Analysis and Design of High Tension Pole System and Comparison with Tower System

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Abstract— The project work is deal with the introduction on the transmission tower and poles and specific objective of the project are presented in it. Studies of different research papers and journals on modeling and analysis of transmission tower and poles. Mathematical modeling of tower and poles with varying configuration and optimization will carried out. Analysis of tower and poles using STAAD -pro software. Gives the comparison between different configurations. Conclusion made from the whole analytical study and future scope of the project.

Key words: Analysis and Design of Tower and Poles, STAAD-Pro software, Comparision between Tower and Pole

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. Also, the disposition of the primary resources for electrical power generation viz., coal, hydro potential, is quite uneven, thus, again adding to the transmission requirements. Transmission line is an integrated system consisting of conductor subsystem, ground wire subsystem and one subsystem for each category of 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 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. The cost of towers constitutes about quarter to half of the cost of transmission line and hence optimum tower design will bring in substantial savings. The selection of an optimum outline together with right type of bracing system contributes to a large extent in developing an economical design of transmission line tower. The height of tower is fixed by the user and the structural designer has the task of designing the general configuration, and member and joint details. The goal of every designer is to design the best (optimum) systems. But, because of the practical restrictions this has been achieved through intuition, experience and repeated trials, a process that has worked well. In the United Kingdom, much of the rural electricity distribution system is carried on wooden poles. These normally carry electricity at 11 or 33 kV (three phases) from 132 kV substations supplied from pylons to distribution substations or pole-mounted transformers. Today, utility poles may hold much more than the uninsulated copper wire that they originally supported. Steel utility poles are becoming more prevalent in the United States thanks to improvements in engineering and corrosion prevention coupled with lowered production costs. However, premature failure due to corrosion is a concern when compared to wood

II. Methedology

In this study Modelling of Transmission line tower with Pole System geometry having three different pole dia. of 2 m, 2.5 m, 3 m is carried out and also the Analysis of Transmission line towers in STAAD PRO v8i. The objective of this research is met by choosing a 132 KV Single Circuit Transmission Line Tower and pole , carrying Square Base Using STAAD Pro, analysis of each of these four towers has been carried out as a three dimensional structure. The tower members are then designed. A comparative study is then carried out to get optimized pole dimensions such as diameter and thickness. The cost effective comparison is made between optimized poles with tower with angles. This exercise consists of those solved parameters which are going to remain same for the complete transmission line that is for all towers and poles.

This exercise is detailed in the following steps:

a) Transmission Line Components
b) Sag Tension for Conductor and Ground Wire
c) Configuration of Towers
d) Loading Calculations for the Transmission Line.

A. *Transmission Line Components:*

As per the guidelines of PGCIL, 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 and CBIP Manual No. “268”:

B. *Sag Tension for Conductor and Ground Wire:*

Sag tensions are calculated by using the parabolic equations as discussed in the I.S. 5613: Part 2: Sec: 1: 1989 by developing integrated program on Microsoft Excel for both the conductor and ground wire.

C. *Configuration of Towers:*

Configurations of all three towers are done by first fixing the outline of all the towers as per the Indian standard requirements. This is achieved using excel program with auto cad drawings.

For the configuration of towers, PGCIL guidelines have been considered as follows:

1) The base width of Triangular Tower is restricted as (4/3) * Base width of Square Tower and Guyed Mast as simply 1000 mm.
2) The width at the hamper level for both the Square Tower and the Triangular. Tower is reduced to (1/3) of the base width but the width of the Guyed Mast is kept constant thought the height of the tower.
3) The members for all the towers are so chosen that the effective length is kept between 1200 mm to 1500 mm.
4) The bracing angle for all the towers is kept in between 400 to 500.

5) The minimum factor of safety is kept as 1.1 for the design of angle Members.

D. Loading Calculations for Transmission Line:

Loading combinations on the ground wire, conductor and all the towers are found using Indian standards.

