ANALYSIS OF FOUR LEGGED STEEL TELECOMMUNICATION TOWER-EQUIVALENT STATIC APPROACH

Ravishankar P[1], Arun L[2], Sudha G C[3]

[1]PG Student Department of civil Engineering EIT Ummathur, chamarajanagar571313 Karnataka, India
[2]Assistant Professor Department of civil engineering VVIET Mysuru, Karnataka, India
[3]Assistant Professor, Department of civil Engineering, E.I.T College, ummathur chamarajanagar, 571313 karnataka India

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Abstract - *The four legged self-supporting towers are widely used worldwide for the telecommunication purposes. The communication industries have seen a tremendous increase in last few years which have resulted in installation of large number of towers to increase the coverage area and network consistency. These are lifeline structures they play a significant role in wireless communication network. Hence failure of such structure in a disaster like wind and earthquake is a major concern. Therefore utmost importance should be given in considering all possible extreme conditions for designing these towers.*

The design of these steel telecommunication towers are done by the help of staad pro. 2007software.

The results obtained from these analyses like joint displacement, natural frequency are tabulated, compared and conclusions are drawn.

Key Words: Telecommunication Tower, self -supporting tower, angle section, types of bracing system, joint displacement.

1. INTRODUCTION

Media Transmission towers are tall structure generally designed for supporting parabolic antennas which are normally used for sending radio signs, also used for microwave transmission for communication, and for television signals to remote places. Lattice towers are mainly classified into three categories: (1) guyed towers, (2) monopole and (3) self-supporting towers. The thesis concentrates on the study of "self-supporting towers".

Self-supporting telecommunication towers are classified as three-legged or four-legged space trussed structures of varying heights and base widths. These towers consist of main legs, horizontal and transverse bracings. The main legs are typically composed of 90° angles (in four-legged towers), 60'xhifflerized or cold-formed angles (in three-legged towers), or tubular hollow sections. Various bracing patterns are used but the most common ones are the chevron and the cross bracing.

Finite Element (FE) method has been the most popular method used in the analysis of communication tower.

Generally, the stiffness matrix method is employed in the tower model.

1.1 Types of bracing system for lattice towers

Mainly six types of bracing systems are seen in tower structures, namely "K, XX, XB, Y, W and Arch bracing" system.

To study the effective and economic performance of bracing system, in this dissertation the concept of "Combined or Hybrid models" are considered.
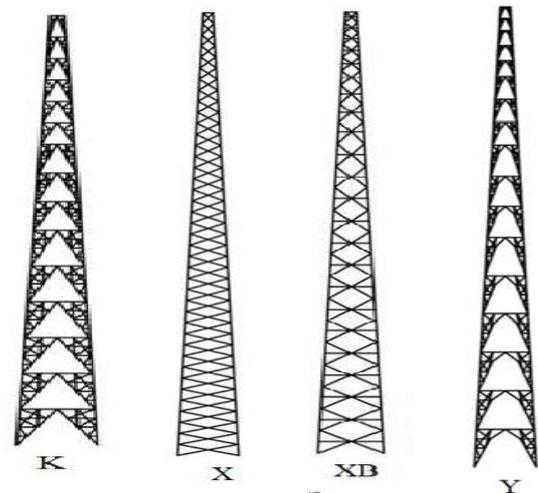

Figure 1.0Types of bracings

1.2 Geometry of the tower: The geometry of the structure with the nodes and beams display for all three models namely M1: (K-XX), M2: (XX-K), M3: (XB-XX).

2. OBJECTIVE

➢   To generate 3D frame model of telecommunication tower using FE software to carry out modelling and analysis.

➢   To study the effects on telecommunication tower due to change in tower parameters like tower height and Height of inclination.

➢   To study the effects on telecommunication tower due to various types of bracing Systems and their combination.

➢   To study the effect of wind load on telecommunication tower structures for different wind zones as per Indian Standard code of practice, IS875 (part-3): 1987 and IS802 (part-1/sec-1): 1995.

