCIEST-2015

Transmission line tower constitute about 28 to 42 percent of the cost of the transmission power line project. An attempt is made to model, analyse and design a 220KV transmission line tower using manual calculations. The tower is designed in wind zone – V with base width 1/5thof total height of the tower. This objective is made by choosing a 220 KV single circuit transmission line carried by square base self-supporting tower with a view to optimize the existing geometry and then analysis of the tower has been carried out as a 2-D structure. Structure is made determinate by excluding the horizontal members and axial forces are calculated using method of joints and design is carried out as per IS 800:2007.

Shivam Panwar, Yogesh Kaushik, Anubhav Singh and Nikhil Sharma "Structural Analysis and Design of Steel Transmission Tower in Wind Zones II and IV- A Comparative Study" International Journal of Engineering Technology, Management and applied sciences May 2016, Volume 4, Issue 5, ISSN 2349-4476
The design and analysis of the considered power system has been done using STAAD.ProV8i.Under the design and analysis of the system, the effect of wind and earthquake loads were studied and the results so obtained were compared for wind zones II and IV (seismic zone IV) for the same configuration of tower. Delhi and Panjim have same seismic zone but there is a lot of difference in the basic wind speed as Panjim is a coastal area. The analysis results have been supplied to the management of the considered system for taking appropriate decisions regarding the improvement of powersystem design. The comparative analysis is carried out with respect to axial force, deflections maximum sectional properties and critical load condition for both the locations.

B. Jyothi, S. Mahesh "Design Transmission Tower and Its Foundation" International Journal of Scientific Engineering and Technology Research ISSN 2319-8885 Vol.06,Issue.06 February-2017, Pages:1008-1
The tower is designed for the wind zone V carrying 132 KV DC. Tower is modeled using constant parameters such as height, bracing system, angle sections, base widths, wind zone, common clearances, span, conductor and ground wire specifications. The loads are calculated using IS: 802(1995). After completing the analysis, the study is done with respect to deflections, stresses, axial forces, slenderness effect, critical sections and weight of tower. Using STAAD PRO v8ianalysis and design of tower has been carried out as a three dimensional structure. Then, the tower members are designed.

TOWER USED FOR WIND FORCES
Suspension Tower
It is used on the line for straight run or for small angle of deviation upto 20 - 50 or upto 150 (with inclined V string) support of conductor and suspension tower (I-string, V-string, Y-string).It is also known as "Tangent tower".Suspension Tower (with I or V suspension insulator string)
a) Tangent tower (00) with suspension string To be used on straight runs only
b) Intermediate tower (00 – 20) with suspension string Straight run and upto 20 deviation
c) Light angle tower(00-50) Straight run and upto 50 deviation
Angle Tower
It is also known as "Tension Tower". It is used where the angle of deviation exceeds.It is classified based on different deviation angle. Tension insulator string is used on tension/section/angle/dead end towers. It is provided on both side of tower in the direction of conductor.
Angle tower
a)Small angle tower with tension string(00 -150)with line deviation 00 - 150)tension string
b) Medium angle tower (00 – 300) or (150 – 300) line deviation 00 - 300
c)Large angle tower (300–600) line deviation 300 - 600
d) Dead end tower with tension string line deviation 00- 150
CODES USED FOR TOWER
IS 802 (Part 1/Sec 1):1995
This standard (Part I/SEC 1) stipulates materials and loads to be adopted in the design of self- supporting steel lattice towers for overhead transmission lines. In this code the tower member; including cross arm shall be of structural steel conforming to any of the grade. Provisions on fabrication including galvanizing, inspection and packing etc and testing of transmission line tower have been covered. For selection of most suitable transmission lines details of types of towers such as suspension and tension

tower with their criteria is covered. Anti-cascading checks, tension limits, broken wire condition of single, double, triple and quadruple circuit tower is given. Strength factors related to quality is provided in this code.

IS 5613 (Part 2/sec 1):1985
This code covers design of overhead power lines above 11kV and up to and including 220kV.Section 1 of each part covers design aspect and section 2 installation and maintenance of power lines. Choice of route of transmission tower, electrical design of transmission voltage, insulation requirements are covered. The supporting structure of transmission tower, choice of spans as per circuits and nominal system voltage is given. As per tower loading normal condition and broken wire loading condition is covered.

