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"Design and Analysis of High Mast Solar Light Pole for Two Cross Sections"

Ms. Dipali. C. Bhoyar
Department of Mechanical Engieering
K.D.K.C.E. Nagpur, India

Dr. A.V. Vanalkar
Professor
Department of Mechanical Engieering
K.D.K.C.E. Nagpur, India

Abstract

The high mast structure (HMS) has widely used around the world. High mast structure has large ratio of height and horizontal dimensions. This means that the HMS is also more wind sensitive than any other common structures. Due to its monotubular structure the wind vibrations are occurs at pole.so, this project discuss the basic theory regarding high mast structure like its specification, design .Here we calculate design wind load and design wind speed .This study compare two cross sections of high mast pole using ANSYS software for better design, which is helpful to reduced stresses at high mast.
Keywords: Fatigue, High-mast Lighting, Wind, cracks

I. Introduction

The high mast structure is widely used around the world .It has monotubular structure with large ratio of height and horizontal dimensions.

The large ratio of High mast structure posses wind vibrations. Due to wind loading fatigue cracks are found at high mast and at the gusset of pole. Stresses are a combination of natural wind gusts and vortex shedding which are occurs at pole.
The cracks formations are also due to a lack of comprehensive construction specifications.

Many of accidents caused were only due to fatigue damage of pole. Large no. of poles collapsed in the foreign countries. So we need to understand the basic available theory of high mast structure.
This paper describes the investigations that were undertaken, and design a high mast pole for hexagonal and octagonal sections.

We analyzed both structure of high mast pole using ANSYS software. We calculate wind speed, wind load for Nagpur city and used it foe analysis. This study is helpful to select best design of high mast pole which will help to increase its vibration resistant capacity.

As the project is being done in collaboration with SAMEER SOLAR INDUSTRY the Static Analysis is carried on High Mast solar light pole.

II. Literature review

It is a way through which we can find new ideas, concept. There are lots of literatures published before on the same task; some papers are taken into consideration from which idea of project is taken.

A. C. W. Chien and J. J. Jang (Taiwan Ocean University): [1]

This paper gives the contributions of high natural frequency components are obtained by Eigen value analysis. This study includes four parts: (1) a survey of geometric configurations and shape factors; (2) along wind and across-wind response analysis; (3) develops criteria for WRD; (wind resistance design); (4) provides case application for WRD procedures.

B. Mal Thomas and Gary Noyes-Brow (Technical consultancy): [2]

This paper describes the investigations that were undertaken, and the recommended modifications that would reduce the stress concentration in the pole mast, and hence extend the pole life. This paper gives the idea about cracks are found at gusset of pole.

C. Counsell Taplin (AASHTO-2006): [3]

In this paper Culminating in the AASHTO "Standard Specifications for Structural Supports for Highway Signs and Traffic Signals. This standard provides a tool for design of light poles and sign gantries. This research by AASHTO has been undertaken in response to the failure of numerous light poles in the USA.

D. Robert J. CONNOR- University of Minnesota: [4]

This paper reports on a long-term in-depth field experimental study on the behavior and static response of high-mast lighting structures being conducted in response to recent fatigue failures. The initial results of the study and suggested strategies for design, inspection and maintenance of these fracture critical structures are summarized.

E. Dr. S. Nawazish Mehdi (Hydrarabad): [5]

This paper reports on optimal high mast pole taking into account its specification, environmental condition for placement and economy This gives the basic and analytical development of the high mast lighting pole.

