International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Email:editorijoer@gmail.com http://www.ijoer.in ISSN: 2321-7758

Vol.4., Issue.5., 2016
(Sept.-Oct.)

RESEARCH ARTICLE

ISSN: 2321-7758

DESIGN AND CALCULATIONS OF DYNAMIC WIND ON 50M HIGH GUYED MAST TOWER

SHANTHI K [1], NAKKA MONICA MADHURI [2]

[1]M.TECH (14C71D2005) DEPARTMENT OF CIVIL ENGINEERING, ELLENKI COLLEGE OF ENGINEERING AND TECHNOLOGY, HYDERABAD.

[2]ASSOCIATE PROFESSOR, HOD OF CIVIL ENGINEERING, ELLENKI COLLEGE OF ENGINEERING AND TECHNOLOGY, HYDERABAD.

SHANTHI K

ABSTRACT

Guyed masts are a specialized type of structure commonly used in the broadcasting industry to support equipment at substantial heights. The main purpose of this tower is to measure air quality of surrounding areas. Tower design must be tested for operational wind speed of 80m/sec. The design of tower legs guys tie members bracings and guy joint at foundation level, bottom hinge for the tower, foundation for the tower mast and guy support including finite element method (FEM) analysis. The static analysis of a one-level guyed mast has been undertaken. The effects of geometrical and physical design parameters on the displacements of the mast were determined with a particular focus on the effect of static loading on the response mast behavior. The wind effect on the structure is studied by using the gust factor method and the seismic effect on the structure is studied by carrying out the modal analysis and response spectrum analysis. The design of tower 50 m high guyed towers, all steel frames should be made of galvanized steel to withstand harsh forest condition. tower installation should include necessary civil foundation work (tower base) for the prescribed tower including guy foundation tension in the guy wires have to be adjusted by means of tension meter or by any other standard method and the vertically assembled tower have to be assured with the tolerance specified.

Keywords: Guyed Masts, Bracings; Wind Analysis; Gust factor method; Structural Analysis.

INTRODUCTION

A Guyed mast is a tall thin vertical structure that depends on guy lines for stability. The mast itself has the compressive strength to support its own weight, but usually does not have the shear strength to stand unsupported, and requires guy lines, diagonal tensioned cables attached to the ground, usually spaced at Equilibrium angles about its base, to resist lateral forces such as wind loads and keep it upright, the structural analysis of a guyed mast is complex, because of non-linear behavior of structural system and the random nature of the loads [1]. The choice of initial tension and the non-linear behavior of the guys can have a very great effect on the deflections as well as dynamic behavior of a whole structure [2]. In this study a behavior of guyed mast with combined guys was undertaken to compare static response predictions for a proposed type of guyed masts. The effects of different geometrical and physical design parameters on the lateral displacements of the mast were investigated. Finally, the paper is illustrated with a numerical simulation and comparison of typical and proposed guyed masts. The mast is simple and is supported and anchored to the ground with steel ropes spaced Equilibrium [3]. The number of guy levels can be arranged depending on the height and design. For easy transportation purpose, the guyed mast is made of segments of suitable lengths. For cables these are all model with exact length hence need to be pre tensioned for tower stability [4].

Experimental Details

Design of steel mast

- Steel mast anchored at different heights, is loaded in bending due to wind, and compression from vertical loads (dead load, live load, pretension forces in the cables.
- Pretension force in cables is determined so that in case the cable is unloaded due to wind action, the cable should still be subjected to a tension force.
- As a rule, if the guy is attached in the top of the tower (100%), the tension should be 8% of the tensile strength.
- For 80% of the tower's height, 10% tension should be applied.
- If the anchor point is at 65% of tower height, 15% tension can be applied as you lose a lot of wind load in this last type of installation.