IS 875 Part 3:1987	IS 875 Part 3:2015	EN 1991-1-4:2005
1.DESIGN WIND SPEED,Vz The basic wind speed (Vz) to get design wind velocity at any height Vz = Vb * k1 * k2 * k3 Where, Vz = Design wind speed at any height z in m/s; Vb = Basic wind speed k1 = Probability factor (risk coefficient) k2 = Terrain, height and structure size factor k3 = Topography factor	**1.DESIGN WIND SPEED, Vz** The basic wind speed (Vz) to get design wind velocity at any height Vz = Vb * k1 * k2 * k3* k4 Where, Vz = Design wind speed at any height z in m/s; Vb = Basic wind speed k1 = Probability factor (risk coefficient) k2 = Terrain, height and structure size factor k3 = Topography factor k4 = Importance factor for the cyclonic region	**1.MEAN WIND VELOCITY,V_z** The Mean wind velocity vm{z) at a height z above the terrain depends on the terrain roughness and orography and on the basic wind velocity, Vb, and should be determined basic wind velocity, the recommended value is using Expression $V_m(z)=C_r(z)*C_o(z)*V_b$ where: Cr(z) = roughness factor, Co(z)= orography factor, NOTE 1: If the orography is accounted for in the 1,0.
3. RISK COEFFICIENT, k1 The suggested life period to be assumed in design and the corresponding k1 factors for	**3. RISK COEFFICIENT, k1** The suggested life period to be assumed in design and the corresponding k1 factors for	**3. RISK COEFFICIENT, k1** No risk coefficient clause is provided.

IS 875 Part 3:1987	IS 875 Part 3:2015	EN 1991-1-4:2005
2.BASIC WIND SPEED, Vb In Map of India gives basic wind speed as applicable to 10 m height above mean ground level for different zones of the country.	**2. BASIC WIND SPEED, Vb** In Map of India gives basic wind speed as applicable to 10 m height above mean ground level for different zones of the country.	**2. BASIC WIND VELOCITY,V_b** The basic wind velocity shall be calculated from Expression $V_b = C_{dir} * C_{season} * V_{b,Q}$ Where, Vb= basic wind velocity, defined as a function of wind direction and time of year at 10m above ground of terrain category II Vb ,Q = fundamental value of the basic wind velocity, Cdir = directional factor, Cseason = season factor
4. TERRAIN, HEIGHT AND STRUCTURE SIZE FACTOR, k_2 Category 1 - Exposed open terrain with few or no	**4.TERRAIN, HEIGHT AND STRUCTURE SIZE FACTOR, k_2** Category 1 - Exposed open terrain with few or no	**4.TERRAIN ROUGHNESS** The roughness factor, cr(z), accounts for the variability of the mean wind velocity at the site of the structure due to: The height above

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)

Vol 3, Issue 1, January 2018

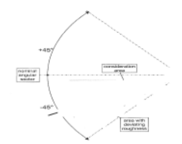
different class of structures for the purpose of design is givenin Table. In the design of all buildings and structures, a regional basic wind speed having a mean return period of50 years shall be used except as specified in the note of Table.	different class of structures for the purpose of design is given in Table. In the design of all buildings and structures, a regional basic wind speed having a mean return period of 50 years shall be used except as specified in the note of Table.	

obstructions and in which the average height of any object surrounding the structure is less than 1.5 m. Category 2 - Open terrain with well scattered obstructions having heights generally between I.5 to 10 m.gory 3 - Terrain with numerous closely spaced obstructions having the size of building-structures up to 10 m in height with or without a few isolated tall structures. Category 4 - Terrain with numerous large high closely spaced obstructions.	obstructions and in which the average height of any object surrounding the structure is less than 1.5 m. Category 2 - Open terrain with well scattered obstructions having heights generally between I.5 to 10 m. Category 3 - Terrain with numerous closely spaced obstructions having the size of building-structures up to 10 m in height with or without a few isolated tall structures. Category 4 - Terrain with numerous large high closely spaced obstructions. Variation of wind speed with height for different sizes of structures in different terrains shown in Table gives multiplying factors (K_2)by which the basic wind speed as per map shall be multiplied to obtain the wind speed at different	ground level The ground roughness of the terrain upwind of the structure in the wind direction considered The determination of the roughness factor at height z is given by Expression and based on a logarithmic velocity profile. $c_r(z)=k_r\cdot\ln\left(\frac{z}{z_0}\right)$ for $z_{min}\le z\le z_{max}$ $c_r(z)=c_r(z_{min})$ for $z\le z_{min}$ Where, Zo = roughness length kr = terrain factor depending on the roughness length Zo calculated using $kr = 0.19(Z_0/Z_{o\ II})^{0.07}$ where, ZO,II = 0,05 m (terrain category II), Zmin = minimum height defined in following Table, Zmax is to be taken as 200 m *Zo*, Zmin depend on the terrain category 2. The terrain roughness to be used for a given wind direction depends on the ground roughness and the distance with uniform terrain roughness in an angular sector around the wind direction. Small areas (less than 10% of the area under consideration) with deviating roughness may be ignored.