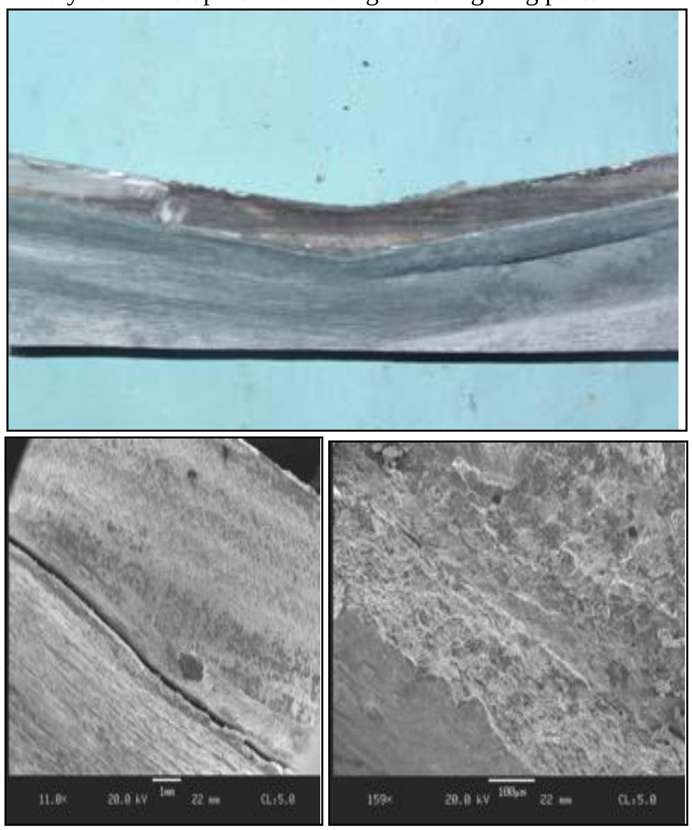

Fig. 1: Crack Surface from Failed Tower
Showing Fatigue Crack and Weld Toe Origin Region

III. OBJECTIVES

1) To discuss the main parameters required to design high mast pole including galvanizing and cold working processes.
2) To presents the frame model of high mast pole for two cross-sections with resistive capacity of wind loading, using PRO-E software.
3) To calculate design winds speed considering any city and then calculate design wind force using various coefficient factors.
4) To perform analysis on High mast solar light pole using ANSYS software for both cross sections and select best design from both.

IV. RESEARCH ELABORATION

We select some research papers and accordingly consider parameters required for structure of high mast pole.We select material for design is mild-steel due to its ductility and hardness. Using technical specification we generate two models of high mast pole, which is hexagonal and octagonal section. We identify which factors responsible for damage of high mast pole like wind vibration, wind loading etc.This study do the analysis on two models of pole and select the best design which conduct minimum stresses.

A. Technical Specifications: High Mast Structure-12 M Pole:-

Table – 1

Height of pole - 12 meter
No. of sections - one
Material construction - As per BS-EN10025
Base Diameter -108.91mm(minimum) Botto -311.77mm(minimum)
Plate Thickness - 4mm
Cross section of mast - 12 side regular continuously tapered polygonal Metal protection treatment of fabricated
Mast section - Hot dip galvanization through single dipping process
Diameter of base plate - 520 mm (minimum)
Thickness of base plate - 25 mm
Max. wind speed - As per IS:875
Number of foundation bolts - 4 no. or 6 no.(as per manufacturing design)
PCD of foundation bolts - 445 mm
Type/ diameter/ length of foundation bolts - TS 600/ 25 mm dia / 750 mm long

The above data is collected from company of Sameer Solar which is required to make a model of high mast solar light for two cross-sections.

B. Model of High Mast Pole:

3D-Model of High mast pole is generated using PRO-E-2.0 Software.

