A. Abstract

The objective of this project is to design, build and test a truss that can withstand a 210 pound point load. The design envelope for this project is 48 inches long, 10 inches in height, and 3.5 inches in width. A 48 inch main beam will be provided and the 210 pound force will be applied at the midpoint of the beam. The members of the truss have cross section restrictions on them. The members have original dimensions of 0.375 inches by 0.375 inches, and an inch and a half on each end of the members must remain at this size. However, for the remainder of each truss member, the width must fall between 0.075 and 0.20 inches. The truss members will be adhesively bonded together using 0.0032 inch thick aluminum gusset plates.

A design was generated and then using tabular data the various failure modes of the truss were determined. The geometry of the truss and the dimensions of the members were altered to obtain a design that could withstand the loading while remaining as light as possible.

B. Body

Member type: Tension

<table>
<thead>
<tr>
<th>Failure Mode</th>
<th>Formula Utilized</th>
<th>Formula Values</th>
</tr>
</thead>
</table>
| Tensile Fracture in the Reduced Cross Section | $P_{1\text{fail}}^T = \sigma_{ut}^W A_{\text{red}}$ | $P_{1\text{fail}}^T = \text{axial tensile force}$  
$\sigma_{ut}^W = 13,000 \text{ psi} [1]$  
(ultimate tensile stress of the basswood parallel to the grain)  
$A_{\text{red}} = \text{area of the reduced cross sectional portion}$ |
| Double Shear Failure of the Gusset/Basswood Adhesive Bond | $P_{2\text{dshear}} = 2(A^*) t_{ut}^W$ | $P_{2\text{dshear}} = \text{tensile failure load}$  
$t_{ut}^W = 949.33 \text{ psi} [2]$  
(ultimate shear failure stress for the basswood parallel to grain – minimum value given)  
$A^* = \text{area of the gusset plate/member adhesive bond}$ |
| Quadruple Shear at the Beam Ends | $P_{3\text{Qshear}} = t_{ut}^W (A_3)$ | $P_{3\text{Qshear}} = \text{tensile failure load}$  
$t_{fall} = 424.35 \text{ psi} [3]$  
(ultimate shear failure stress for the basswood parallel to the grain – minimum value given)  
$A_3 = \text{total area associated with shear failure on four surfaces}$ |
Member type: Compression

<table>
<thead>
<tr>
<th>Failure Mode</th>
<th>Formula Utilized</th>
<th>Formula Values</th>
</tr>
</thead>
</table>
| Global Buckling                  | $P_{cr}/A = 0.0116(l_0/k_{min})^2 - 16.058(l_0/k_{min}) + 4073.9$ | $P_{cr} = \text{axial compression force}$  
$A = bh = 0.375h$  
$k_{min} = h/(12)^{1/2}$  
l_0 = length of member |
| Crushing due to Axial Compressive Force | $\sigma_{ut}^{WC} = P_{2C_{fail}}/A_{red}$ | $\sigma_{ut}^{WC} = 3,000 \text{ psi} [1]$ (compressive ultimate stress parallel to the grain)  
P_{2C_{fail}} = \text{compressive axial load force}$  
$A_{red} = \text{area of the reduced cross sectional portion}$ |
| Double Shear Failure of the Gusset/Basswood Adhesive Bond | $P_{3d_{shear}} = 2(A^*)t_{ut}^{WS}$ | $P_{3d_{shear}} = \text{tensile failure load}$  
t_{ut}^{WS} = 949.33 \text{ psi} [2]$ (ultimate shear failure stress for the basswood parallel to grain – minimum value given)  
$A^* = \text{area of the gusset plate/member adhesive bond}$ |
| Quadruple Shear at the Beam Ends | $P_{4Q_{shear}} = t_{ut}^{WT}(A_d)$ | $P_{3Q_{shear}} = \text{tensile failure load}$  
t_{all} = 424.35 \text{ psi} [3]$ (ultimate shear failure stress for the basswood parallel to the grain – minimum value given)  
$A_3 = 2[1.5(0.375) + 2(1.25)h]$ (total area associated with shear failure on four surfaces) |

C. Results

<table>
<thead>
<tr>
<th>Member Label</th>
<th>Member Type</th>
<th>Axial Design Load</th>
<th>&quot;h&quot; Dimension</th>
<th>Failure Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Tension</td>
<td>213.991 lb</td>
<td>0.075 in</td>
<td>Tensile Fracture</td>
</tr>
<tr>
<td>7</td>
<td>Compression</td>
<td>142.416 lb</td>
<td>0.16782 in</td>
<td>Global Buckling</td>
</tr>
<tr>
<td>8</td>
<td>Tension</td>
<td>148.661 lb</td>
<td>0.075 in</td>
<td>Tensile Fracture</td>
</tr>
<tr>
<td>9</td>
<td>Compression</td>
<td>188.007 lb</td>
<td>0.20 in</td>
<td>Global Buckling</td>
</tr>
<tr>
<td>10</td>
<td>Tension</td>
<td>148.68 lb</td>
<td>0.075 in</td>
<td>Tensile Fracture</td>
</tr>
<tr>
<td>11</td>
<td>Compression</td>
<td>142.43 lb</td>
<td>0.16782 in</td>
<td>Global Buckling</td>
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<tr>
<td>12</td>
<td>Tension</td>
<td>213.912 lb</td>
<td>0.075 in</td>
<td>Tensile Fracture</td>
</tr>
<tr>
<td>14</td>
<td>Tension</td>
<td>157.495 lb</td>
<td>0.075 in</td>
<td>Tensile Fracture</td>
</tr>
<tr>
<td>15</td>
<td>Tension</td>
<td>157.486 lb</td>
<td>0.075 in</td>
<td>Tensile Fracture</td>
</tr>
</tbody>
</table>

D. References
Works Cited:


