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Investigation of anchor nut loosening in high mast light poles using ANSYS

[1]Bissy Varghese and [2]Jobil Varghese
[1]M.Tech pursuing in M.G University, [2]Asst. Professor, Dept. of Civil Engineering, MBITS
[1]Computer Aided Structural Engineering,
[1]Dept. of Civil Engineering, MBITS
[1]Kerala,[1]India

***Abstract* - High mast lighting poles (HMLP) are tallest lighting poles that are used in highway and intersections. This lighting pole helps to cover major area unlike smallest lighting poles. These poles vary in height from 30 to 76m. HMLP's are supported at the bottom that is connected to concrete foundation with the help of large size anchor rods. In this study investigation is carried on about the post yield and anchor nut loosening. Due to the rotation of nuts after the post yield that leads to plastic deformation due to some external load factors like wind load. This problem can be analyzed by simulating non-linear post yield behavior using complex model. Finite-element (FE) modeling satisfies these requirements in the most accurate way possible. Octagonal, hexagonal and circular steel poles are the three different models considered for the analysis. Among these three models choose the model with highest stress and also adopting methods to reduce the stress at the anchoring due to the nut loosening.**

***Index Terms* - Base Plate, Bolt, Circular Pole, Gusset Plate, Hexagonal Pole, Pretension, Octagonal pole**

I INTRODUCTION

High mast lighting as a concept in area lighting is being preferred over conventional lighting, especially where large areas are to be illuminated without the need for numerous lighting columns that under certain circumstances, can be a hazard to movement. This is possible because the high mast lighting system achieves very large space to height ratios.

High mast lighting poles are cost effective structures for lighting highways and intersections. They are 100 to 250 feet (30m to 76m) tall, and can hold a variety of lamp configurations.

The principal method for installing a high mast involves a flange plate supported by a prepared foundation. The flange plate, which is welded to the base of the mast, is designed to accommodate the overturning moments (forces) for each specific mast. Bolt holes in the flange plate are arranged in one of two ways, either in a square method or in a circle method.

Anchor rods and their associated nuts are used to secure the HMLP base plate to the pole's foundation. The bolts should then be tightened in accordance with the final torque value.

II BACKGROUND

Recent failures of high-mast lighting towers have increased the awareness of the problems associated with these cantilevered structures. The failures of these steel poles primarily occur just above the weld at the base plate connection indicating a fatigue type failure. Although these structures are designed to the current 2001 AASHTO Specification, their susceptibility to fatigue failure has become a nationwide problem. High-mast lighting towers are vertical, cantilevered structures that are used to illuminate a relatively large area. Although primarily used for highway intersection lighting in rural areas, they are also utilized in other large areas such as parking lots, sporting venues, or even penitentiaries. As a result, failures of these structures are critical due to the potential for them to fall across highway lanes or other occupied areas.

III METHODOLOGY

Specimen Geometry

All modelling was conducted using ANSYS 14.5 finite element software. The project proceeded in several stages of modelling; all specimens were modelled as 3D solid objects elements with identical geometry. The dimensions of the sections were chosen to match those being used in the experimental testing of the author's thesis project. Modelling in ANSYS using top down method.

Modelling Procedure

Modelling in ANSYS using top down method. All specimens were modelled as 3D solid objects using solid structural elements. SOLID45 is used for the three-dimensional modelling. The element is defined by eight nodes having three degrees of freedom at each node: translations in the nodal x, y, and z directions.