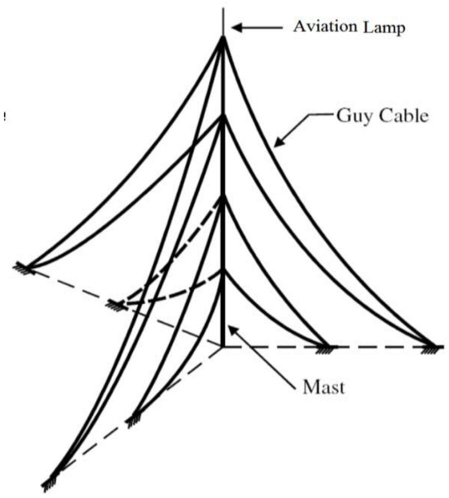


Figure 1: Mast Tower Diagram

The load acting on the towers are

1. Dead load Self-weight of the tower and the sensor's and conductors
2. Live load is assumed as per IS: 875 (part 2): 1987
3. Wind load calculated as per IS: 875 (part 3): 1987

LOAD CONSIDERATION: Truss members are designed to resist the gravity loads and lateral loads. The loads considered in the designing of structure are mentioned below

Gravity loads

- Dead load
- Live load

Lateral Load

Wind Load (Wind load calculated as per is 802 (part1/sec 1): 1995)

- Earthquake load (Earthquake load as per IS 1893 (Part 1): 2002
- Temperature load.

Dead Loads: Tentative weight associated with sensor's position on the tower: 2m from ground - 10 kg mounted On 2 Nos 2m length 2" x 2"galvanized Steel rods

4m from ground - 03 kg mounted On 2 Nos 2m length 2" x 2"galvanized Steel rods

8m from ground - 03 kg mounted On 2 Nos 2m length 2" x 2"galvanized Steel rods

16m from ground -03 kg mounted On 2 Nos 2m length 2" x 2"galvanized Steel rods

25m from ground -03 kg mounted On 2 Nos 2m length 2" x 2"galvanized Steel rods

28/30m from ground - 10 kg mounted On 2 Nos 2m length 2" x 2"galvanized Steel rods

32m from ground - 05 kg mounted On 2 Nos 2m length 2" x 2"galvanized Steel rods

50m from ground - 02 kg mounted On 2 Nos 2m length 2" x 2"galvanized Steel rods

Total weight should consider the galvanized steel rods which are used to mount the sensors. 8mm thick Chequred plates are considered at every loading.

Live Loads: Live load is based on the purpose of the usage of the building and can be assumed using IS:875 (part-2)-1987.

International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Email:editorijoer@gmail.com http://www.ijoer.in ISSN: 2321-7758
Vol.4., Issue.5., 2016 (Sept.-Oct.)

Live load is taken on Chequred plate at staircase landing is id 0.75 KN/ Sqm

Wind Load: Wind load are to be considered based on IS: 875 (part-3)-1987. The major considerations of the wind load depend upon the class of the structure, terrain category, height of the structure, Topography factor and permeability conditions. As per IS: 875 (part-3)-1987, the country is divided into 6 wind zones i.e.

Design steps for calculating wind load on the structure are as follow:

- Determine the basic wind speed (V_b) of the structure depending upon the location.
- Calculate the design wind speed (V_z)

  V_z = design wind speed,(m/s)

  $V_z = V_b{*}K1{*}K2{*}K3$

  Where V_b = basic wind speed (m/s)

  K1 = probability (Risk coefficient)

  K2 = Hourly mean wind speed

  K3 = topography factor
- Calculating design wind pressure (P_z)

  $P_z = 0.6{*}\,(V_z)^2$

Seismic Loads- Is 1893 (Part 1)-2002: Seismic forces are lateral loads on the structure which depends on the location of structure in terms of representing in the location of zone, zone factor, importance factor, response reduction factor and its time period. Seismic forces are determined using IS 1893 (Part 1)-2002 "criteria for earthquake resistance design of structure".

