Review Paper on Comparative Study of Dynamic Analysis of Transmission Towers

Tanvi G. Londhe[1], Prof. M.S.Kakamare[2]

[1]Student of M.E. Structural Engineering, Department of Civil Engineering, P.V.P.I.T Budhgaqon, Sangli – 416414 India

[2]Associate Professor, Department of Civil Engineering, P.V.P.I.T Budhgaqon, Sangli – 416414 India

---***---

Abstract – *This paper describes the estimation of feasible solution to optimize transmission line tower for weight parameter. The cost of transmission line towers is about 35% to 40% of the total cost of the transmission tower. But lesser study is carried out in the field of minimizing weight of transmission line tower; also less literature is available on transmission line tower with cold form sections. Analysis of transmission line tower carried out as per standard codes, also comparative study is carried on the basis of different types of bracing systems (warren, horizontal, diagonal and diamond) and materials such as hot rolled and cold form sections. By designing transmission line tower with hot rolled sections using STAAD pro, hot rolled sections gives light weight design.*

***Key Words*: Optimization of tower, Hot rolled steel section, STAAD Pro.**

1. INTRODUCTION

Now a day's electricity is on high demand in the field of industries, commercial and residential use. The need of electricity increases due to rapid progress in industrial area and infrastructure. Requirement of electricity varying across the country and for far away locations of power plants, a network of electric transmission lines is required. The shape and size of the transmission line tower have received extensive attention. The tower is defined as tall structures with relatively small cross section and with a large ratio between the height and the maximum width. Tower structure acts as a single cantilever beam which is freely standing self-supporting and fixed at base. Guy tower is the structure which is pin- connected to its foundation and supported with guys or another element. Water towers, radio and television towers and the towers of power transmission lines are the examples of structures which belonging to the tower family. The transmission line tower is used to support conductors carrying electrical power and one or two ground wires at suitable distances above the GL and from each other the cost of transmission line towers is about 35% to 40% of the total cost of the transmission tower. The aim of every designer is to design the best (optimum) system, so that towers are constructed economical by developing different light weight configuration of transmission line tower. Following points are to be considered while designing the transmission line tower:

a) Selection of clearance

b) Tower configuration analysis

c) Tower weight estimation

d) Line cost analysis and span optimization

e) Economic evaluation of line

1.1 Types of tower

Tower structure is act as a single cantilever beam which is freely standing self-supporting and fixed at base. The structure which is pin- connected to its foundation and supported with guys or another element. Depending upon the size and type of loading, towers are grouped into two heads. a) Towers with large vertical loads (b) Towers with mainly horizontal wind loads. Towers with large vertical loads (such as those of overhead water tanks, oil tanks, meteorological instrumentation towers etc.) have their sides made up of vertical or inclined trusses. The towers, falling under the second category and subjected predominantly to wind loads, may be of two types:

i. Self-supporting tower

ii. Guyed Tower

i. Self-supporting tower

Free standing towers, known as lattice towers, are generally square in plan and are supported by four legs, fixed to the base. These towers act as vertical cantilever trusses, subjected to wind or seismic loads.

ii. Guyed tower

In contrast to this, guyed towers are hinged to the base, and are supported by guy wires attached to it at various levels, to transmit the wind forces to the ground.

1.1.1 Tower configurations and bracings

The self-supporting towers, subjected predominantly to wind loads, are called lattice towers. Such towers are square or rectangular in plan. Following are the different types of bracings:-

a) Single web horizontal bracings: This is the simplest form of bracing. The wind shear at any level is shared by the single diagonal of the panel. Such bracings are used for towers up to 30 m height.

b) Warren type bracings: This is a double diagonal system without horizontal bracings and used for towers up to 50 m height.

c) Single web diagonal bracings: Struts are designed in compression and diagonals in tension.

d) Diamond type bracings: Similar to warren system. Horizontal member carries no primary loads designed as redundant supports.

1.2 METHODOLOGY

Based on the objectives of present work following methodology has been set.

