An Investigation of Wind Load Effect on a Light Pole Structure with Stiffener Using ANSYS

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Abstract—Light poles are long tapered poles and single tube structures used in highways. Wind load is the primary design force on this structure. In this study a comparison of the strength of steel and FRP light pole is made when wind loads act on it. This work makes it possible to extend the study of light pole by varying shapes with two materials. Circular and hexagonal shapes are considered here. Also the variation of stress and deformation of light pole are checked when stiffener is placed. Stress and deformation results are compared.

Keywords—light pole; composite natural fibre; static analysis; FEA.

I. INTRODUCTION

Previously concrete and timbers were the materials used in light poles. Light poles are tall, single tube structures that support luminary fixtures used to illuminate large outdoor areas. Concrete poles easily corroded with steel reinforcement which leads to maintenance. Wooden poles easily damage due to environmental changes. As required by their function and placement in generally open surrounding, wind loading is the primary design force on these structures. Because of lightweight slender configuration, the light poles are extremely flexible with typical fundamental natural frequencies. The poles must be designed to minimize vibration and deflection. Now a days designers choose steel and composite FRP used for making light poles. Steel poles are most commonly used tapered poles. FRP is light weight and corrosion resistance. Fibres are two types natural and synthetic fibre. Synthetic fibres are commonly used in structures and recent studies.

Here, natural fibre is selected. Kenaf is used as natural fibre. Kenaf belongs to species of hibiscus cannabinus. Treated kenaf fibre shows good properties. The properties of FRP used in the study are those of Kenaf fibre added to polypropylene. Wind induced deformation affects pole’s geometric variables. Wind loads vary in different regions. Height of light pole varies from 20 feet to 100 feet. It is very essential to design the light pole with sufficient strength and stability.

II. OBJECTIVES

• To perform Static Analysis on steel and FRP poles in order to obtain their load vs. deflection characteristics.

• Stiffeners are placed in order to know whether the stress and deformation are reduced.

II. SCOPE

The scope of this work is to implement light poles in a highly economic manner with adequate strength and standard length. The aim is also to check whether there is any change in light pole using stiffener.

III. LIGHT POLE DESCRIPTION AND PARAMETERS

The cross section dimensions of the poles have been selected based on material available in the market. The total height of pole is 19.8m with a horizontal arm length of 2m. The base of the pole is welded to base plate which is bolted to foundation shown in fig .1. The light pole has tapering hollow circular section with base diameter of 300mm and thickness 15mm. Top diameter is 100mm and thickness is 10mm. The size of base plate is 400*400*20mm. Base plate is designed based on IS code 800 : 2007. Width of foundation is 0.5m and depth 0.8m. The thickness of FRP is 5mm.
A. Material properties

The materials used are steel and natural fibre. Kenaf fibre is used as natural fibre. The orthotropic property of fibre is listed in Table.1. The properties of steel are available from ANSYS software that are shown in Table.2.

<table>
<thead>
<tr>
<th>Material</th>
<th>Young’s modulus (MPa)</th>
<th>Poisson’s ratio</th>
<th>Shear Modulus (MPa)</th>
<th>Density (kg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FRP</td>
<td>E_ZZ = 7.891</td>
<td>μ_ZX = 0.3698</td>
<td>G_XY = 1.0961</td>
<td>1500</td>
</tr>
<tr>
<td></td>
<td>E_XX = 3.3080</td>
<td>μ_ZY = 0.3698</td>
<td>G_YZ = 2.8120</td>
<td></td>
</tr>
<tr>
<td></td>
<td>E_YY = 3.3080</td>
<td>μ_YX = 0.509</td>
<td>G_XZ = 2.8120</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SI No</th>
<th>Material</th>
<th>Young’s modulus</th>
<th>Poisson’s ratio</th>
<th>Shear modulus</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Steel</td>
<td>2*10^6 kN/m²</td>
<td>0.3</td>
<td>7.69*10^7 kN/m²</td>
</tr>
</tbody>
</table>

V. METHODOLOGY

Light pole is modeled in CATIA software. It is imported to ANSYS. Material properties are assigned. Fine mesh is done for accurate results. Solid 185 is the element used in ANSYS. Stress and deformation results obtained from the static analysis are compared. From the results the better shape and material are identified. Stiffener is placed in better shape to identify the variation of stress and deformation.

A. Statistical analysis

In this study the circular and hexagonal steel pole are statically analysed. Wind loads are considered. Wind velocity \( v_z \) is calculated based on IS 875 (part III). After the analysis stress and deformation values are obtained. Results are shown in Table. 3. Comparison of stress and deformation of steel and FRP circular pole is shown in Table 4.

B. Results and conclusion
Fig. 2: Stress diagram of circular steel pole

Fig. 3: Deformation diagram of circular steel pole

Fig. 4: Stress diagram of hexagonal steel pole
Fig. 5: Deformation diagram of hexagonal steel pole

Fig. 6: Stress diagram of circular FRP pole

Fig. 7: Deformation diagram of circular FRP pole
Fig. 8: Stress diagram of hexagonal FRP pole

Fig. 9: Deformation diagram of hexagonal FRP pole

TABLE 3: Stress and deformation of two materials without FRP

<table>
<thead>
<tr>
<th>Shape</th>
<th>Stress (MPa)</th>
<th>Deformation (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circular without FRP</td>
<td>20.497</td>
<td>104.75</td>
</tr>
<tr>
<td>Hexagonal without FRP</td>
<td>20.451</td>
<td>127.31</td>
</tr>
</tbody>
</table>

TABLE 4: Stress and deformation of two materials with FRP

<table>
<thead>
<tr>
<th>Material</th>
<th>Stress (MPa)</th>
<th>Deformation (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circular with FRP</td>
<td>16.297</td>
<td>98.85</td>
</tr>
<tr>
<td>Hexagonal with FRP</td>
<td>19.484</td>
<td>124.42</td>
</tr>
</tbody>
</table>
From the above results circular pole with FRP is selected. Its stress and deformation are less compared to that of hexagonal pole with FRP. Stiffener is placed in circular pole with FRP 200*200*15mm is the size selected for stiffener based on steel table. Variation in stress and deformation after the stiffener placed is checked. Stress diagram of circular FRP pole with stiffener is shown in fig 10. Deformation diagram of circular FRP pole with stiffener is shown in fig 11. Table 5 shows the details of stress and deformation when stiffener is placed in circular pole with FRP.

<table>
<thead>
<tr>
<th>Light Pole Model</th>
<th>Stress (MPa)</th>
<th>Deformation (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circular pole with FRP Without Stiffener</td>
<td>16.297</td>
<td>98.85</td>
</tr>
<tr>
<td>Circular Pole with FRP with Stiffener</td>
<td>28.729</td>
<td>97.183</td>
</tr>
</tbody>
</table>

Fig. 10 Stress Diagram of Circular pole with FRP with Stiffener

Fig. 11 Deformation Diagram of Circular pole with FRP with Stiffener
VI. CONCLUSION

- Both Circular and hexagonal shapes were statically analysed.
- Result shows that there is slight difference in stress value of circular and hexagonal light pole.
- In hexagonal pole with FRP the stress increase is 16.4% compared to that of circular pole with FRP.
- There is an increase of 20.55% of deformation in hexagonal pole with FRP compared to that of circular pole with FRP.
- Maximum stress is obtained at base of light pole before the stiffener is placed.
- When stiffener is placed in circular pole with FRP the deformation decreased, because the stiffener bears the stress.

VII. FUTURE SCOPE

- Find the natural frequencies and mode shapes of light poles.
- To check the cyclonical effects of composite light pole.

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REFERENCES