In present Indian Standards, the security conditions for suspension towers correspond to nil wind condition whereas for tension towers this requirement is stipulated for 100% full wind condition. But, with the operational experience of towers designed on this basis the power utilities (PGCIL) have initiated amendment through BIS stipulating security conditions of suspension and tension tower corresponding to 75% of full wind load at every day temperature. Tower being a space truss, loadings are synchronized as the point loadings at the tip of peak and at the three tips of the cross arms. These are shown in the form of Load Tree (Fig. 7) with the aid of AutoCAD. This Load tree consists of:

1) Reliability Condition – Normal Condition
2) Security Condition – Normal Condition
   Ground Wire Broken Condition
   Top Conductor Broken Condition
   Bottom Left Conductor Broken Condition
   Bottom Right Conductor Broken Condition
3) Safety Condition - Normal Condition
   Ground Wire Broken Condition
   Top Conductor Broken Condition
   Bottom Left Conductor Broken Condition
   Bottom Right Conductor Broken Condition.

III. RESULTS & DISCUSSION

In this study Modelling of Transmission line tower with Pole System geometry having three different pole dia of 2m,2.5m, 3m is carried out and also the Analysis of Transmission line towers in STAAD PRO v8i.

A. Absolute Displacement

Type of section	Absolute displacement (mm)
MS angles	23.656
MS Tube 2.0m Dia	101.932
MS Tube 2.5m Dia	56.005
MS Tube 3.0m Dia	39.544

The absolute displacement is less in MS angle tower and more in Ms Tube tower of 2.0m base dia.

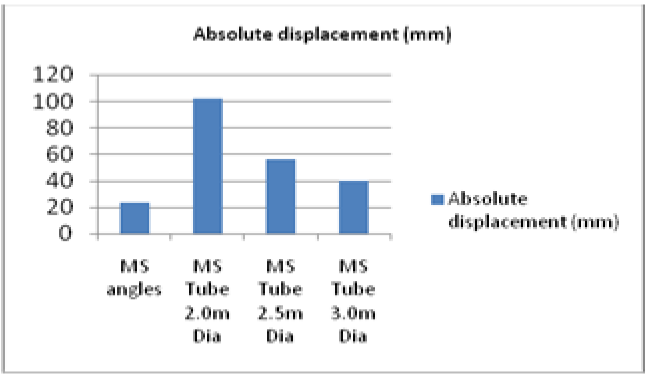


Fig. 1: Absolute displacement in mm

B. Support reactions

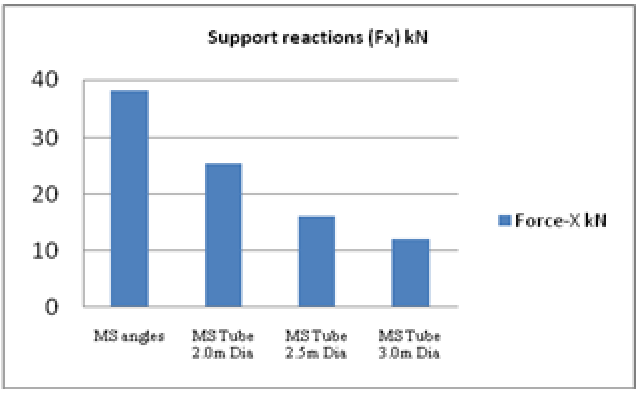
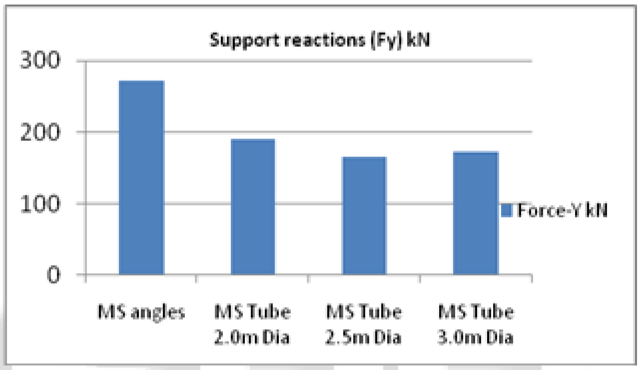


Fig. 2: Support reaction Fx in kN

The max support reactions Fx is more in MS angle tower and decrease in Ms Tube tower of 2.0m base dia. To 3.0 m dia.



The max support reactions Fy is more in MS angle tower and decrease in Ms Tube tower of 2.0m base dia. To 3.0 m dia.