$A_h = \frac{ZISa}{2Rg}$

Where Z = Zone factor

I = Important of the structure

R = Response reduction factor

Sa/g Average response acceleration coefficient

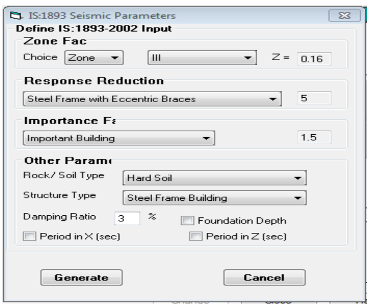


Figure 2: Seismic load parameters

LOAD CASES & COMBINATIONS

LOADS

1. DL (dead load)
2. LL (live load)
3. EQ - X
4. EQ - Z
5. WL - X
6. WL - Z
7. TL
8. TL

LOAD COMBINATIONS

Limit state of strength load combinations with gust factor

LOAD COMB 11 DL+LL+TL
3 1.5 4 1.2 7 1.05
LOAD COMB 12 DL+LL+TL
3 1.5 4 1.2 8 1.05
LOAD COMB 13 DL+LL+TL+WLX
3 1.2 4 1.2 7 1.05 5 0.6
LOAD COMB 14 DL+LL+TL+WLZ
3 1.2 4 1.2 7 1.05 5 0.6
LOAD COMB 15 DL+LL-TL+WLX
3 1.2 4 1.2 8 1.05 5 0.6
LOAD COMB 16 DL+LL-TL+WLZ
3 1.2 4 1.2 8 1.05 5 0.6
LOAD COMB 17 DL+LL+TL+EQ+X
3 1.2 4 1.2 7 1.05 1 0.6
LOAD COMB 18 DL+LL+TL+EQ-X
3 1.2 4 1.2 7 1.05 1 -0.6
LOAD COMB 19 DL+LL-TL+EQ+X
3 1.2 4 1.2 8 1.05 1 0.6
LOAD COMB 20 DL+LL-TL+EQ-X
3 1.2 4 1.2 8 1.05 1 -0.6
LOAD COMB 21 DL+LL+TL+EQ+Z
3 1.2 4 1.2 7 1.05 2 0.6
LOAD COMB 22 DL+LL+TL+EQ-Z
3 1.2 4 1.2 7 1.05 2 -0.6
LOAD COMB 23 DL+LL-TL+EQ+Z
3 1.2 4 1.2 8 1.05 2 0.6
LOAD COMB 24 DL+LL-TL+EQ-Z
3 1.2 4 1.2 8 1.05 2 -0.6
LOAD COMB 25 DL+EQ+X
3 1.5 1 1.5
LOAD COMB 26 DL+EQ-X
3 1.5 2 -1.5

LOAD COMB 27 DL+EQ+Z
3 0.9 1 1.5
LOAD COMB 28 DL+EQ-Z
3 0.9 2 -1.5
LOAD COMB 29 DL+WLX
3 1.5 5 1.5
LOAD COMB 30 DL+WLZ
3 1.5 6 1.5
LOAD COMB 31 DL+WLX
3 0.9 5 1.5
LOAD COMB 32 DL+WLZ
3 0.9 6 1.5

DESIGN CONSIDERATION

In the design of truss members the following parameters were considered

Young's modulus of the steel (E): 2 x 10^5 N/mm^2
Unit mass of the steel or density (ρ): 7850 kg/m3
Poisson's ratio (μ): 0.3
Damping ratio: 0.03
Yield stress (f_y): 310, 250, 345Mpa

Effective Length Factor: This is calculation based on the distance between leg members. It is calculated using the effective length factor 0.85 for in plane (k_y) bending and for out of plane (k_z) bending.

K_z = 0.85* (total unsupported length) / (length of the each member)

PROJECT DATA

Design Parameters:

Type of tower : Guyed mast tower
Tower length (base) : 2.8 m
Tower length (top hamper): 2.8 m
Tower width (base) : 2.8 m
Tower width (top hamper): 2.8 m
Tower height: 50 m
Tower configuration : 4 legged hybrid
Tower Type : based (Ground based)
Panels In tower : 20
Each panel height : 2.5m
Height of top vertical : Straight
Wind Zones IS 875 (Part 3): 1987): V
Earthquake Zones IS 1893 (Part 1): 2002: III

Tower Detail: In this present study, the following tower ground based tower has a 2.8mx2.8m and 50m ht.