ISSN (Online) 2456-1290

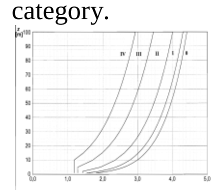
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 3, Issue 1, January 2018

5.TOPOGRAPHY FACTOR, k_3 The effect of topography will be significant at a site when the upwind slope is greater than about 3^o, and below that, the value of **ks**may be taken to be equal to 1.0. The value of k_3 isconfined in the range of 1.0 to 1.36 for slopes greater than 3^o. It may be noted that the value of $k_3$varies with height above ground level, at a maximum near the ground, and reducing to 1.0 at higher levels.	**5.TOPOGRAPHY FACTOR, k_3** The effect of topography will be significant at a site when the upwind slope is greater than about 3^o, and below that, the value of **ks**may be taken to be equal to 1.0. The value of k_3 isconfined in the range of 1.0 to 1.36 for slopes greater than 3^o. It may be noted that the value of $k_3$varies with height above ground level, at a maximum near the ground, and reducing to 1.0 at	**5.TERRAIN OROGRAPHY** Where orography (e.g. hills, cliffs etc.) increases wind velocities by more than 5% the effects should be taken into account using the orography factor co. The effects of orography may be neglected when the average slope of the upwind terrain is less than 3°. The upwind terrain may be considered up to a distance of 10 times the height of the isolated **Large and**

	heights, in each terrain category for different sizes of buildings/structures.	 **Assessment of terrain roughness** (3) When a pressure or force coefficient is defined for a nominal angular sector, the lowest roughness length within any 30° angular wind sector should be used. (4) When there is choice between two or more terrain categories in the definition of a given area, then the area with the lowest roughness length should be used.
6.No this factor is provided.	**6.IMPORTANCE FACTOR FOR CYCLONIC REGION (k_4)** The wind speed and damage to buldings and structures point to the fact that the speeds given in the basic wind speed map are often exceeded during the cyclones. The following values of k_4 are stipulated as applicable according To the importance of the importance of the structure: **K_4**	**6. No this factor is provided.**

IFERP
connecting engineers... developing research
ISSN (Online) 2456-1290
International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 3, Issue 1, January 2018

	higher levels.	**considerably higher neighbouring structures** If the structure is to be located close to another structure, that is at least twice as high as the average height of its neighbouring structures, then it could be exposed (dependent on the properties of the structure) to increased wind velocities for certain wind directions. Such cases should be taken into account. **Closely spaced buildings and obstacles** The effect of closely spaced buildings and other obstacles may be taken into account.

DESIGN WIND PRESSURE,P_Z The design wind pressure at any height above mean ground level shall be obtained by the following relationship between wind pressure and wind velocity: $P_z = 0.6V_z^2$ Where, P_z = design wind pressure in N/m^2 height z v_z - design wind velocity in m/s at height z	Structures of post cyclone importance for emergency services (such as cyclone shelter,hospital,schools,communication tower etc.) 1.30 Industrial structure 1.15 All other structure 1.00 **DESIGN WIND PRESSURE,P_Z** The design wind pressure at any height above mean ground level shall be obtained by the following relationship between wind pressure and wind velocity $P_z = 0.6\ V_z^2$ Where, P_z = design wind pressure in N/m^2 height z v_z - design wind velocity in m/s at height z The design wind pressure $p_d$can be obtained as, P_d= Kd*Ka*Kc*Pz Where, Kd = wind directionality factor, Ka = area averaging factor, Kc =combination factor	**PEAK VELOCITY PRESSURE** The peak velocity pressure qp(z) at height z, which includes mean and short-term velocity fluctuations, should be determined. $q_p(z) = [1 + 7 \cdot l_v(z)] \cdot \frac{1}{2}$ where: *p* = air density, which depends on the altitude, temperature and barometric pressure to be expected in the region during wind storms $C_e(Z)$ = exposure factor $C_e(z) = q_{p*}Z*q_b$ *qb*= basic velocity pressure given in Expression $q_b = \frac{1}{2} \cdot \rho \cdot v_b^2$ For flat terrain where *co(z)* = 1,0 the exposure factor cc(z) is illustrated as a function of height above terrain and a function of terrain category.  Illustrations of the exposure factor ce(z) for *co=1* ,0, *k,=1,0* **Wind pressure on surfaces** The wind pressure