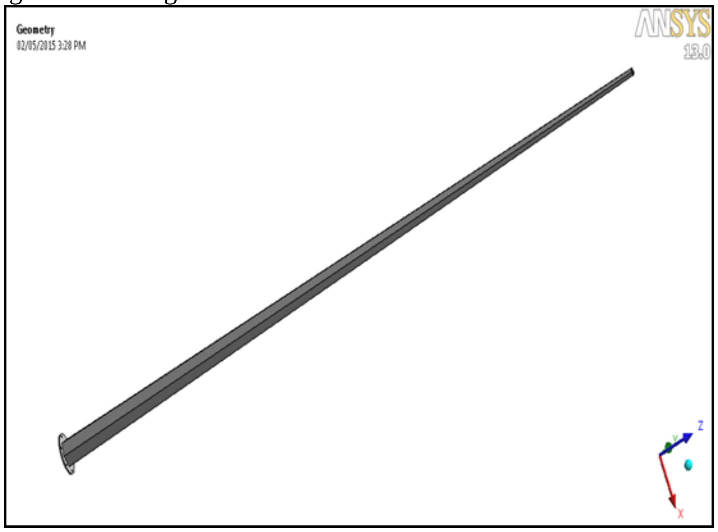

Fig. 2: Shape Factor N=6

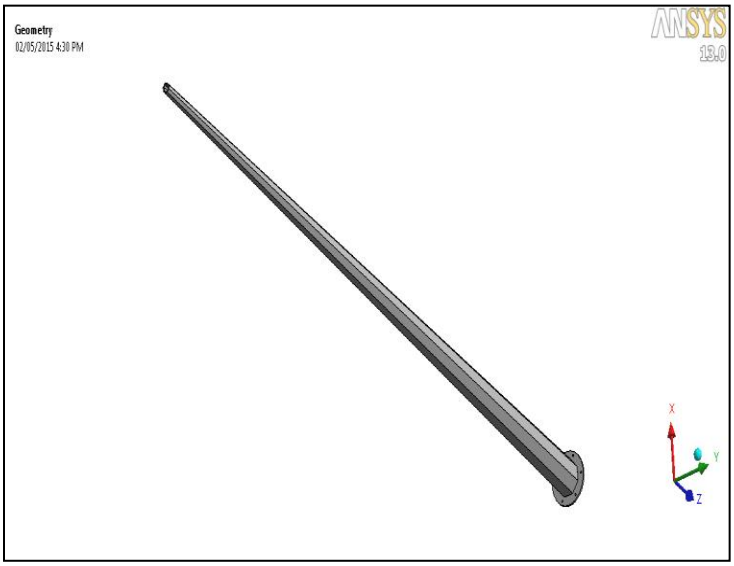

Fig. 3: Shape Factor N=8

C. Drafting Of High Mast Solar Light Pole:

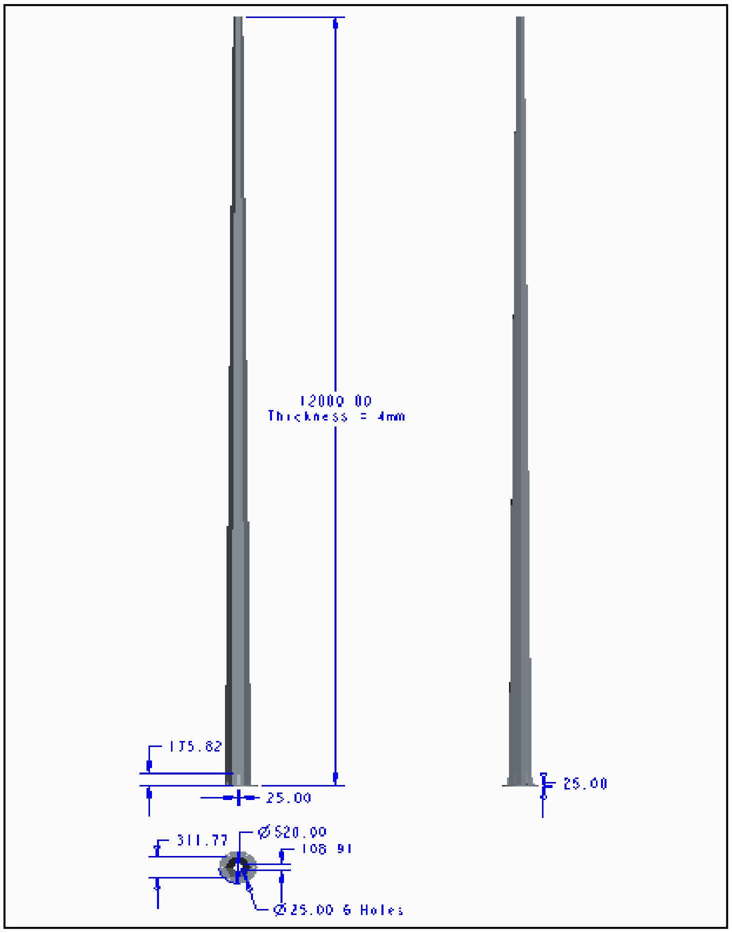

Fig. 4: Drafting Of High Mast Solar Light Pole

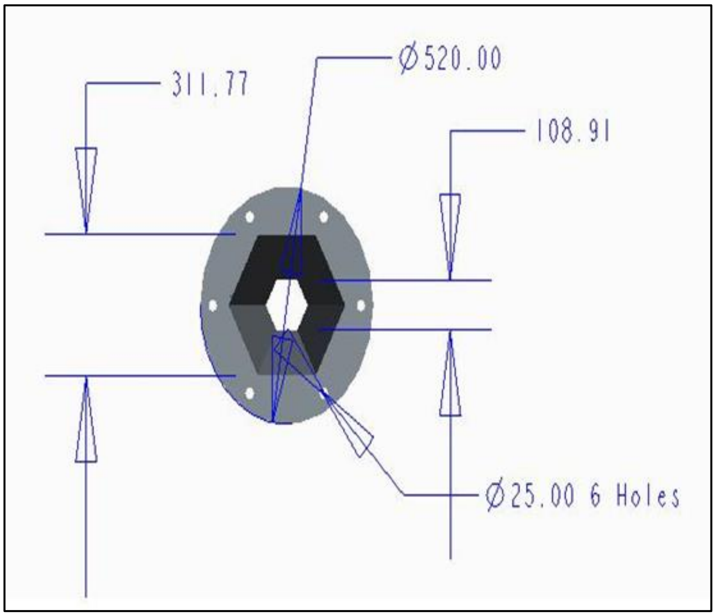

Fig. 5: Bottom-View

V. CALCULATIONS

A high mast lighting poles are fabricated using mild-steel due to its high strength, ductility property and wear resistance. The high mast structure (HMS) has the characters of light weight and high cost efficiency. It possess large ratio of height (H) to least horizontal dimension (D) that makes it more slender and wind-sensitive than any other structures

In this project we find design wind speed for Nagpur location and the calculate design wind load considering various coefficient.

A. Force Calculation of High Mast Light:

1) Pole Parameters:

Base plate diameter : 520 mm
Thickness of base plate: 25 mm
Height of pole : 12000 mm (12 m)

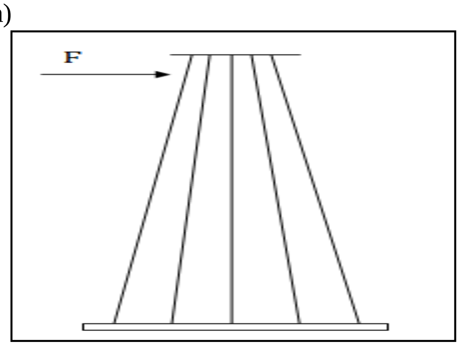

Fig. 6: Force Calculation of High Mast Light

2) Calculation:

For Nagpur:

Maximum wind speed (V_w) :

V_w = 180 Km/hr

$= \frac{180*1000}{3600}$

V_w = 50 m/sec

Design wind speed (V_z) :

$V_z = K_1 * K_2 * K_3 * V_w$

Where,

K_1 = risk co-efficient (i.e, life of structure in 100 years) = 1.05

K_2 = terrain factor (for pole height in between 11m - 50m) = 1.01

K_3 = the ground is assumed to be plain surface, So, the topography factor is 1

V_w = wind speed (m/sec)

Therefore,

$V_z = K_1 * K_2 * K_3 * V_w$

$= 1.05 * 1.01 * 1 * 50$

$V_z = 53.025$ m/sec

B. *Design Wind Load Including Carriage Weight:*

$F = 0.6 * (Vz)^2$