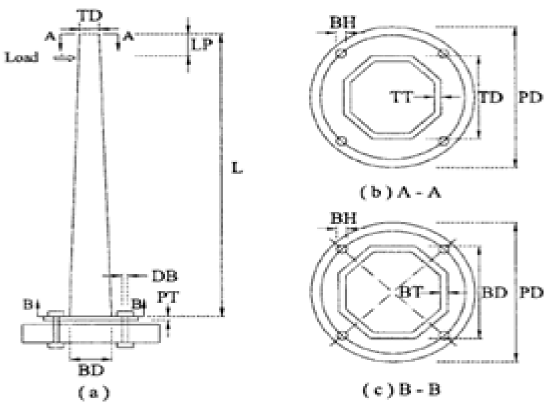

Fig. 3.Geometry of Steel Pole

Table 1 Geometry of Steel pole

Sl No	Item	Notations	Dimensions (m)
1	Pole length	L	6.096
2	Length of below top of pole	LP	0.460
3	Diameter at top of pole	TD	0.084
4	Diameter at bottom of pole	BD	0.132
5	bolt diameter	DB	0.013
6	Diameter of bolt hole	BH	0.014
7	Wall thickness of pole at top	TT	0.003
8	Wall thickness of pole at the bottom	BT	0.003
9	Thickness of base plate	PT	0.107
10	Side length / diameter of square/circular base plate	PD	0.221

Concrete foundation = 914 mm x914 mm x 1219mm

Table 2 Material Properties

Material Properties	Plate	Bolt	Pole
E	206 GPa	206 Gpa	207 Gpa
F_y	248 Mpa	634 Mpa	305 Mpa
υ	0.29	0.29	0.3
E_t	2 Gpa	2 Gpa	1000 Mpa
μ	0.2	0.2	

Due to the external load there will be the effect of rotating the nut. This effect can be simulated by using pretension analysis in ANSYS. Each bolt were simulated by applying compressive forces equivalent to proof load (70% of bolt's ultimate tensile strength) to the end plate at the location of bolt head and nut. Pretension load of 5.79 x 10^8 N/mm^2 was applied.

IV RESULTS AND DISCUSSIONS

Analytical modelling of light poles is carried out using ANSYS. Light poles with different shapes like octagonal, hexagonal, and circular are modelled. The maximum stress that the light poles modelled undergoes is noted for a concentrated load of 250 N. It was observed that the stress for the hexagonal light pole is maximum. The anchor nut loosening is the phenomena due to the high stress at the anchorage of base plate. The maximum stress will be at the shank of bolt.

Table 3 Analytical Results

Sl No	Shape of pole	Von mises stress (N/m^2)
1	Octagonal	0.637E+09
2	Hexagonal	0.276E+10
3	Circular	0.156E+10

