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COMPARATIVE STUDY ON TRANSMISSION LINE TOWER CONSIDERING DIFFERENT BASE WIDTH RATIOS AND MATERIALS

Nirav M. Kyada[1], Prof.K.J.Dhandha[2]

1Civil Engineering Department Darshan Institute of Engineering and Technology, Rajkot.

2 Engineering Department Darshan Institute of Engineering and Technology, Rajkot.

***Abstract*— In this study, transmission line towers are compared for the best economic combination and minimization of their weight according to their base widths, base extension and material used for designing of the transmission line tower truss members that is either mild steel or high tensile steel and also combination of both and finalizing a base width ratio which governs to minimum weight and therefore minimum cost.**

First of all, tower base width ratio is fixed to 1:1 and weight of tower and cost is figured out. Then longitudinal face is reduced with respect to fixed transverse face. And several models are compared with different base width, materials and combination of materials.

***Keywords*— Transmission line tower, self supported tower, suspension tower, tension tower**

I. INTRODUCTION

Electrical energy is the simplest form of energy. This electrical energy needs to be transmitted in very economic way so it can be affordable and useful for farthest areas from power plants.

The technical, environmental and economic considerations involved development of power generation projects. Which results in longer transmission distances? And introduction of higher transmission voltage and use of high voltage direct current transmission systems. In India, 66kV, 132 kV-120kV-110 kV, 230 kV-220 kV-210kV, and 400 kV A.C. systems are already in service and up to 800 kV A.C. systems are introduced nowadays.

With the increase in transmission voltage levels, the dimensions heights as well as weights of towers have also increased and so has their cost. The transmission line towers constitute about 30 to 44 percent of the cost of transmission line. Therefore minimum weight of towers for same voltage can bring about significant economy in the cost of transmission lines.

Transmission line towers broadly classified as following as per designation.

Suspension Tower

Suspension towers are used for straight run or for small angle of deviation up to 2° or 5°. Conductor on suspension towers may be supported by means of I-string, V-string, or a combination of both I&V Strings.

Tension Tower

Tension towers also known as angle towers are used at locations where the angle of deviation exceeds that permissible on suspension towers and also at places where towers are subject to uplift loads. These towers are further classified as 2°/5° to 15°, 15° to 30°, 30° to 60°. One of the classes of angle towers depending on the site conditions is also called as Section Tower. The section tower is introduced in the line after about 10 km to avoid cascade failure.

II. OBJECTIVE OF STUDY

One of the objectives of this study is focuses on weight of tower. The weight of tower required for transmission line tower is influenced to a great extent by the selection of tower configuration, choice of structural Steel for tower, type of tower, types of connections etc.

To design tower conforming to the governing specifications and bring about optimum reduction in tower weight without sacrificing stability and reliability features.

To study parametric effect on the loading of transmission tower and design a transmission line tower in accordance with IS:875 (part-3), IS:802(part 1/sec 1,2), IS:802(part 2/sec 1,2), IS:800-2007. Also to generate models with varying base width ratio and material.

III. TOWER LOADINGS

After the geometry and topography of the tower are finalized the design loads for structure are to be determined. Tower loading is most important part of tower design as it concerns with its stability. Any mistake or poor judgement in the load assessment will make the tower design erroneous. Various types of loads are to be calculated accurately depending on the design parameters. In the load calculation the wind plays a vital role. The correct calculation of wind load will lead to proper load assessment and reliable design of tower structure.

Transverse loads: These loads are acting perpendicular to the transmission line i.e. in the transverse direction.

Transverse load are considered based on following:

- Wind acting on tower structure, conductor and ground wire and insulator string.
- Component of mechanical tension of conductor and Ground wire.

Vertical loads: These vertical loads are considered on the following scenario.

Load due to weight of each conductor, ground wire based on appropriate weight span, weight of insulator strings and fittings.

- Due to self-weight of structure.
- Vertical load during construction and maintenance

Longitudinal loads: These are horizontal loads in longitudinal direction due to mechanical tension of conductors and Ground cables during broken wire condition and unbalanced tension due to unequal span.