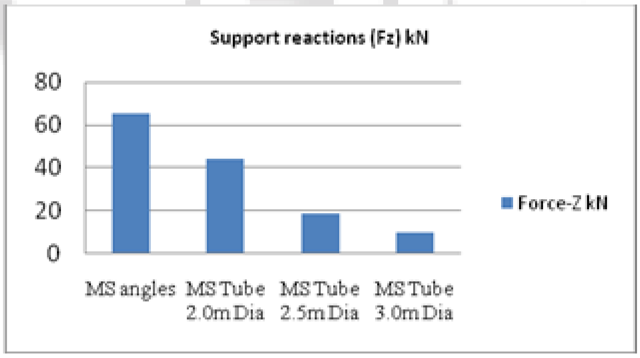


Fig. 4: Support reaction Fz in kN

The max support reactions Fz is more in MS angle tower and decrease in Ms Tube tower of 2.0m base dia. To 3.0 m dia.

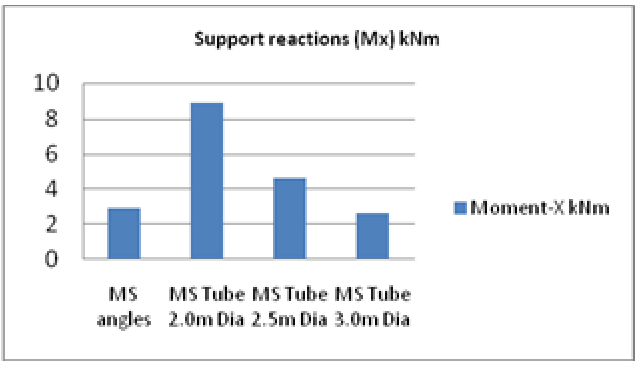


Fig. 5: Support reaction Mx in kNm

The max support reactions (Mx) is more in MS Tube tower of 2.0m base dia. and least in MS angle tower.

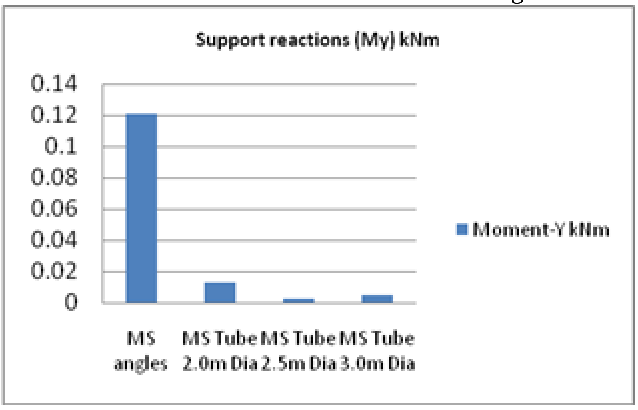


Fig. 6: Support reaction My in kNm

The max support reactions (My,) is more in MS angle tower of 2.0m base dia .and least in MS Tube tower of 2.5m

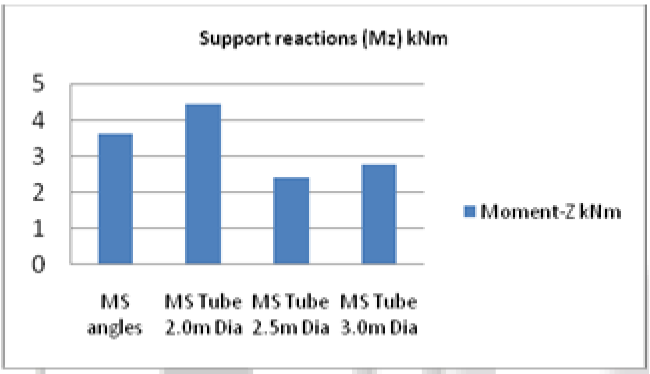


Fig. 7: Support reaction Mz in kNm

The max support reactions (Mz,) is more in MS angle tower of 2.0m base dia. and least in MS Tube tower of 2.5m.

C. Member/Plate stresses

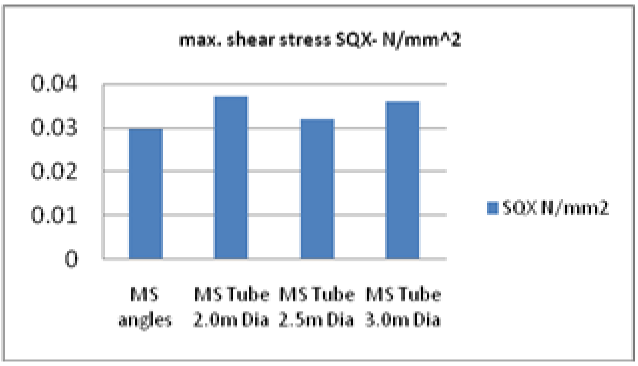


Fig. 8: Max. shear stress SQx in N/mm²

The max Shear stress SQx is more in MS Tube tower of 2.0m base dia. and least in MS angle tower.