	The value of P_d however shall not be taken as less than 0.70Pz. **Wind Directionality Factor, Kd** Considering the randomness in the directionality of wind and recognizing the fact that pressure or force coefficients are determined for specific wind directions.For solid signs,opensigns,lattice frameworks and trussed towers (triangular,square,rectangular) a factor of 0.90 may be used on the design wind pressure.For circular or near circular forms this factor may be taken as 1.0. For the cyclone affected regiona also the factor $K_d$shall be taken as 1.0. **Area Averaging Factor, Ka** Pressure coefficients are a result of averaging the measured pressure values over a given area. As the area becoming larger, the correlation of	acting on the external surfaces, We, should be obtained from Expression $w_e = q_p(z_e) \cdot c_{pe}$ where: $q_p(Z_e)$ = peak velocity pressure Z_e= reference height for the external pressure C_{pe}= pressure coefficient for the external pressure The wind pressure acting on the internal surfaces of a structure, Wi $w_i = q_p(z_i) \cdot c_{pi}$ Q_p(Zi) = peak velocity pressure Zi = reference height for the internal pressure Cpi = pressure coefficient for the internal pressure

ISSN (Online) 2456-1290

International Journal of Engineering Research in Mechanical and Civil Engineering (IJERMCE)
Vol 3, Issue 1, January 2018

				measured values decrease and vice-versa. The decrease in pressures due to larger areas may be taken into account. **Combination factor, Kc** When taking the combined effect of wind loads on the frame,a reduction factor of Kc = 0.90 may be used over the building envelope when roof is subjected to pressure and internal pressure issuction,or vice versa.	

III. CONCLUSION

• In this paper 3 different wind codes are studied. Factors governing for wind analysis of tower are same but its clauses are different therefore its results will changes and in IS 875 part 3:2015 some new changes in clauses are provided as compared to other wind code.

• Codes used for Loading on tower is also studied. Therefore on the basis of this loading tower will analysed.

• Compared to revised IS 875: Part 3-2015 changes occurs in axial forces, reactions and moment in result is carried out.

• In revised code IS 875: Part 3-2015, loading and design parameters are changed. In this paper the comparison of code IS 875: Part 2-1987 and EN 1991-1-4:2005 will be carried out.

REFERENCES

1. V. Lakshmi, A. RajagopalaRao "Effect of Medium Wind Intensity on 21m 132kv Transmission Tower" International Journal of Engineering Science & Advanced Technology, Jul-Aug 2012
2. Alaa C. Galeb, Ahmed Mohammed Khayoon "Optimum Design of Transmission Towers Subjected to Wind and Earthquake Loading" Jordan Journal of Civil Engineering, Nov 2013
3. C. Preeti , Jagan Mohan “Analysis of Transmission Towers with Different Configurations”Jordan Journal of Civil Engineering, Volume 7, No. 4, 2013
4. •Sumit Pahwa, Vivek Tiwari, Harsha Jatwa“Analytical Study of Transmission Tower Subjected toWind and Seismic Loads Using Optimization Technique”International Journal of Emerging Technology and Advanced EngineeringVolume 4, Issue 9, September 2014
5. AlokDua, Mathias Clobes, Thomas Höbbel, VasantMatsagar “Dynamic Analysis of Overhead Transmission Lines under Turbulent Wind Loading”Open Journal of Civil Engineering,5, 359-371December 2015
6. IS 875-Part 2 1987: Code of Practice for Design Loads (Other Than Earthquake) For Buildings And Structures, Part 3: wind Loads

7. IS 875-3 (2015): Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures, Part 3: Wind Loads IS 802 (Part 1/sec 1):1995 Use of Structural Steel in Overhead transmission line towers Code of Practice Part 1 Materials, loads and Permissible Stresses

8. IS 5613 (Part 2/sec 1):1985 code of practice for design, installation and maintenance of overhead power lines Part 2 lines above 11kv and upto and including 220 kv

9. EN 1991-1-4-2005 Eurocode 1: Actions on structures - Part 1-4: General actions Wind actions