Comparison of Hollow Spherical and Solid Spherical Connectors Used In Guyed Tower

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Abstract— Transmission line tower is important in the operation of a reliable electrical power system that is considered as a lifeline system. The erection time for angle section with bolted connection is more. The connector connecting the members of transmission line tower plays an important role in designing the tower. So in this study tubular circular section with different spherical connector are used to develop more effective connector by comparing hollow spherical and solid spherical connector. Analysis of the tower is carried out in STAAD.Pro V8i software using tubular circular section and axial forces obtained from these software is used for the analysis of connector. Modeling of these connectors is done in Creo. Four different diameters 120, 130, 140 and 150 mm are used to compare the results of the principal and shear stresses of hollow and solid spherical connectors from ANSYS. It is observed that by using hollow spherical connector stresses of connector is increased while weight of the connector decreases.

Keywords— Hollow Spherical Connector, Solid Spherical Connector, Guyed Tower, ANSYS, STAAD.Pro V8i, CREO

I. INTRODUCTION

Electricity is most versatile and convenient form of energy. Per capita consumption of electricity is considered to be yard stick for assessing the growth of economy of any state or a country. Power generation, transmission and distribution system is therefore growing exponentially all over the world. The guyed tower have become the dominant type for use on transmission lines remote from urban areas or where land use restrictions are prohibitive. Generally the erection time of bolted connection is more, so by using tubular pipe section and spherical connectors makes work more rapid.

There have been many studies for different types of connectors. Koushky et al. [1] investigated the behavior of connector at composite nodes for space structures. They found out the stresses at joints and concluded that length of end flattening in members is important. Luo et al. [2] developed the flexible connector for the plane truss structures based on finite element method. Sheth and Arekar [3] developed the THH 150 connector for the 3D space structures and compared the maximum principal stresses of both the connectors. They concluded that, in the top layer of the structure compressive forces are predominant. Patil and Arekar [4] observed that the critical connector for the double layer grid structures. They found that the THH connector due to its uncomplicated geometry and ease of fabrication are the alternative option of the double layer grid structures.

In this present study, hollow spherical and solid spherical Connectors are used in guyed tower and compared on the basis of maximum principal stress, minimum principal stress and maximum shear stress.

II. ANALYSIS OF THE GUYED TOWER

Guyed tower is analyzed using IS 802-2015 [5] in which tubular circular sections is used. Figure 1 show the loads assigned in the guyed tower as per reliability, security and safety condition in the STAAD.Pro V8i software. Analysis of the tower is carried out using normal wire and broken wire condition considering transverse, longitudinal and vertical loads.
III. MODELLING AND ANALYSIS OF SPHERICAL CONNECTORS

In present study, solid spherical connector and hollow spherical connector of different diameters (120mm, 130mm, 140mm and 150mm) in which hollow connector has constant 20mm thickness are modelled in CREO and analysed in ANSYS to calculate the stresses. Analysis of the guyed tower is carried out with pipe sections in STAAD.Pro V8i. and the axial forces from these software is used to design the spherical connector at all joints. In present study, the spherical connectors are used at the joint shown in Figure 1.

In present study the theory adopted to calculate permissible stress is maximum shear stress theory which is shown in equation 1.

\[ \frac{1}{2}(\sigma_1 - \sigma_3) \geq \frac{1}{2} \sigma_y \]  

(1)

where,

\( \sigma_1 = \) Maximum principal stress  
\( \sigma_3 = \) Minimum principal stress  
\( \sigma_y = \) Maximum shear stress

Figure 2 shows solid spherical and hollow spherical connector.

IV. RESULT OF HOLLOW SPHERICAL CONNECTORS

The analysis of hollow spherical connectors is carried out in finite element software ANSYS, the maximum principal stress (tension), minimum principal stress (compression), maximum shear stress are shown in Figures 4 to 15 for different diameters which are 120mm, 130mm, 140mm and 150mm respectively.
Figure 4 Maximum principal stress (N/mm²) for 120mm hollow connector

Figure 5 Minimum principal stress (N/mm²) for 120mm hollow connector

Figure 6 Maximum shear stress (N/mm²) for 120mm hollow connector

Figure 7 Maximum principal stress (N/mm²) for 130mm hollow connector

Figure 8 Minimum principal stress (N/mm²) for 130mm hollow connector

Figure 9 Maximum shear stress (N/mm²) for 130mm hollow connector
Figure 10 Maximum principal stress (N/mm$^2$) for 140mm hollow connector