$F = 0.6 * (53.025)^2$

$F = 1686.99$

$F = 1687$ N

C. *Analysis of High Mast Solar Light Pole:-*

1) Static Structural Analysis:

Static structural analysis determines the displacements, stresses, strains, and forces in structures or components caused by loads that do not induce significant inertia and damping effects. Steady loading and response conditions are assumed; that is, the loads and the structure's response are assumed to vary slowly with respect to time. The types of loading that can be applied in a static analysis include:

1) Externally applied forces and pressures
2) Steady-state inertial forces
3) Imposed (nonzero) displacements
4) Temperatures (for thermal strain)

VI. ELEMENT PROPERTIES:

The Discreatization of the structure or body into Finite Elements forms the basic first step in the analysis of a complicated structural system.

Rules for Discreatization of the Structure into Elements:

1) Sub-division of a body or structure into Finite Elements should satisfy the following requirements:
2) Two distinct elements can have common points only on their common boundaries if such boundaries exist. No overlapping is allowed. Common boundaries can be points, lines or surfaces.
3) The assembled element should leave no holes within the two elements and approximate the geometry of the real body or structure as closely as possible to do.

When the boundary of a structure or body cannot be exactly represented by the elements selected, an error cannot be avoided. Such error is called Geometric Discreatization Error and it can be decreased by reducing the size of the elements or by using elements allowing boundaries to become curved.

