THERMOSTRUCTURAL ANALYSIS OF STRUCTURAL PLATES

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ABSTRACT

This paper aims the evaluation of the thermal responses, stresses, deformations and frequencies for Structural Steel and Aluminum. Thermal, Static, Modal and Random vibration analysis are performed on the plates for Structural Steel and Aluminum using Solid Element. The modeling of the plate has been carried out, as per the required dimensions for all the selected materials to all the cases. The analysis of the results has been compared with all the selected materials, in all the cases.

KEYWORDS: Thermal analysis, Equivalent stress, Equivalent strain, Frequencies & Total deformation

INTRODUCTION

The research areas are focusing to identify the future materials, with the help of solving the analysis for present materials. This research work is focused on behavior of material for the given boundary conditions, with the specified geometry for all conditions.

MODELING OF PLATES

The modeling of plate has been done as per the required geometry.

Figure 1: 3D Model of Structural Plate

For modeling of plate, the following dimensions have been taken.

Plate length: 500 mm
Plate width: 500 mm
Plate thickness: 60 mm

MESHING AND BOUNDARY CONDITIONS

For the developments of thermo structural analysis, meshing and boundary conditions should be given. The structural plate has been analyzed, for pressure 20 MPa. The figure.2, shows the meshed model of structural plate.

Table.1: Material Properties

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>Density (g/cc)</th>
<th>Young’s Modulus(GPa)</th>
<th>Poisson’s ratio</th>
<th>Allowable Strength (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STRUCTURAL STEEL</td>
<td>7.87</td>
<td>200</td>
<td>0.26</td>
<td>275</td>
</tr>
<tr>
<td>ALUMINUM</td>
<td>2.6989</td>
<td>68.0</td>
<td>0.36</td>
<td>310.26</td>
</tr>
</tbody>
</table>

The table.1, shows the material properties of the structural steel and aluminium material.

FORCE CALCULATIONS

Pressure value taken as 20 Mpa

\[ P = \frac{F}{A} \]

\[ P \rightarrow \text{Pressure} ; F \rightarrow \text{Force} ; \]

\[ A \rightarrow \text{Area} ; \]

\[ F = P \times A \times 20 \text{ N/mm}^2 \times (500 \times 60) \text{ mm}^2 \]

\[ F = 120 \times 500 = F = 60000 \text{ N} \]

STRUCTURAL ANALYSIS OF PLATE

The structural analysis of plate has been carried out for the given materials, by applying the given boundary conditions for selected geometry of the plate.

MATERIAL – STRUCTURAL STEEL

The structural analysis has been carried out for the selected steel material, with the selected boundary conditions.
The structural analysis has been carried out for the selected Aluminium material, with the selected boundary conditions.

The Modal analysis has been carried out for the selected steel material, with the selected boundary conditions.
MATERIAL – ALUMINUM

The Modal analysis has been carried out for the selected Aluminium material, with the selected boundary conditions.

![Figure 15: Total Deformation at Mode 1](image1)

![Figure 16: Total Deformation at Mode 2](image2)

![Figure 17: Total Deformation at Mode 3](image3)

RANDOM VIBRATION ANALYSIS OF PLATE

Enter frequencies and deformation values from modal analysis.

<table>
<thead>
<tr>
<th>Frequency [Hz]</th>
<th>Displacement [mm²/Hz]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 1179.8</td>
<td>5.1542</td>
</tr>
<tr>
<td>2 1364.5</td>
<td>7.7911</td>
</tr>
<tr>
<td>3 2172.5</td>
<td>8.4108</td>
</tr>
</tbody>
</table>

![Figure 18: Displacement](image4)

MATERIAL - STRUCTURAL STEEL

The Vibration analysis has been carried out for the selected steel material, with the selected boundary conditions.

![Figure 19: Directional Deformation](image5)

![Figure 20: Shear Stress](image6)

![Figure 21: Shear Strain](image7)
MATERIAL – ALUMINIUM

The Vibration analysis has been carried out for the selected Aluminium material, with the selected boundary conditions.

![Figure 22: Directional Deformation](image)
![Figure 23: Shear Stress](image)
![Figure 24: Shear Strain](image)

THERMAL ANALYSIS OF PLATE

The following are the boundary conditions to develop the thermal analysis of the plate.

Enter temperature value 100°C → Select convection → select required area → click on apply → Enter film coefficient value → 1000 W/m².K

Enter bulk temperature value 22°C →

![Figure 25: Temperature Contour Plot](image)
![Figure 26: Convection Contour Plot](image)

MATERIAL – STRUCTURAL STEEL

The Thermal analysis has been carried out for the selected steel material, with the selected boundary conditions.

![Figure 27: Temperature Distribution](image)
![Figure 28: Heat Flux](image)

MATERIAL – ALUMINUM

The Thermal analysis has been carried out for the selected Aluminium material, with the selected boundary conditions.
RESULTS & DISCUSSIONS

After completion of the analysis of the plate the results are tabulated in the tabular column.

STRUCTURAL ANALYSIS

The structural analysis results has been plotted in the table 2.

<table>
<thead>
<tr>
<th>Material</th>
<th>Deformation (mm)</th>
<th>Strain</th>
<th>Stress (Mpa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural steel</td>
<td>0.013187</td>
<td>5.3522e-5</td>
<td>10.704</td>
</tr>
<tr>
<td>Aluminum</td>
<td>0.038755</td>
<td>0.00016155</td>
<td>10.985</td>
</tr>
</tbody>
</table>

MODAL ANALYSIS

The Modal analysis results have been plotted in the table 3.

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>MODE 1</th>
<th>MODE 2</th>
<th>MODE 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Deformation (mm)</td>
<td>Frequency (Hz)</td>
<td>Deformation (mm)</td>
</tr>
<tr>
<td>Structural steel</td>
<td>5.1542</td>
<td>1179.8</td>
<td>7.7911</td>
</tr>
<tr>
<td>Aluminum</td>
<td>9.0672</td>
<td>1188.3</td>
<td>13.466</td>
</tr>
</tbody>
</table>

RANDOM VIBRATION ANALYSIS

The Vibration analysis results have been plotted in the table 4.

<table>
<thead>
<tr>
<th>Material</th>
<th>DirectionalDeformation (mm)</th>
<th>Shear Stress (Mpa)</th>
<th>ShearStrain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural steel</td>
<td>7.965e-8</td>
<td>6.1031e-5</td>
<td>7.934e-10</td>
</tr>
<tr>
<td>Aluminum</td>
<td>2.2361e-8</td>
<td>6.0767e-6</td>
<td>2.4307e-10</td>
</tr>
</tbody>
</table>

THERMAL ANALYSIS

The Thermal analysis results have been plotted in the table 5.
Thermo structural Analysis of Structural Plates

### Table 5: Thermal Analysis Results of Plate

<table>
<thead>
<tr>
<th>Material</th>
<th>Temperature</th>
<th>Heat flux (W/mm$^2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structural steel</td>
<td>373.15</td>
<td>1.6043e5</td>
</tr>
<tr>
<td>Aluminum</td>
<td>373.15</td>
<td>1.9189e5</td>
</tr>
</tbody>
</table>

### CONCLUSIONS

Thermal, Static, Modal and Random vibration analysis have been performed, on the plates for Structural Steel and Aluminum using Solid Element. By observing the structural analysis results, for deformation values, the values are less, when Aluminum is used compared to Steel. By observing the modal analysis results, for deformation values, the values are less for Aluminum than steel material.

### REFERENCES