1. Static Analysis – Dead Load or Self-Weight and live load.
2. Dynamic Analysis – Seismic Analysis, wind analysis.
3. Modelling is carried out.
4. IS 875 Part III- 1987- Code of practice for design loads (Other than earthquake) for buildings and other structure.
5. IS 802 (Part 1)-1995 section I - Use of Structural steel in Overhead transmission line towers- Code of Practice.
6. IS 1893 (Part 1) – 2016 – Criteria For Earthquake Resistant Design Of Structures, Part 1: General Provisions and Buildings
7. IS 1893 (Part 4) – 2005 – Criteria for Earthquake Resistant Design of Structures, Part 4: Industries Structures.

1.3 ANALYSIS OF TOWER

In tower design is based primarily on dead load, wind load, sag tension, broken wire condition, temperature effects, safety criteria, load acting on conductor, insulator, ground wire and in addition wind load acting on tower as per IS 875-2016.

A. Problem for Research:-

The following parameters for transmission line and its components are assumed from I.S. 802: Part 1: Sec: 1:1995, I.S. 5613: Part 2: Sec: 1:1989.

- Transmission Line Voltage : 220 kV (A/C)
- No. of Circuits : Double Circuit
- Right of Way (recommended): 35, 000 mm
- Tower Configuration : Vertical Conductor
- Angle of Line Deviation : 0 to 2 degrees
- Bracing Pattern : Four types
- Terrain Type : Plain
- Cross Arm : Pointed

B. Geometry of Tower

i. Height of Tower Structure

$H = h_1 + h_2 + h_3 + h_4$

$= 31.61$ m

ii. Base width of tower:

As per IS 802 (part 1 / section 1) 1995, base width of tower is to be taken as 1/5 th to 1/10th of total height.

Base width of tower = 1/6 X Total height of tower

= 5.3 m

C. Loads on Tower

a. Dead Load on Tower

1. Self-weight of tower taken by STAAD PRO itself.
2. Dead load on conductor = 8.579 kN
3. Dead load on ground wire =3.47 kN

b. Wind Load on Tower

Wind load is major load acting on tower. A wind load on tower is calculated separately by following Indian Standards. For finding the drag coefficients for members of tower, the solidity ratio is taken from Table 30 in IS 875 (part 3) -2016 in the similar way prescribed in IS 826 (part 1/section 1).

$$\mathbf{F_{wc} = P_d \times C_{dc} \times L \times D \times G_C}$$

Where, F_{wc} = wind load on conductor

P_d = design wind pressure

C_{dc} = drag coefficient for ground wire

L = wind span

d = diameter of conductor/ground wire

G_c = gust response.

Following data is to be taken from IS: 802 (Part 1/section 1):1995

Wind zone = 3

Basic wind speed(V_B) =44 (m/s)

Design period =150 years

Reliability level = 2

Risk coefficient (k_1) =1.11

Terrain category = 2

Terrain coefficient = 1.00

Reference wind speed = $V_R = V_b/k_0$

= 32 m/s

Design wind speed (V_d) = V_R x k_1 x k_2

= 35.52 m/s

Design wind pressure (P_d) = 0.6 $V_d{}^2$

= 757 N/m^2

1. Wind load on conductor: -

$$F_{wc} = P_d \times C_{dc} \times L \times D \times G_C$$

= 9.3 kN

Where, F_{wc} = wind load on conductor

P_d = design wind pressure

C_{dc} = drag coefficient for ground wire=1.2

Drag coefficient for conductor = 1.0

L = wind span = 175 m

d = diameter of conductor/ground wire = 28.62mm

G_c = gust response. = 2.34

2. Wind load on ground wire:

$$F_{wg} = P_d \times C_{dc} \times L \times D \times G_C$$

= 3.52 kN

Where, F_{wg} = wind load on ground wire
P_d = design wind pressure
C_{dc} = drag coefficient for ground wire=1.2
Drag coefficient for conductor = 1.2
L = wind span = 175 m
d = diameter of ground wire = 9.45x10^{-3} m
G_c = gust response = 2.3

3. Wind load on insulator string:

$$F_{wi} = P_d \times C_{di} \times A_i \times G_i -$$

= 0.04 kN

Where, F_{wi} = wind load on insulator string

P_d = design wind pressure
C_{di} = drag coefficient for insulator string =1.2
A_i = 50 % of the area of insulator string projected on a plane which is parallel to longitudinal axis of the string.
Gi = gust response = 2.4

c. Calculation of Sag Tension

Indian standard codes of practice for use of structural steel in over-head transmission line towers have prescribed following conditions for the sag tension calculations for the conductor and the ground wire:

1. Maximum temperature (75°C for ASCR and 53°C for ground wire) with design wind pressure (0% and 36%).

2. Every day temperature (32°C) and design wind pressure (100%, 75% and 0%).

3. Minimum temperature (0°C) with design wind pressure (0% and 36%).

In this paper, the consideration of the sag of ground wire as 90% the sag of the conductor at 0°C and 100% wind condition.