Figure 11 Minimum principal stress (N/mm$^2$) for 140mm hollow connector

Figure 12 Maximum shear stress (N/mm$^2$) for 140mm hollow connector

Figure 13 Maximum principal stress (N/mm$^2$) for 150mm hollow connector

Figure 14 Minimum principal stress (N/mm$^2$) for 150mm hollow connector

Figure 15 Maximum shear stress (N/mm$^2$) for 150mm hollow connector
V. RESULT OF SOLID SPHERICAL CONNECTORS

The analysis of solid spherical connectors carried out from finite element software ANSYS, the maximum principal stress (tension), minimum principal stress (compression) and maximum shear stress are respectively shown in Figures 16 to 27 for different diameters are 120mm, 130mm, 140mm and 150mm.

Figure 16 Maximum principal stress (N/mm²) for 120mm solid connector

Figure 17 Minimum principal stress (N/mm²) for 120mm solid connector

Figure 18 Maximum shear stress (N/mm²) for 120mm solid connector

Figure 19 Maximum principal stress (N/mm²) for 130mm solid connector

Figure 20 Minimum principal stress (N/mm²) for 130mm solid connector
Figure 21 Maximum shear stress (N/mm$^2$) for 130mm solid connector

Figure 22 Maximum principal stress (N/mm$^2$) for 140mm solid connector

Figure 23 Minimum principal stress (N/mm$^2$) for 140mm solid connector

Figure 24 Maximum shear stress (N/mm$^2$) for 140mm solid connector

Figure 25 Maximum principal stress (N/mm$^2$) for 150mm solid connector

Figure 26 Minimum principal stress (N/mm$^2$) for 150mm solid connector
VI. COMPARISON OF HOLLOW SPHERICAL AND SOLID SPHERICAL CONNECTORS

Tables 1, 2 and 3 shows result of maximum principal stress, minimum principal stress and maximum shear stress of hollow connector and solid connector. Figures 28, 29 and 30 shows the graphical comparison of these results.

<table>
<thead>
<tr>
<th>Diameter(mm)</th>
<th>Maximum Principal Stress(N/mm²)</th>
<th>Percentage of Stress Increased in Hollow Connector</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hollow connector</td>
<td>Solid connector</td>
</tr>
<tr>
<td>120</td>
<td>577.69</td>
<td>519.82</td>
</tr>
<tr>
<td>130</td>
<td>511.41</td>
<td>441.13</td>
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<tr>
<td>140</td>
<td>443.36</td>
<td>357.33</td>
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<td>150</td>
<td>435.37</td>
<td>345.71</td>
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<thead>
<tr>
<th>Diameter(mm)</th>
<th>Minimum Principal Stress(N/mm²)</th>
<th>Percentage of Stress Increased in Hollow Connector</th>
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<tr>
<td>120</td>
<td>248.67</td>
<td>240.4</td>
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<tr>
<td>130</td>
<td>223.69</td>
<td>203.82</td>
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<td>140</td>
<td>116.62</td>
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<td>150</td>
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<th>Diameter(mm)</th>
<th>Maximum Shear Stress(N/mm²)</th>
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<td>250.43</td>
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Table 4 shows the comparison between weight of hollow spherical and solid spherical connector. This weight is obtained from CREO software.

<table>
<thead>
<tr>
<th>Diameter (mm)</th>
<th>Weight (kg)</th>
<th>Percentage of Weight Decreased in Hollow Connector</th>
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<td>130</td>
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<td>150</td>
<td>8.39</td>
<td>13.86</td>
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VII. CONCLUSIONS

Conclusions are derived from this comparative study are as follow:

1) The value of both principal stress and shear stress decreases with increase in diameter for spherical connector.
2) The value of maximum principal stress, minimum principal stress and maximum shear stress are increased from 10% to 21%, 3% to 24% and 8% to 37% respectively as diameters of connector are increased from range of 120 to 150 while using hollow spherical connector instead of solid spherical connector.
3) The value of weight decreased from 30% to 40% as hollow spherical connector is used instead of solid spherical connector.
4) From above results it is observed that hollow spherical connector is more effective than solid spherical connector.

References