2.1 METHODOLOGY

Modelling of 3D frame telecommunication tower structure is done using the Staad pro 2007 software for three different types of combination of bracings in three different heights 50m, 65m and 80m. The model descriptions with the bracing arrangements are given in table 1.0

Table 1.0 Model descriptions with the bracing arrangements

Sl. No.	Model		Tapered portion	Straight portion
1	M1	K-XX	K	XX
2	M2	XX-K	XX	K
3	M3	XB-XX	XB	XX

2.2 MATERIAL PROPERTIES

1. The density = 7870 kg/m^3

2. Tensile strength of steel in yielding = 500 N/mm^2

3. The modulus of elasticity, E = 2 x 10^5 N/mm^2

4. Poisson's ratio = 0.3.

3. LOAD CASES AND COMBINATIONS

Load case1: Earthquake load

Load case 2: Dead load

Load case 3: live load

Load case 4: wind load ($\theta = 0^0$)

Load case 5: wind load ($\theta = 45^0$)

Load case 6: response spectrum load

Load case 7combination: DL+LL

Load case 8 combination: DL+LL+WL ($\theta = 0^0$)

Load case 9 combination: DL+LL+WL ($\theta = 45^0$)

Load case 10combination: DL+LL+ Earthquake load

Load case 11combination: DL+LL+RS

Table -2: Member details of the towers

Sl.no.	Height			Bracing System	Section
	50m	65m	80m		
1	0-30m	0-45m	0-60m	Bottom leg	ISA200X200X25
2				Bracing	ISA150X150X18
3	31-40m	46-55m	61-70	Upper leg	ISA200X200X15
4				Bracing	ISA130X130X12
5	41-50m	56-65m	71-80m	Top leg	ISA110X110X12
6				Bracing	ISA90X90X10

3.1 LIVE LOAD

3.1.1 CDMA Antenna (Code Division Multiple Access)

Vertical load of CDMA antenna at each node

= (6 x 20 x 9.81) / (1000 x 4) = 0.294Kn at 48m,63m, 78m.

3.1.2 Microwave Antenna

Vertical load due to microwave antenna at each node

[(77 x 9.81) + (45 x 9.81) + (2 x 25 x 9.81)] / (1000 x4)

 0.421 KN at 44m, 59m, 74m.

3.1.3 Platform Load

Vertical load due to platform provided

= 0.82 kN at 46m, 61m and 74m respectively

4.0 Wind load on telecommunication towers (F_z):

Case I: 33m/sec

Case II: 55m/sec

The wind load on telecommunication Towers is calculated by the following formula as per IS 875 (part 3) – 1987, clause 6.3.3.5 to 8.3 F= C_f x A x P_z

 Where,
C_f = force coefficient

A = area considered for the structure at height
P_z = design wind pressure at height z.

5. FE ANALYSIS AND DESIGN OF TOWER

Table 3.0 Details of tower models

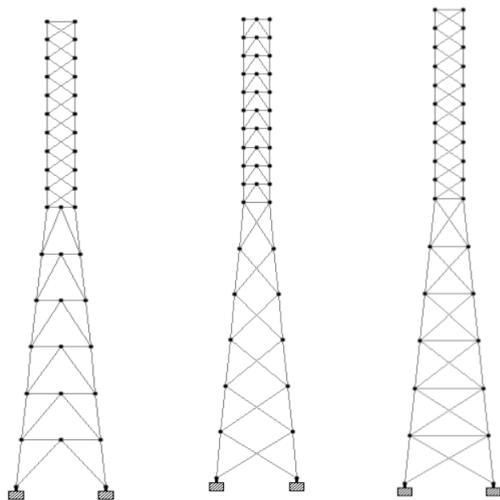| PARAMETER	MODEL(M)		
Height of tower	50	65	80
Height of straight portion at top of tower	20	20	20
Height of inclined portion	30	45	60
Base width	8	8	8
Top width	2.5	2.5	3.0
Number of 5m high panels	6	9	12
Number of 2m high panels	10	10	10

Figure 2.0 geometry of the Model 1: (K-XX), Model 2: (XX-K), Model 3: (XB-XX) tower respectively.

5.1 Wind along x direction (θ = 0⁰) on tower

Wind load acting on the tower structures are one of the major loads which govern the design of the towers. The wind loads are applied as nodal loads at that particular height.

The basic wind speed considered in this dissertation for tower analysis are

1. Case 1: 33m/s

2. Case 2: 55m/s

The variation of joint displacements at the top of the tower models by the wind analysis in x direction (θ = 0⁰) is

tabulated in table 4.and figure 3(a)3(b)3(c)shows the plot of variation of joint displacements verses tower height.