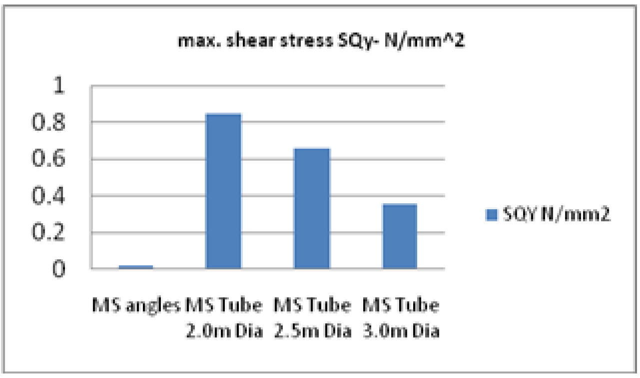


Fig. 9: Max. shear stress SQy in N/mm²

The max Shear stress SQy is more in MS Tube tower of 2.0m base dia. and least in MS angle tower.

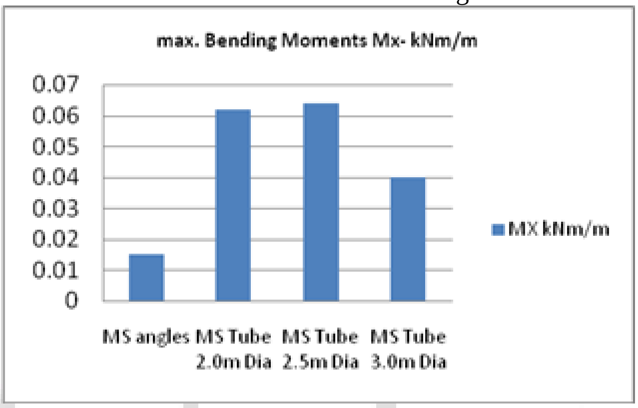


Fig. 10: Max.bending moment Mx in kNm/m

The max Bending moment Mx is more in MS Tube tower of 2.5m base dia. and least in MS angle tower.

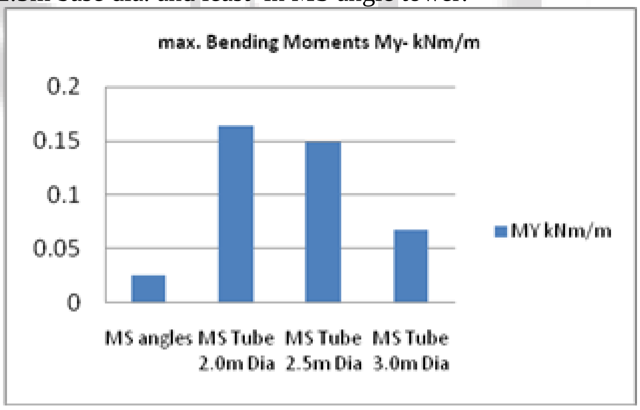


Fig. 11: Max. bending moment My in kNm/m

The max Bending moment My is more in MS Tube tower of 2.5m base dia. and least in MS angle tower.

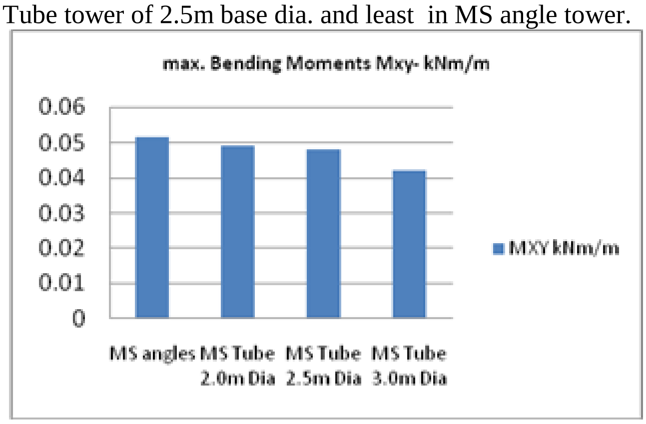


Fig. 12: Max. bending moment Mxy in kNm/m

The max Bending moment Mxy is more in MS MS angle tower. base dia. and least in MS Tube tower of 2.5m base dia.