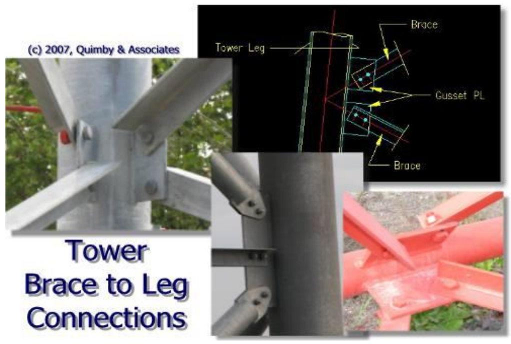


Figure 3: Tower Brace to Leg Connections

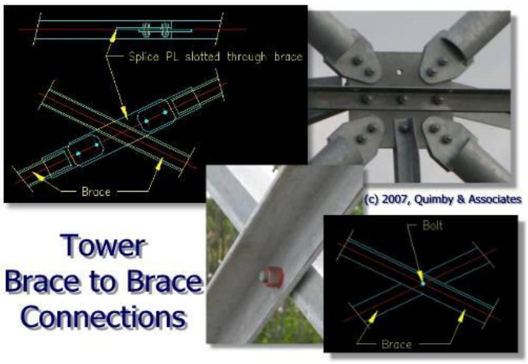


Figure 4: Tower Brace To Brace Connections

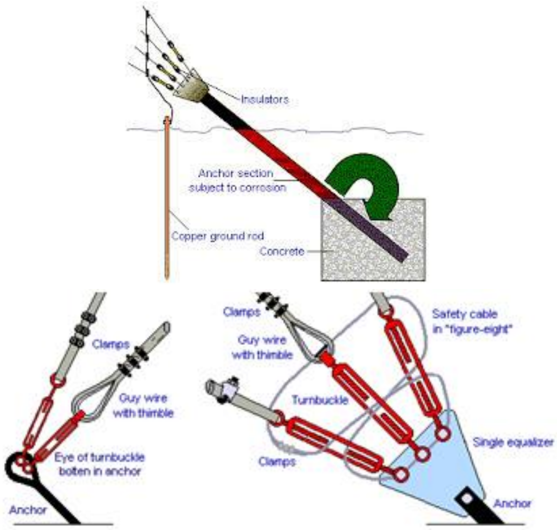


Figure 5: Typical details of guy cable anchoring

RESULTS AND DISCUSSION

The Analysis of Guyed mast tower Section Properties members are carried out as per Staad Analysis, all the Tower members are safe.

International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Email:editorijoer@gmail.com http://www.ijoer.in ISSN: 2321-7758

Vol.4., Issue.5., 2016
(Sept.-Oct.)

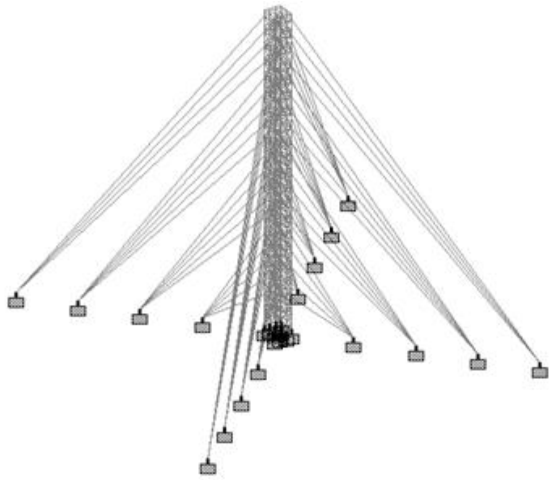
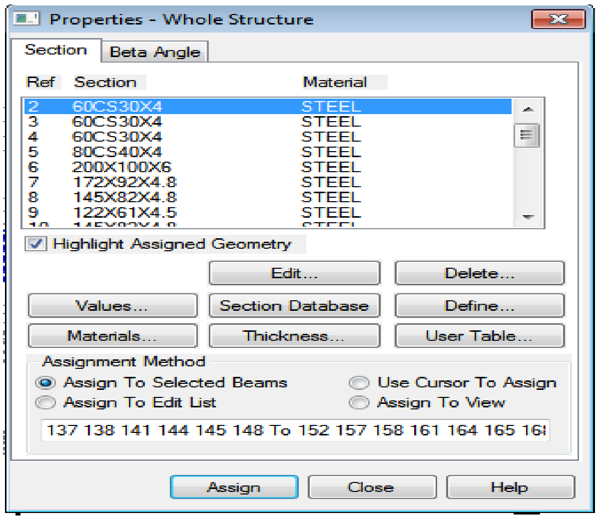


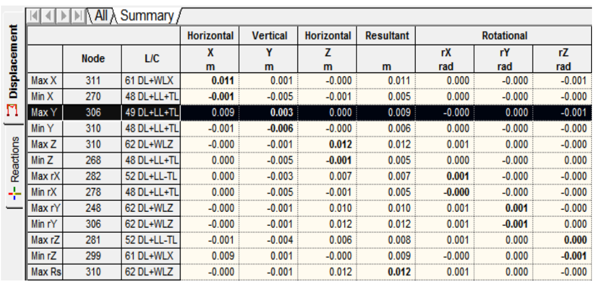
Figure 5: Tower Model in Staad.pro

Table 1: Tower section properties



Displacement Result: Maximum Deflection is obtained for load combination 1.0(DL+LL+TL+WLX)