Table-4: Variation of joint displacements (mm) at the top of tower (along wind)

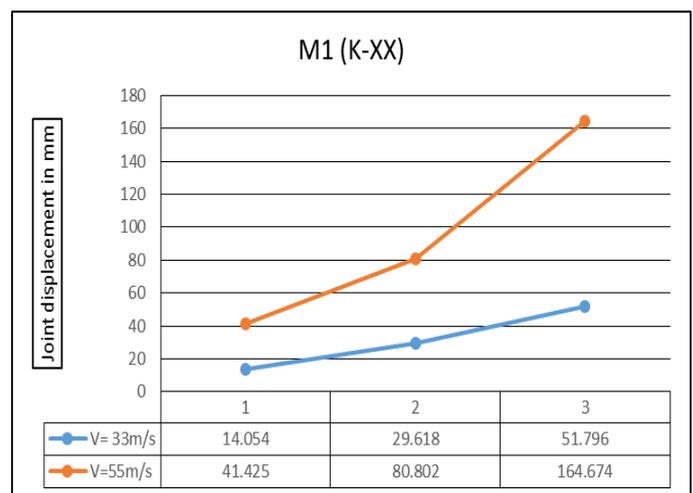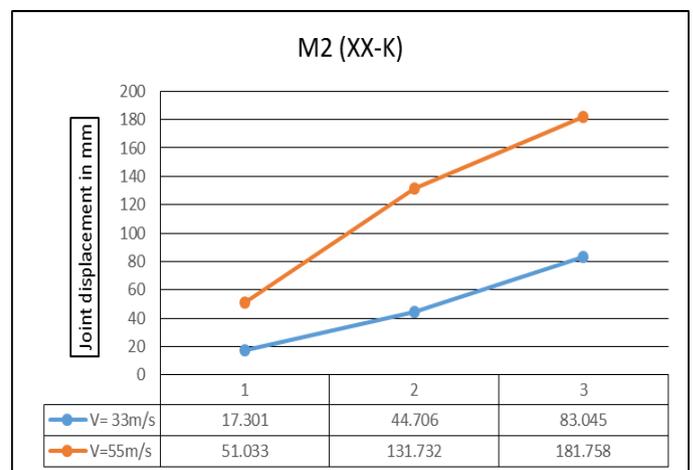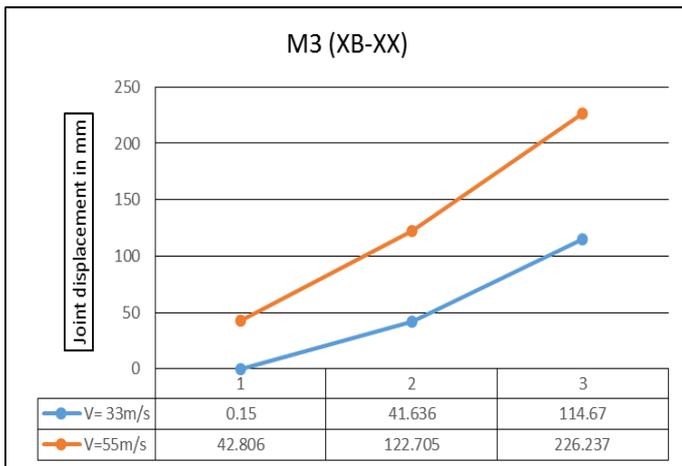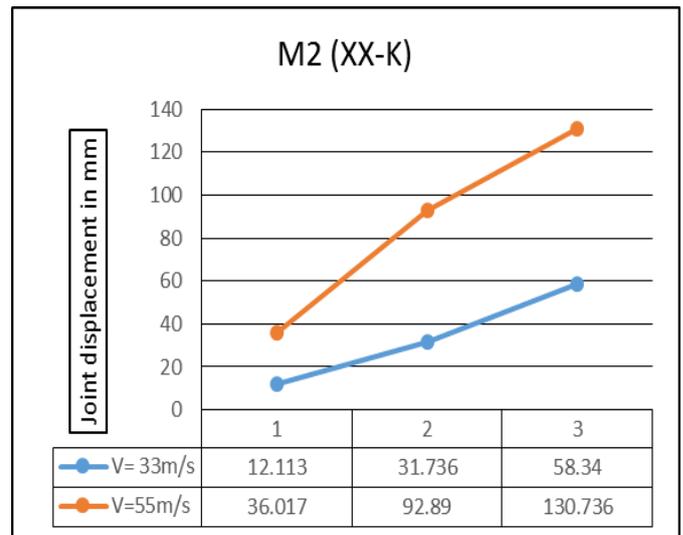| Tower Height in (m)	Joint Displacement (mm) (normal wind θ = 0⁰) at Top of Tower					
	Case1: V= 33m/s			Case2: V= 55m/s		
	M1	M2	M3	M1	M2	M3
	K-XX	XX-K	XB-XX	K-XX	XX-K	XB-XX
50	14.0	17.30	0.15	41.4	51.0	42.806
65	29.6	44.70	41.6	80.8	131.	122.70
80	51.7	83.0	114.	164.	181.	226.2

Fig 3(a)

Fig 3(b)

Fig 3(c)

5.2 Wind analysis (θ = 45⁰)

The variation of joint displacements at the top of the tower models by the wind analysis in both x and z direction (θ = 45⁰) is tabulated in table 5 and figure 3(d)3(e)3(f)showing the variation of joint displacements at the top of tower.

Table-5: Variation of joint displacements (mm) at the top of tower (cross wind)

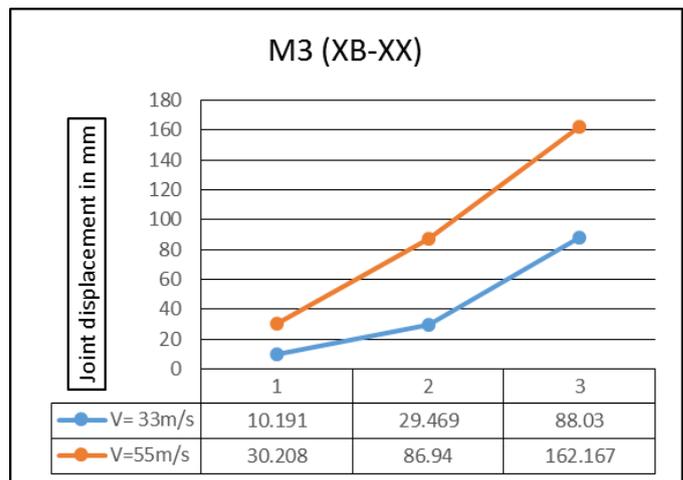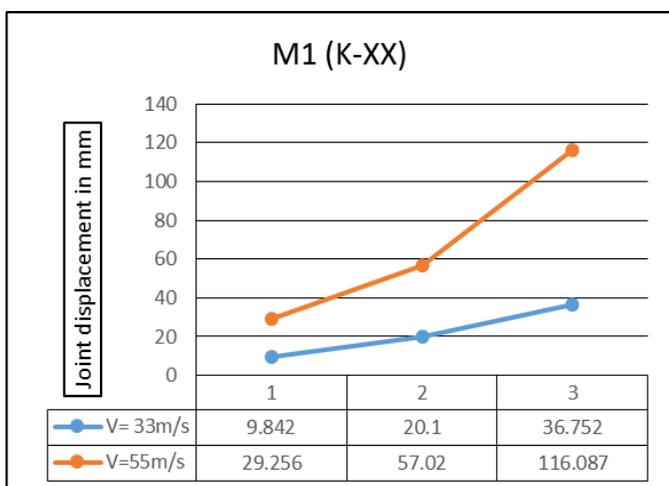| Joint Displacement (mm) (cross wind θ = 45⁰) at Top						
Tower Height in (m)	**Case1: V= 33m/s**			**Case2: V= 55m/s**		
	M1	**M2**	**M3**	**M1**	**M2**	**M3**
	K-XX	**XX-K**	**XB-XX**	**K-XX**	**XX-K**	**XB-XX**
50	9.84	12.1	10.19	29.25	36.01	30.20
65	20.1	31.7	29.46	57.02	92.89	86.94
80	36.7	58.3	88.03	116.0	130.7	162.1

Fig 3(d)

Fig 3(e)

Fig 3(f)

5.2.1   Free vibration analysis

The natural frequencies of the towers of all the models are tabulated in table 6.The respective mode shapes of the model XX-K with the height of 50m are shown in figure 4-1 to 4-3. The first mode is the natural excitation of the structure in x direction, second mode in z direction and the torsion mode shows the response of structure under torsion.
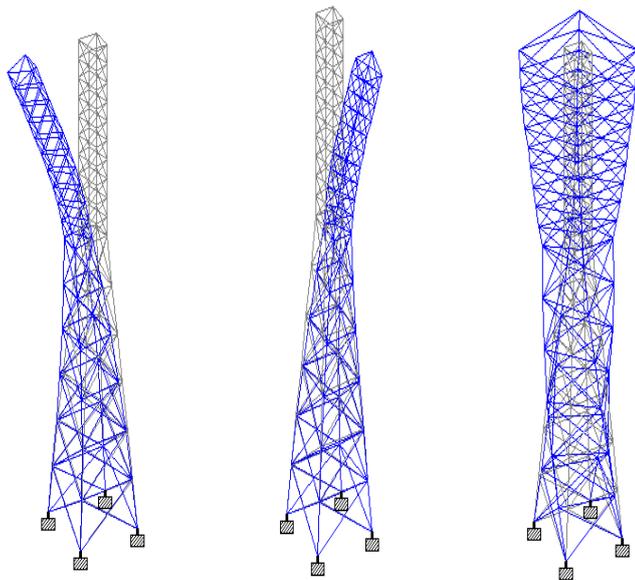
Table 6. Natural frequencies of the tower structures