Permanent Loads: These loads act constantly on the tower during the life of transmission line. Weights of cables, insulators, component due to mechanical tension of cables are considered as permanent loads.

Random loads: These loads are imposed on tower due to action of wind on transmission line and do not act continuously. These loads act in addition to permanent loads on tower.

Construction and maintenance loads: These loads are acting on tower during construction and maintenance of transmission line. These loads act in addition to permanent loads on tower.

Requirements of loads on transmission lines.

- Climatic loads related to reliability requirements
- Failure containment loads related to security requirements.
- Construction and maintenance loads related to safety requirements.

IV. DESIGN PARAMETERS

→ Design span: 400.00 m

→ Wind spans NC: 400.00 m

→ Wind Spans BWC: 240.00 m

→ Weight-Spans- NC- max:600.00 m min: 200.00 m

→ Weight-Spans-BWC-max:360.00 m min:100.00 m

- **Wind Pressure Details:**

→ Basic Wind Speed for Zone- III: 44.00 m/sec.

→ Reliability Level : 2

→ Terrain Category: 1

→ Drag co-efficient for the conductor: 1.0

→ Drag co-efficient for the ground wire: 1.2

→ Drag co-efficient of the insulators: 1.2

V. MODELLING AND ANALYSIS

Over here, 400 kV Multi Circuit Self Supported Suspension And Tension Towers has been analyzed in Staad-pro software.

Double Web Bracing system and Warren bracing System is used below cross arm of tower body and can be economically adopted throughout the cage and body of suspension and small angle towers and also in wide base large towers. This system consists of diagonal cross-bracings. Shear is equally distributed between the two diagonals with one in compression and the one in tension.

Multiple bracing system is adopted in the tower body from bottom cross arm to peak since the magnitude of torsional loads of higher magnitude acts there, the cage width is kept large to withstand the torsional loads.