Sagging = $wl^2/8T_2 = 0.973\ x\ 320\ x 320/8\ x\ 2282.5$

= 5.46 m

By increasing 4% of calculated sag we get

= 5.46 × 4%

= 5.70 m.

As per IS 5613 (part 2), section 1:1989

For both conductor and ground wire, all tension values are given FOS < 4 .So consider the minimum tension (tension for FOS = 4).To finding maximum sagging in all condition, parabolic equation used.

d. Broken Wire Condition

As per IS 802 (part 2/section 1) 1995 clause 12.3.3, for self-supporting transmission line tower, longitudinal load per sub conductor and ground wire shall be considered as 10 kN and 5 kN respectively.

e. Temperature Effects

As per IS 802 (Part 1/section 1) 1995 clause 10.24, the tower may be designed to suit the conductor temperature of 750 C (max) for ACSR conductor.

Safety Criteria

As per CBIP manual for transmission line tower, safety criteria are to be considered for the calculation of safety criteria separate excel sheet is prepared to avoid repetitive calculations.

2. DESIGN OF TOWER

Design of tower is carried out in STAAD Pro.V8i software. Loads on tower are calculated manually as per IS 802:1995 & CBIP manual.

3. MODELLING APPROACH

Transmission tower is modelled using STAAD Pro.V8i. Tower with different type of bracing system are modelled. Tower configuration for each viz. base width, height length etc. is same.

4. CONCLUSION

The conclusions are drawn from previous literature papers for transmission tower by using four different types of bracing viz. diamond bracing, single web horizontal bracing, single web diagonal bracing and warren bracing on the basis of the researches and analysis done through the STAAD Pro V8i.

REFERENCES

[1] Gopiram Addala, D.Neelima Satyam and Ramancharla Pradeep Kumar, "Dynamic Analysis of Transmission Towers under Strong Ground Motion", 3rd International Earthquake Symposium, Bangladesh, Dhaka, March 5-6 2010.

[2] Yoganantham.C and Helen Santhi.M, "Dynamic Analysis of Transmission Towers", International Journal of Advanced Information Science and Technology, Vol.2, No.12, December 2013.

[3] C.Preeti and K.Jagam Mohan, "Analysis of Transmission Tower with Different Configuration", Jordan Journal of Civil Engineering, Vol. 7, No. 4, 2013.

[4] C.Sudheer, K.Rajashekar, P.P.Reddy, Y. Bhargava Gopi Krishna, "Analysis and Design of 220kV Transmission Line Tower in Different Zones I & V with Different Base Widths – A Comparative Study", International Journal of Technology Enhancements and Emerging Engineering Research, Vol. 1, Issue 4, 2013.

[5] Lingampally Srikanth and Dr.D Neelima Satyam, "Dynamic Analysis of Transmission Line Towers", International Conference on Civil Engineering and Applied Mechanics (ICCEAM) 2014, Paris, France.

[6] Mujamil, Banulatha.G.N., Dr.Narayana.G., Rajeeva S.J., "Dynamic Analysis of Transmission Line Towers for Different Sectional Properties with Fluid Viscous Dampers", International Journal of Advanced Research in Education Technology, Vol.2, Issue No.12, April – June 2015.

[7] IS 875 Part III- 1987- Code of practice for design loads (other than earthquake) for buildings and other structure.

[8] IS 802 (Part 1)-1995 section I - Use of Structural steel in Overhead transmission line towers- Code of Practice.

[9] IS 1893 (Part 1) – 2016 – Criteria For Earthquake Resistant Design Of Structures, Part 1: General Provisions and Buildings

[10] IS 1893 (Part 4) – 2005 – Criteria for Earthquake Resistant Design of Structures, Part 4: Industries Structures.