Height of tower(m)	Number of Modes	Natural frequency Hz		
		Model (K-XX)	**Model (XX-K)**	**Model (XB-XX)**
50	Mode1	3.04	3.05	2.53
	Mode2	3.04	3.06	2.53
	Mode3	8.09	12.7	12.40

65	Mode1	2.07	1.53	1.44
	Mode2	2.07	1.65	1.58
	Mode3	6.75	5.49	5.55
80	Mode1	1.39	1.12	1.2
	Mode2	1.39	1.12	1.2
	Mode3	5.05	5.99	6.67

Mode1:3.05 hz   **Mode 2: 3.06 hz**   **Mode3:12.7hz**

Figure (4-1-4.3) mode shapes of 50m tower Model:

(XX-K)

6. Response spectrum analysis: Equivalent static approach

As per IS 1893 (part 1) - 2002 the response spectra are generated for seismic zone-II. As a result of which the joint displacements are obtained and tabulated in table 7, the comparison of obtained joint displacements are plotted in figure 5(a)

Seismic parameters

Zone factor=0.1

Response reduction factor=5

Importance factor=1.5

Rock and soil site factor=2

Damping ratio=5%

Table 7 Joint Displacement (mm) at Top of Tower (Response spectrum analysis)

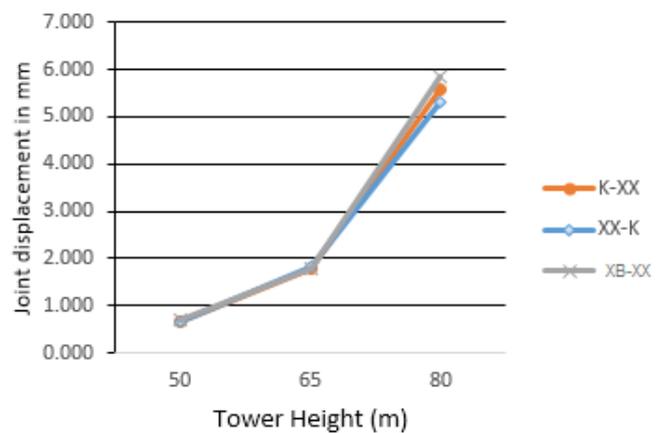| Tower height (m)	Zone	Joint displacement (mm)		
		M1	**M2**	**M3**
		K-XX	**XX-K**	**XB-XX**
50	II	0.658	0.665	0.711
65		1.794	1.804	1.762
80		5.562	5.318	5.859

Fig 5(a)

7. CONCLUSIONS

➢ From wind analysis it can be observed that, the joint displacement increases with the increase in height of the tower.

➢ In case of cross wind i.e. wind applied in X and Z both axes, the displacement in X and Z both directions will be proximally equal.

➢ The displacements also increase significantly with the increase in wind speed 33m/s to 55m/s in both along wind and cross wind.

➢ In wind analysis Model3 (M3) with XB-XX bracing has highest displacement whereas Model1 (M1) with K-XX bracing has least displacement in both along wind and cross wind conditions.

➢ Based on the results obtained from the analysis it can be seen that the wind is the dominate factor in the tower modelling than the seismic forces but the seismic effect cannot be neglected as observed from the results

8. Future Scope

In this dissertation work only three types of bracings are considered. For further Work other types of bracing systems can be considered in analysis.

- ➢ The tower can be analyzed for different wind speed conditions and can be

- ➢ Compared with the earthquake zones to know the critical load combination for design of towers.

- ➢ The study can be carried out by using different types of antennas and changing the position of placing the antennas on the tower to know its effects on tower.

- ➢ Guyed tower and monopoles can be analyzed for same conditions and effects can be studied

9. REFERENCES

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AUTHORS

Ravishankar P is presently studying M.Tech (structural engineering) in EIT,Ummathur, chamarajanagar,Karnataka.He received his B.E Degree in Civil Engineering from VTU during 2011-2015

Arun L is presently working as Assistant professor, Dept. of Civil Engineering at VVIET, mysuru Karnataka. He obtained his M.Tech degree in Structures from VTU.

Sudha G C is presently working as Assistant professor, Dept of Civil Engineering at EIT, ummathur, chamarajanagar Karnataka. She obtained her M.Tech degree in Structures from VTU.