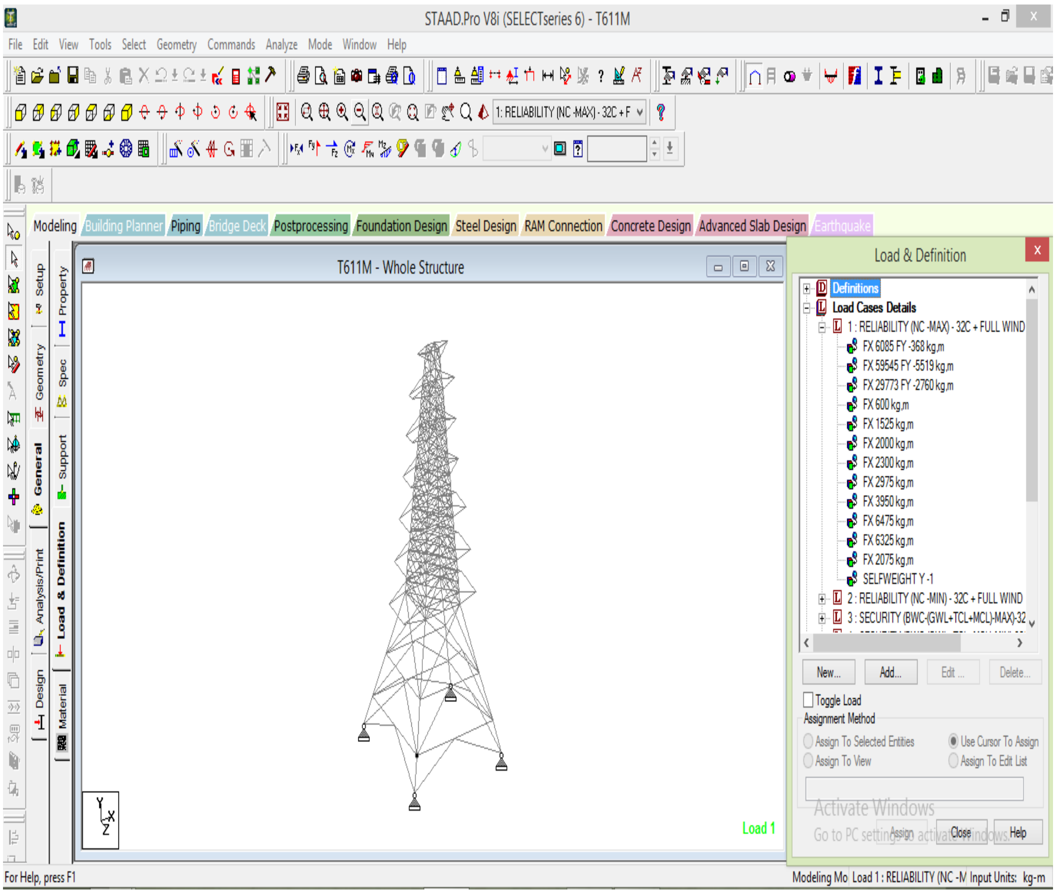

Fig.1 Geometry of 400 KV Suspension tower

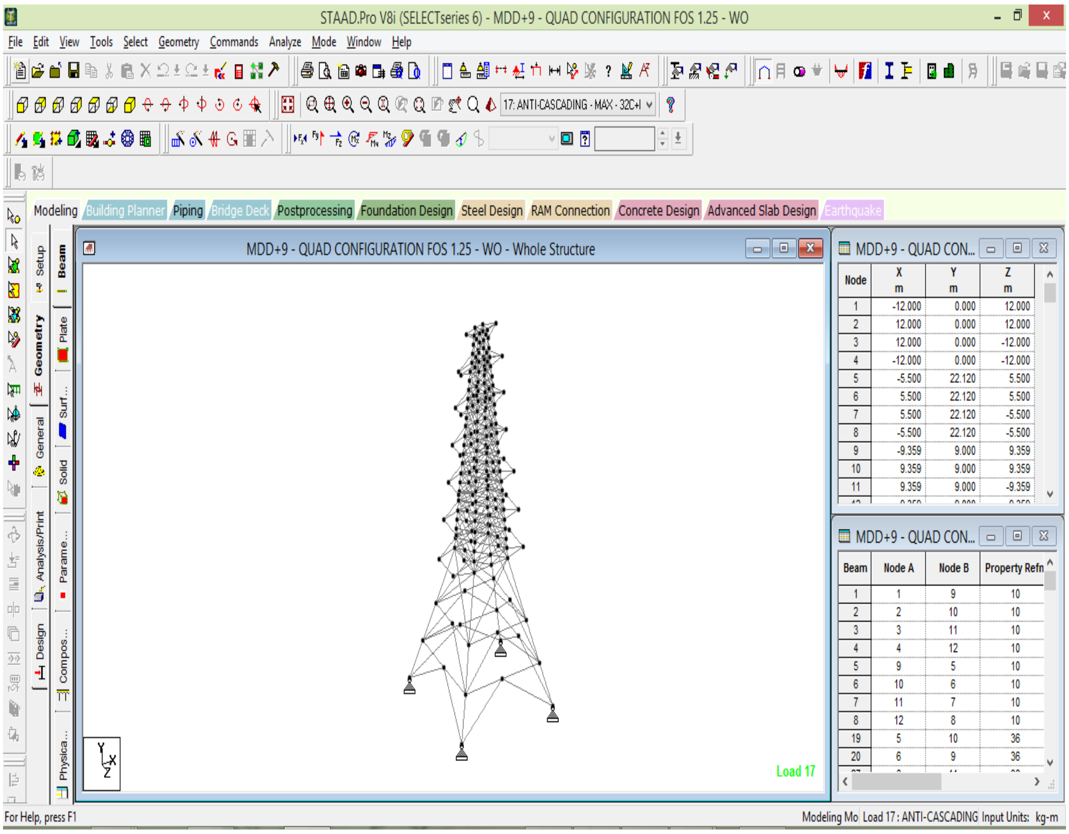

Fig.2 Defining Panel Points

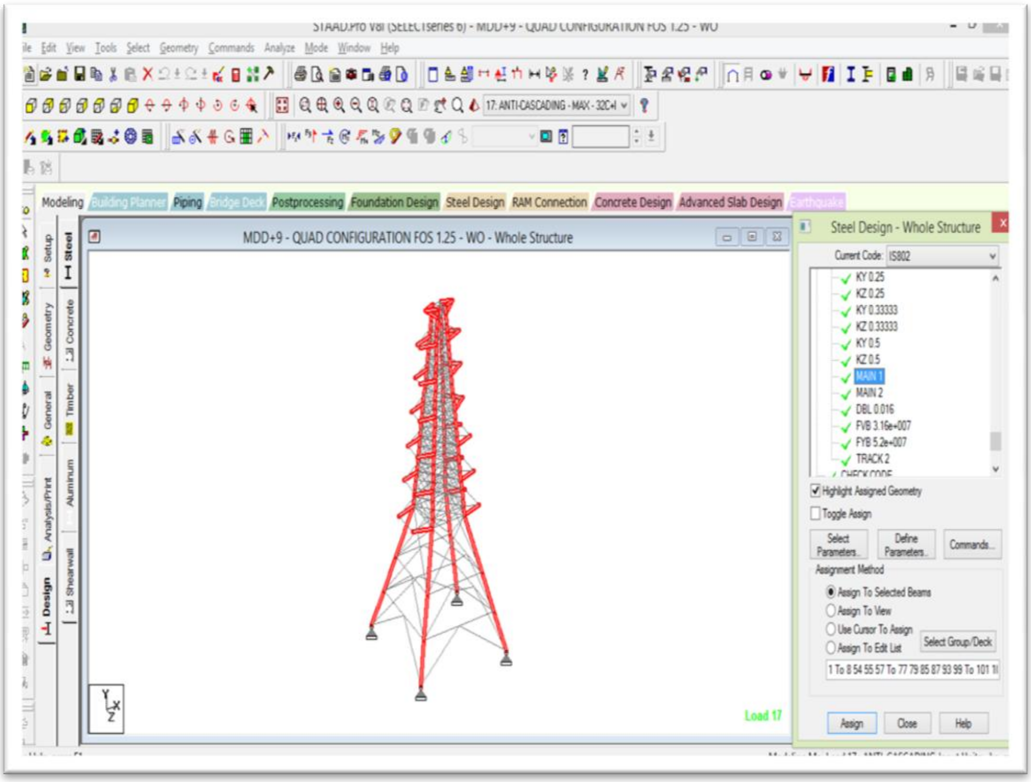

Fig.3 Application Of Loads

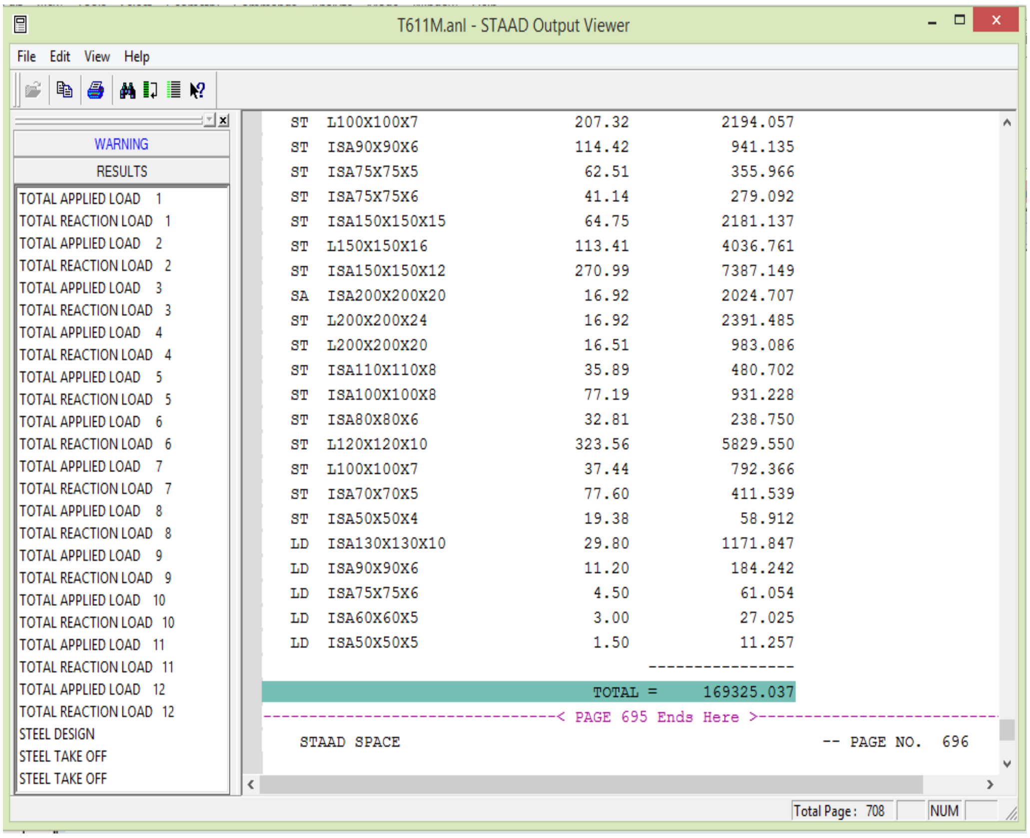

Fig.4 Total weight calculation.

VI. RESULT AND DISCUSSION

→ The graphical representation of different base to width ratios are discussed below.

(A) Graphical presentation of comparison of Suspension (With +3.0 m Body Ext.) Towers with Square and Rectangular Base :

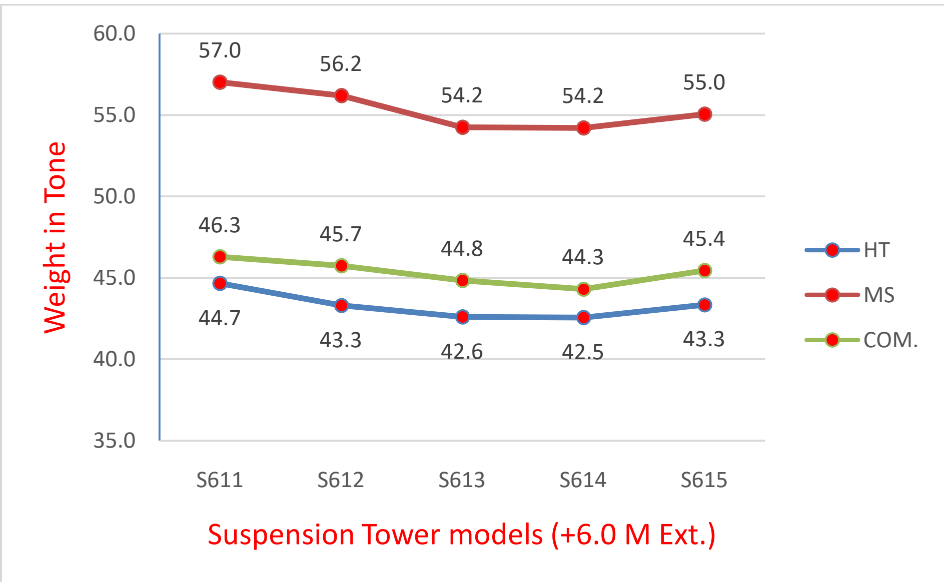

Fig.5 Comparison between Suspension Tower Models (+6.0 M Body Ext.) of Square and Rectangular Base