A. *Geometry:-For Hexagonal Section:*

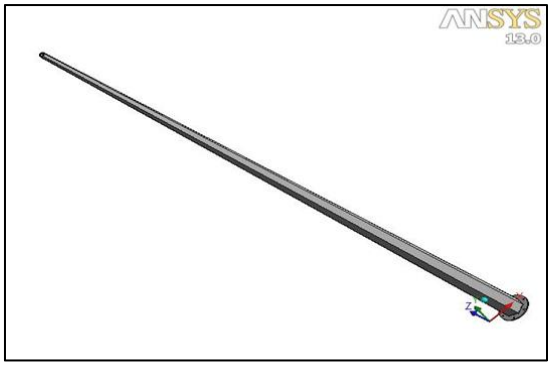

Fig. 7:

1) Meshing:
Nodes 236262
Elements 136545

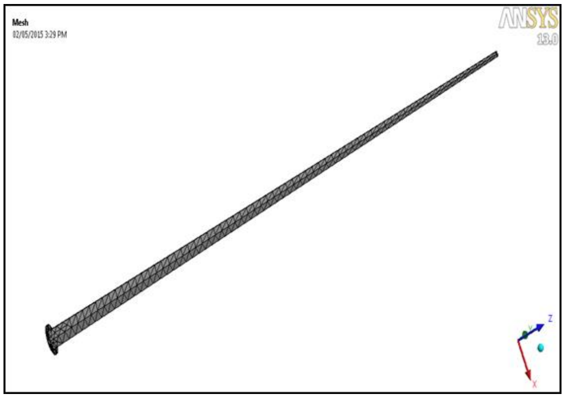

Fig. 8:

2) Boundry Condition:-Fixed Support:

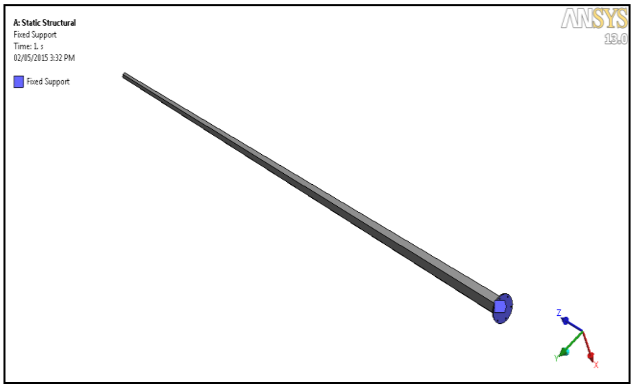

Fig. 9: Boundry Condition:-Fixed Support

3) FORCE:-F=1687N:

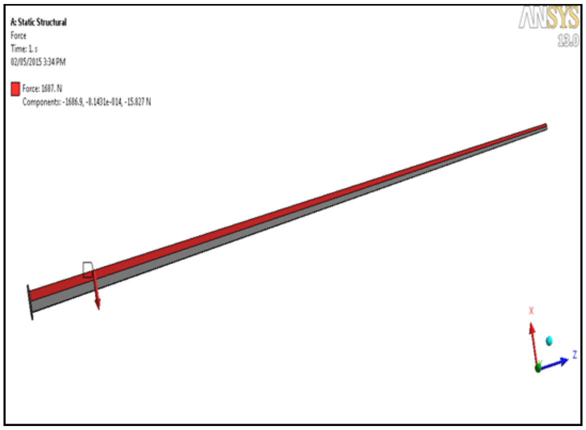

Fig. 10: H. FORCE:-F=1687N

B. Material Properties:-Mild Stee:

Properties of Outline Row 6: Mild Steel

	A	B	C	D	E
1	Property	Value	Unit		
2	Density	7850	kg m^-3		
3	Isotropic Elasticity				
4	Derive from	Young's M...			
5	Young's Modulus	2.1E+05	MPa		
6	Poisson's Ratio	0.3			
7	Bulk Modulus	1.75E+11	Pa		
8	Shear Modulus	8.0769E+10	Pa		
9	Tensile Yield Strength	370.2	MPa		
10	Compressive Yield Strength	370.2	MPa		
11	Tensile Ultimate Strength	439.89	MPa		
12	Compressive Ultimate Strength	0	MPa		

Fig. 11: I. Material Properties:-Mild Stee:

VII. RESULTS

A. Total Deformation=16.137 mm:

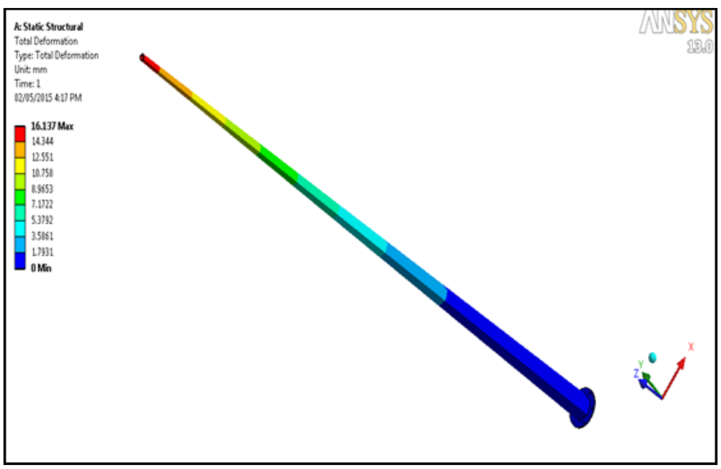

Fig. 12

B. Equivalent Stresses=25.679 mpa:

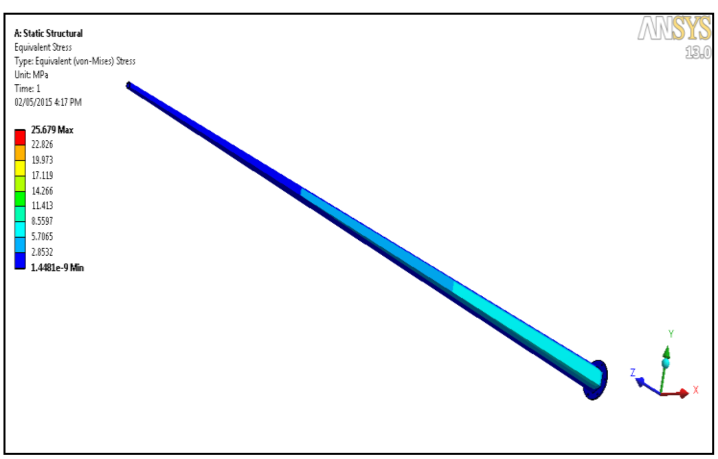

Fig. 13

C. Maximum Shear Stresses=14.826mpa:

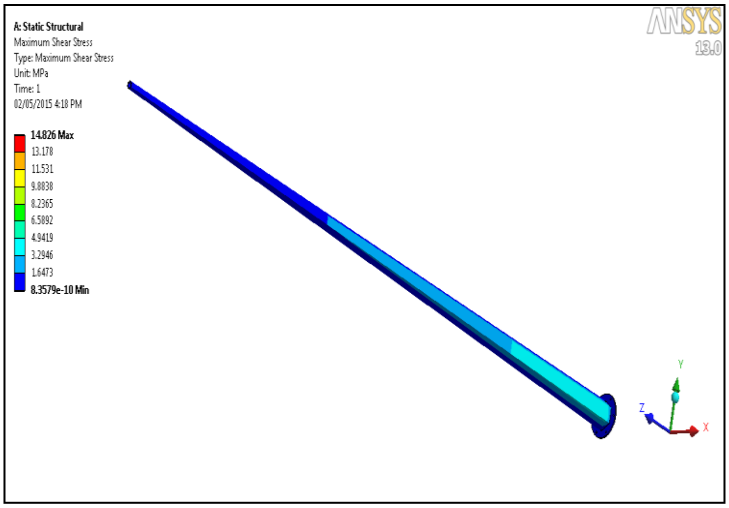