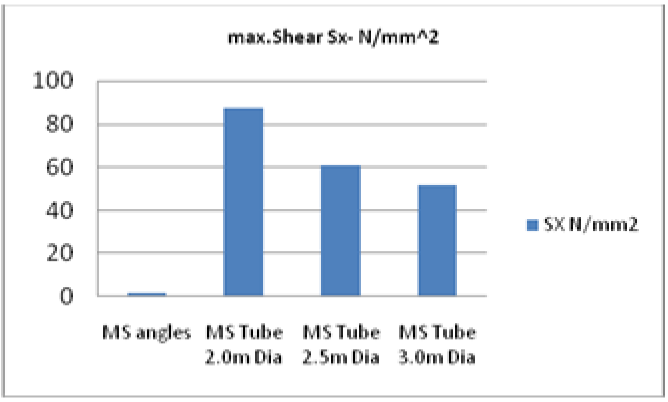


Fig. 13: Max. shear stress Sx in N/mm

The max Shear stress Sx is more in MS Tube tower of 2.0m base dia. and least in MS angle tower.

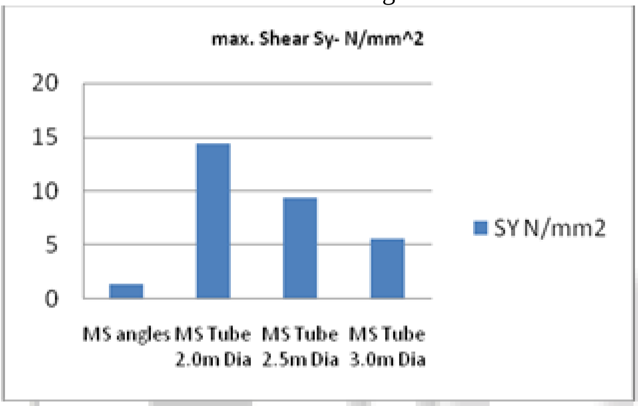


Fig. 14: Max. shear stress Sy in N/mm²

The max Shear stress Sy is more in MS Tube tower of 2.0m base dia. and least in MS angle tower.

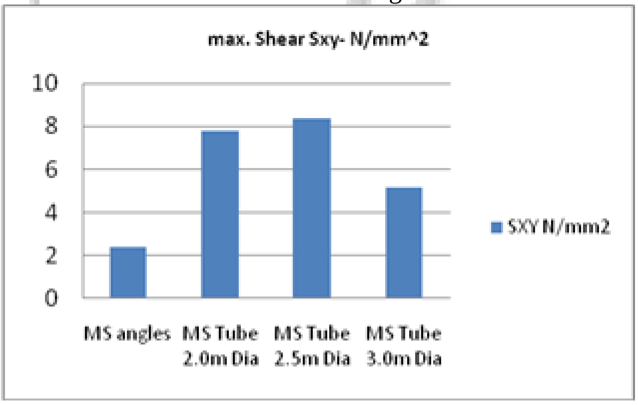


Fig. 15: Max. shear stress Sxy in N/mm²

The max Shear stress Sxy is more in MS Tube tower of 2.5m base dia and least in MS angle tower.

IV. MAXIMUM PRINCIPAL STRESSES

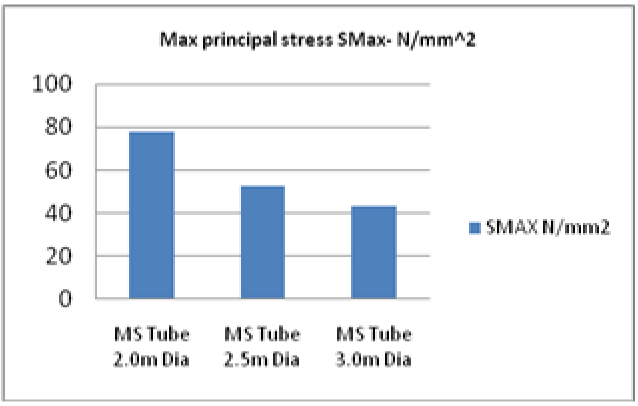


Fig. 16: Max. principal stress Smax in N/mm²

The Major Principal stresses Smax is more in MS Tube tower of 2.0m base dia. and Decreases as base dia increases.