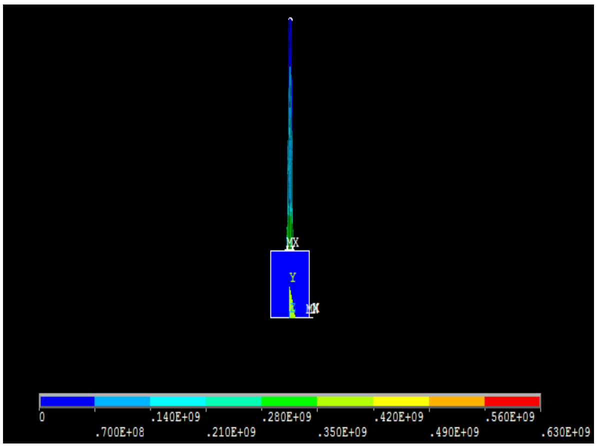

Fig. 4. Octagonal pole

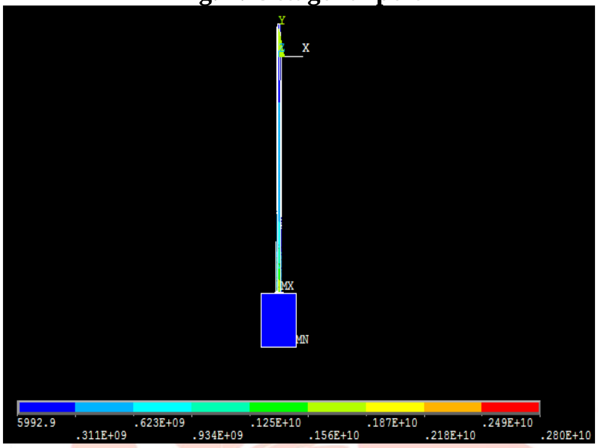

Fig 5. Hexagonal Pole

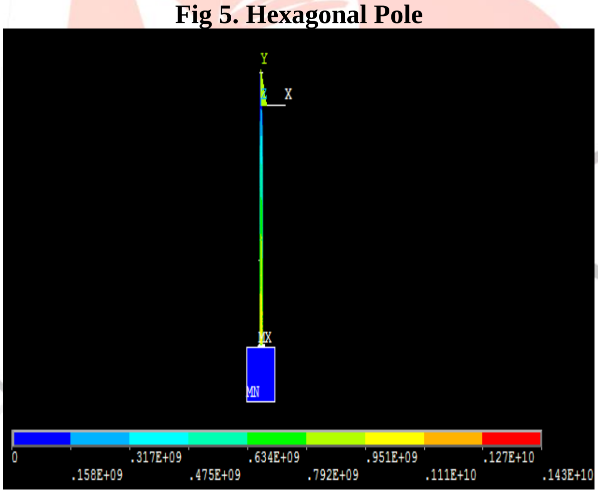

Fig. 6. Circular Pole

Here the model with circular pole is selected for further modification. To reduce the stress at the anchorage certain measures adopted. Providing gusset plate at the anchorage, doubling the base plate thickness, increasing the pole thickness.

The gusset plate dimension is 250 × 300 × 15 mm. The base plate thickness is increased to 0.214m.The pole thickness is increased to 0.005m. After implementing all the requirements the stress at the anchorage in the light pole is reduced to 0.691E+09 N/m^2

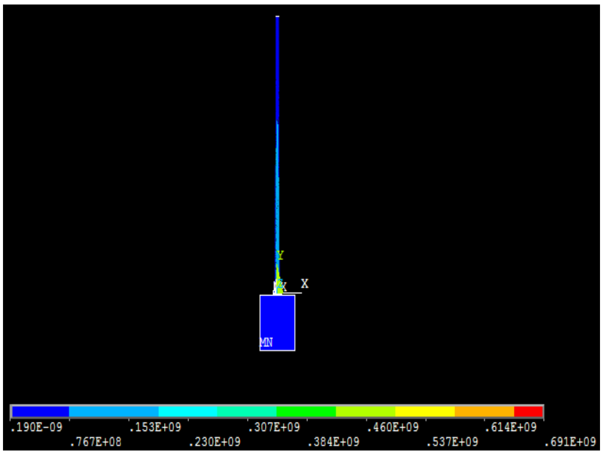

Fig. 7 Circular pole with gusset plate, increasing bp thickness, increasing pole thickness

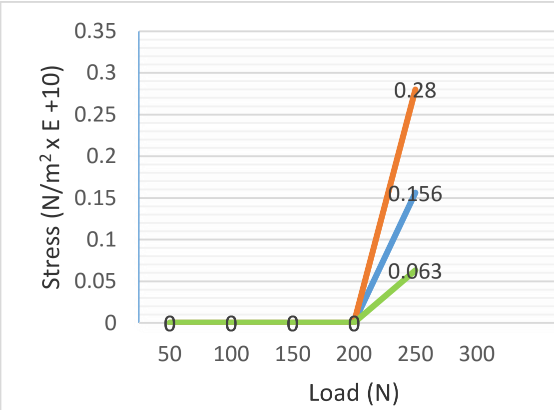

Fig. 8 Load Vs Stress of poles

Octagonal   Circular
Hexagonal

V CONCLUSION

The following conclusions are obtained from the results. The implementation of light poles at high way intersections is increasing day by day. Due to the external load like wind load the anchor nuts are loosening. The maximum stress at the anchor base is in hexagonal light poles.so in this case the chances for nut loosening is high. The minimum stress at the shank is associated with octagonal light poles. By using gusset plate, doubling the base plate thickness and pole thickness the stress at the anchorage can be reduced.

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