. **Table 2: Displacement Result**



	Node	L/C	Horizontal X m	Vertical Y m	Horizontal Z m	Resultant m	Rotational rX rad	Rotational rY rad	Rotational rZ rad
Max X	311	61 DL+WLX	0.011	0.001	-0.000	0.011	0.000	-0.000	-0.001
Min X	270	48 DL+LL+TL	-0.001	-0.005	-0.001	0.005	0.000	-0.000	-0.000
Max Y	306	49 DL+LL+TL	0.009	0.003	0.000	0.009	-0.000	0.000	-0.001
Min Y	310	48 DL+LL+TL	-0.001	-0.006	-0.000	0.006	0.000	-0.000	-0.000
Max Z	310	62 DL+WLZ	-0.000	-0.001	0.012	0.012	0.001	0.000	-0.000
Min Z	268	48 DL+LL+TL	0.000	-0.005	-0.001	0.005	0.000	-0.000	0.000
Max rX	282	52 DL+LL-TL	0.000	-0.003	0.007	0.007	0.001	-0.000	-0.000
Min rX	278	48 DL+LL+TL	0.000	-0.005	-0.001	0.005	-0.000	-0.000	-0.000
Max rY	248	62 DL+WLZ	-0.000	-0.001	0.010	0.010	0.001	0.001	-0.000
Min rY	306	62 DL+WLZ	-0.000	-0.001	0.012	0.012	0.001	-0.001	0.000
Max rZ	281	52 DL+LL-TL	-0.001	-0.004	0.006	0.008	0.001	0.000	0.000
Min rZ	299	61 DL+WLX	0.009	0.001	-0.000	0.009	-0.000	0.000	-0.001
Max Rs	310	62 DL+WLZ	-0.000	-0.001	0.012	0.012	0.001	0.000	-0.000

Steel Takeoff: The following table gives the total amount and type of square hollow sections (Tata structural) required for the safe and economical, Steel takeoff as per STAAD Pro analysis

Table 3: Steel take-off for Rectangular hollow sections

PROFILE	LENGTH (MMS)	WEIGHT(NEWT)
ST 200X100X6	40000.01	10642.02
ST 172X92X4.8	140000.45	26321.34
ST 145X82X4.8	158800.28	25513.63
ST 122X61X4.5	436781.02	52655.74
ST 96X48X4.0	245091.03	20528.00
ST 80X40X3.2	120117.53	6722.87
ST 66X33X3.6	329840.32	16782.99
ST ISMC100	221551.16	20807.68
TOTAL	**1692181.80**	**179974.27**

CONCLUSIONS

1. After the study of tower with base width, it is clear that height of tower is directly proportional to the base width.
2. The study of different loading conditions on structures is very important to recognize the case that will cause the larger deflection in tower model and exceed the yield stress to decide which case will be optimized.
3. The geometry parameters of the tower can efficiently be treated as design variables, and considerable weight reduction can often be achieved as a result of geometric changes
4. The tower with different steel section decides the weight of Tower. And the Tower structure with least weight is directly associated in reduction of the foundation cost.
5. The mast tower with X-bracing is lighter than that with Y-bracing with angle sections under wind and seismic load conditions.
6. The tower with steel section and X-bracing has the greater reduction in weight after optimization
7. Optimization of tower geometry with respect to member forces. The tower with base width 2.8 M is concluded as the optimum tower configuration with respect to geometry.
8. Geometric nonlinearities and cable-mast interaction are important and should be simulated properly by using appropriate type and number of elements in the cable model, suitable formulation, and also the correct

modelling of inertia properties of both the mast and the guy cables.

9. Cable-mast interaction and local resonance of the cables sets at the upper levels which are connected to the outer anchor contribute to the response.

REFERENCES

[1]. Subramanian N., Design of steel structures, Oxford University Press, 7th edition, 2011, 173-209.
[2]. IS 1893 (Part-1): 2002 Criteria for Earthquake Resistant Design of Structures, Part 1 General Provisions and Buildings.
[3]. IS : 875 (Part 5) - 1997 Code of practice for Design Loads (Other than Earthquake) for buildings and structures, Part 5- Special Loads and Combinations.
[4]. IS: 801 - 1876 Code of practice for use of Cold-Formed Light Gauge Steel Structural members in general building construction.