→ **Table 1 Width and Weight of Suspension Tower Models (+6.0 M Body Ext.)**

MODEL	RATIO	WIDTH (m)		WEIGHT (T)		
	LF : TF	TF	LF	HT	MS	COM.
S611	1 : 1	18.09	18.09	44.7	57.0	46.3
S612	1:1.1	18.09	16.44	43.3	56.2	45.7
S613	1:1.2	18.09	15.07	42.6	54.2	44.8
S614	1:1.3	18.09	13.91	42.5	54.2	44.3
S615	1:1.4	18.09	12.92	43.3	55.0	45.4

When the width in longitudinal face decrease, there is reduction in weight of members. but further decreasing width of longitudinal face 1.3 times lesser than transverse face there will be increase in weight due to increase in member size to overcome the effect of overturning moment generated by wind and broken cable condition**.**

(B) Graphical presentation of comparison of Tension (With +6.0 m Body Ext.) Towers with Square and Rectangular Base :

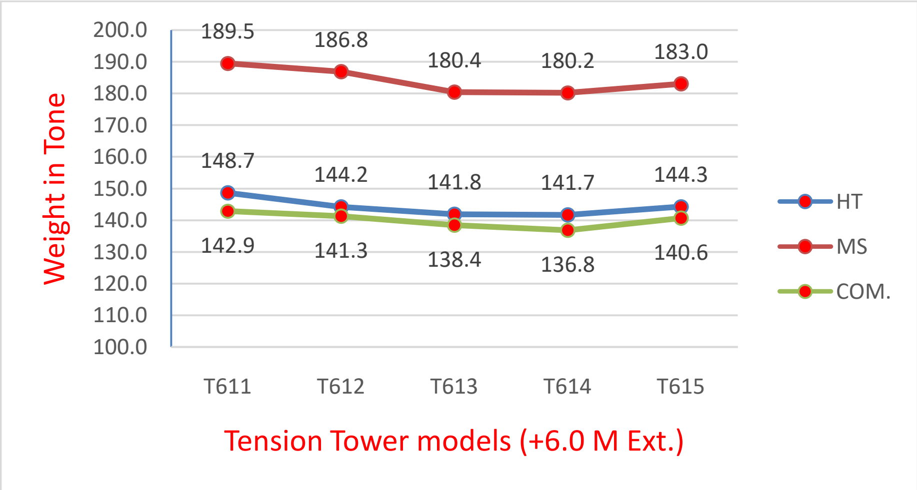

Fig.6 Comparison between Tension Tower Models (+6.0 M Body Ext.) of Square and Rectangular Base

→ **Table 2 Width and Weight of Tension Tower Models (+6.0 M Body Ext.)**

MODEL	RATIO	WIDTH (m)		WEIGHT (T)		
	LF : TF	TF	LF	HT	MS	COM.
T611	1 : 1	27.50	27.50	148.7	189.5	157.0
T612	1:1.1	27.50	25.00	144.2	186.8	155.2
T613	1:1.2	27.50	22.92	141.8	180.4	152.2
T614	1:1.3	27.50	21.15	141.7	180.2	150.5
T615	1:1.4	27.50	19.64	144.3	183.0	154.2

Also in this case suspension tower is 3 to 4 times lighter than tension towers, while using combination of mild steel and high tensile steel at the base width ratio of longitudinal face to transverse face between 1:1.2 to 1:1.3 minimum cost can be achieved.

VII. CONCLUSION

→ Tension Towers are 2.5 to 3.5 times heavier than Suspension Towers because of high tensile force generated due to deviation of electric line.

→ Minimum Weight is achieved when Base width ratio of Longitudinal Face: Transverse Face is Between 1:1.2 to 1:1.3. (in any case of HT, MS and Combination of HT & MS)

→ Optimum Weight can be obtained by using HT at Base width ratio, Between 1:1.2 to 1:1.3…But minimum Cost can be achieved in case of Combination of MS & HT at this base width ratio when HT steel used in Legs and cross arm and bracings are made of MS.

→ Cost of Towers made of mild steel are around 14 to 20 % higher than towers made of high tensile steel and cost of tower made of combination of high tensile and mild steel are around 12 to 14 % lesser than Mild Steel.

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