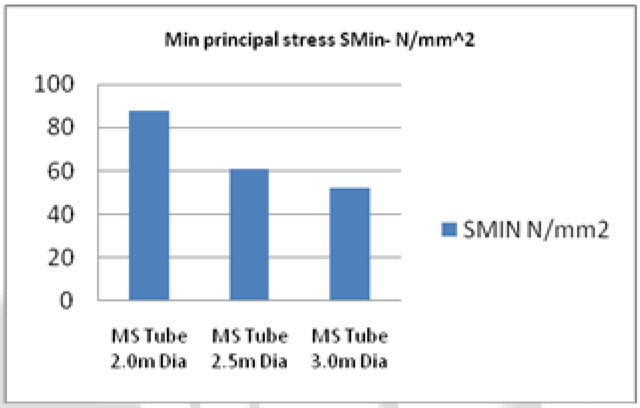


Fig. 17: Min.principal stress Smin in N/mm²

The Minor Principal stresses Smin is more in MS Tube tower of 2.0m base dia. and Decreases as base dia increases

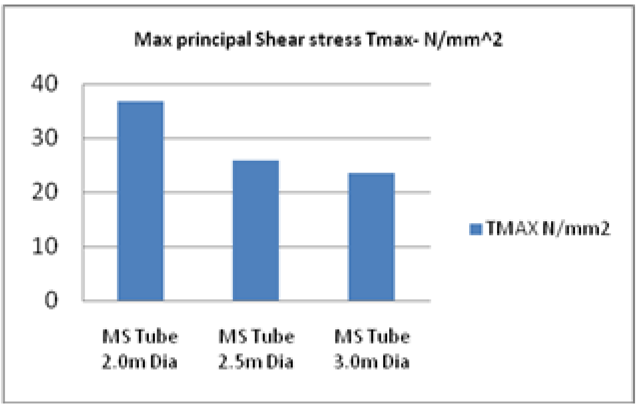
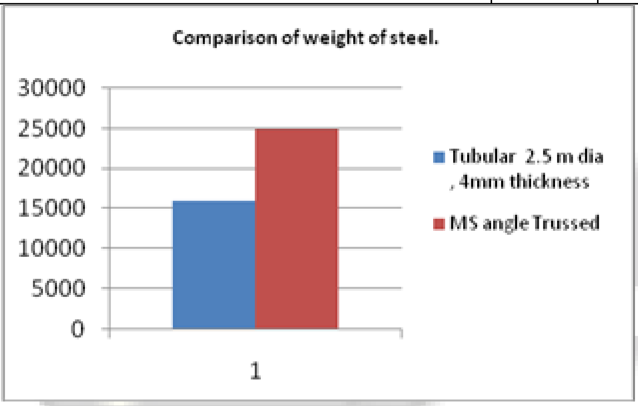


Fig. 18: Max. principal stress Tmax in N/mm²

The Major shear stresses Tmax is more in MS Tube tower of 2.0m base dia. and Decreases as base dia increases.

Optimized dimensions and stresses		
dia of tube	2.5	m
Thickness of plate	4	m m
Grade of steel	fe250	
max. lateral deflection :	174.63 5	m m
Base reactions :		
Force-X kN	16.49	

Force-Y kN	161.658	
Force-Z kN	19.105	
Moment-X kNm	4.933	
Moment-Y kNm	0.001	
Moment-Z kNm	2.573	
Principal stresses		
SMAX N/mm2	107.625	
SMIN N/mm2	118.708	
TMAX N/mm2	50.049	
Angle (deg)	89.99	
Comparison of weight of steel weight of steel : kN	156.585	
Tubular 2.5 m dia , 4mm thickness =	15961.77	kG
MS angle Trussed	24926.18	kG
% saving in materials or pole of 2.5m dia 4mm thickness :	35.96381	%



A. Comparison of weight of steel

From the above results it is found that Pole with 2.5m dia is optimised dia for this 132 KV Single Circuit Transmission Line. The final dimensions and stresses for optimized 2.5m base dia and 4mm thick Plate thickness is as follows:

Principal stresses of optimized tubular Tower	
SMAX N/mm2	107.625< (250/1.1)
SMIN N/mm2	118.708< (250/1.1)
TMAX N/mm2	50.049< (250/1.1)
	Angle (deg) 89.99

From cost comparison the weight of steel requirement in MS angle tower is nearly 36% more than that required for MS Tube tower of 2.5m base dia and 4mm thick MS plates.

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