Fig. 14

D. Geometry:-Octagonal Section:

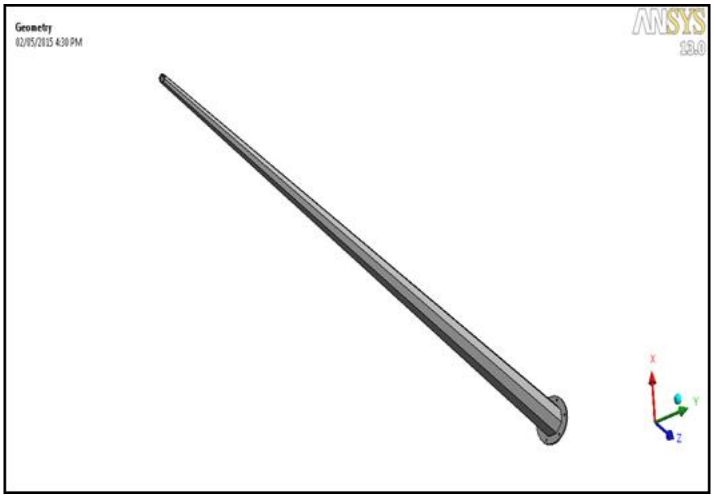

Fig. 15

1) Meshing:
Nodes 52934
Elements 26416

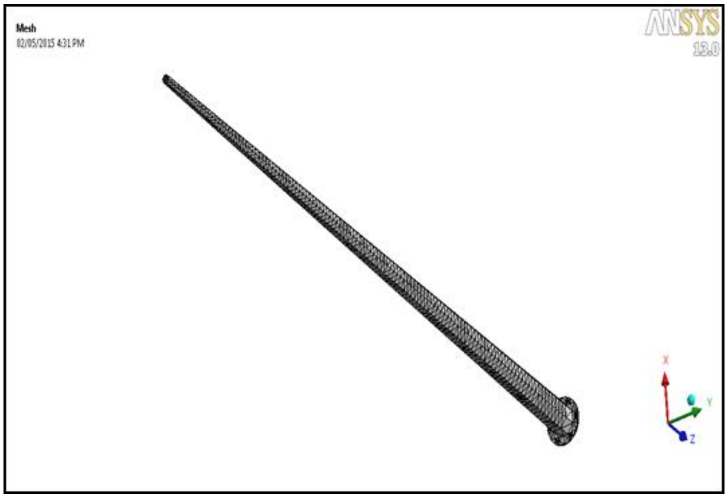

Fig. 16

2) Boundary Condition:-Fixed Support

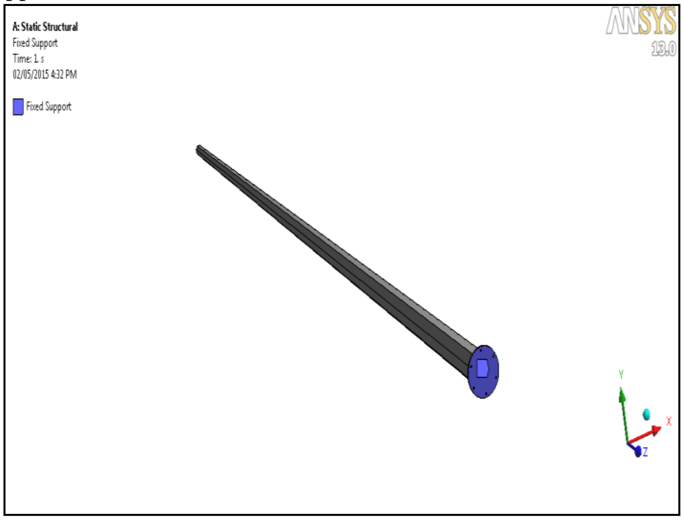

Fig. 17:

3) FORCE:-F=1687N

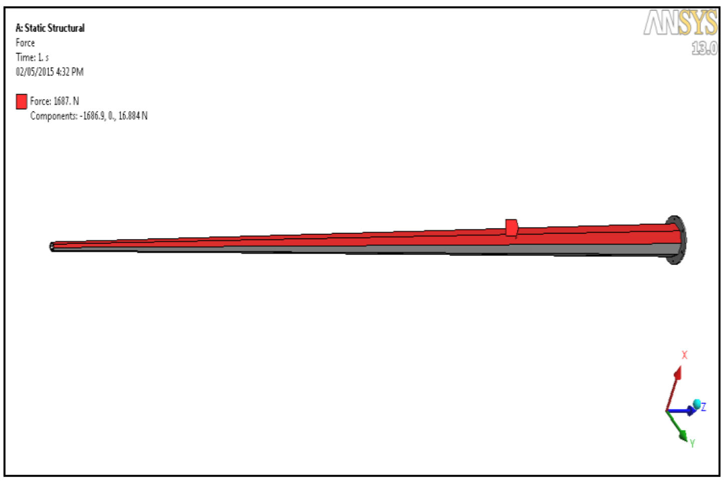

Fig. 18

VIII. RESULTS

A. Total Deformation=13.731mm

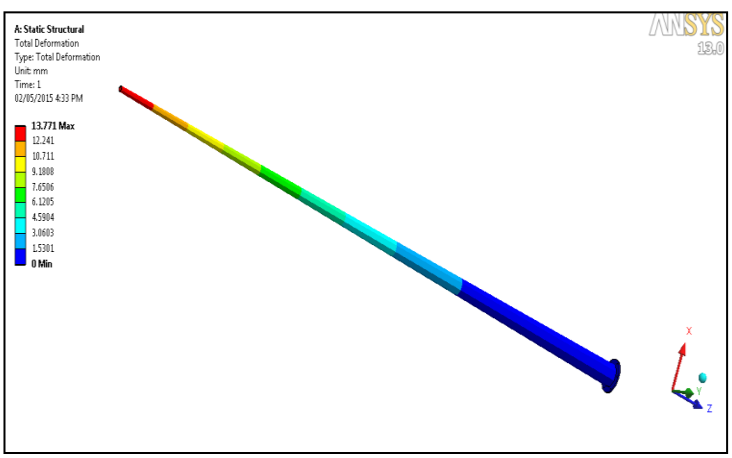

Fig. 19:

B. Equivalent Stresses=7.9896mpa

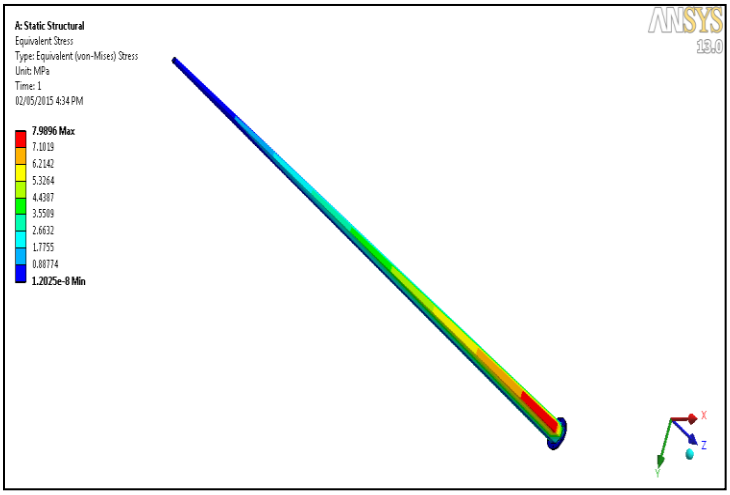

Fig. 20

C. Maximum Shear Stresses=4.0743mpa:

Table - 2

Cross-Section	*Six-Sides*	*Eight Sides*
Total Deformation	*16.137 mm*	*13.771 mm*
Equivalent Stresses	*25.679 mpa Cross-Section*	*7.9896 mpa*
Max. Shear Stresses	*14.826 mpa*	*4.0743 mpa*

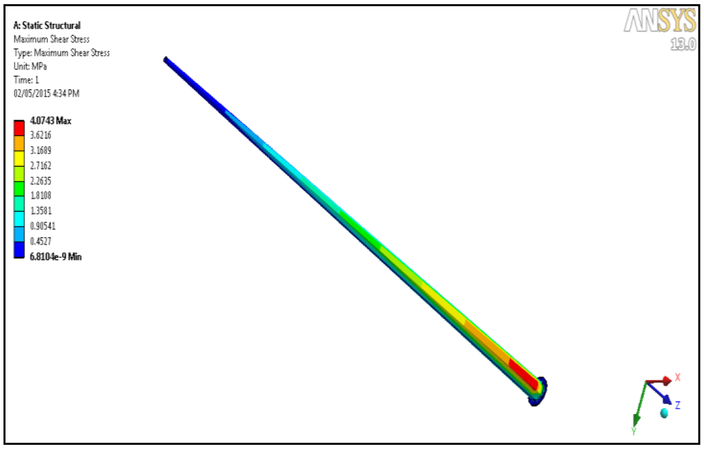

Fig. 21:

D. Comparison of Two Cross-sections:

Above table shows that total deformation,equivalent stresses and max-shear stresses found at eight sides cross section are less as to as compared to six sides cross-section so,we can consider that octagonal cross-section is better design to reduced damage at high mast pole.

IX. CONCLUSION

This paper has considered some of key factors associated with the design of HMS due to the effects of wind loading. Then major findings are design wind speed and design wind load considering location of Nagpur city. Considering max wind speed we identify better design of high mast pole which is having lower stresses and helpful to reduced damages at pole due to winding.

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