Date: 2016-3-11

To: Dr. Gross

From: Group Q: Zachary Anderson, Jerome O’Driscoll, William Jobson, and Jordan Ketring

Subject: AERO 3610 Minimum Weight Structural Design Project Technical Memorandum

Eliminate the blank spaces!
Abstract

The task for the structure being designed is to hold a 210 lb load, but fail at a load value as close to 210 lb as possible. The structure is designed to be suspended from two ends 48 in apart and hold the load in the center. The structure is designed to be minimum weight. Detailed in this memorandum are the potential failure modes for the structure and the loads at which each member is expected to fail.

Several constraints have been put onto the design of the structure. The materials used to construct it are limited to American basswood for the members and aluminum gusset plains for the joints between members. The structure must consist of a main beam that stretches the 48 in span between ends. The dimensions of this main beam are .375 in by .8 in. Other members have dimensions of .375 in by .375 in, but may be trimmed. The aluminum gusset plates at the joint are .032 in thick. The overall structure is limited to a design box that is 48 in long, 3.5 in wide, and 10 in high.
## Member Type: Tension

<table>
<thead>
<tr>
<th>Failure Mode</th>
<th>Formula Used</th>
<th>Formula Values</th>
</tr>
</thead>
</table>
| Tensile Fracture in the Reduced Cross-Section            | $P_{\text{fail}}^T = \sigma_{ut}^W A_{\text{red}}$ | $P_{\text{fail}}^T = \text{axial tensile force}$  
$\sigma_{ut}^W = 13,000 \text{ psi} [1]$ (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 | $P_{d\text{shear}} = 2(A^*)t_{ut}^WS$  | $P_{d\text{shear}} = \text{tensile failure load}$  
$t_{ut}^WS = 1087.6952 \text{ psi} [2]$ (ultimate shear failure stress for the basswood parallel to the grain – average of values given)  
$A^* = \text{area of the gusset plate/member adhesive load}$ |
| Quadruple Shear at the Beam Ends                         | $P_{3\text{shear}} = t_{ut}^WS (A_3)$ | $P_{3\text{shear}} = \text{tensile failure load}$  
$t_{ut}^WS = 467.1801 \text{ psi} [3]$ (ultimate shear failure stress for the basswood parallel to grain – average of values given)  
$A_3 = \text{total area associated with shear failure on four surfaces}$ |
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| Global Buckling                     | \[
\frac{P_{cr}}{0.375h} = -0.0001 \left(\frac{l_0}{h/\sqrt{12}}\right)^3 + \\
0.1306 \left(\frac{l_0}{h/\sqrt{12}}\right)^2 - 45.829 \left(\frac{l_0}{h/\sqrt{12}}\right) + \\
6430.9 \text{ (third-order polynomial curve fit)}
\] | \(P_{cr}\) = critical axial compressive force  \\
h = minimum cross-section height that is necessary to support the applied compressive load  \\
l_0 = length of the reduced cross-section |
| Crushing Failure in the Reduced Cross-Section | \(0.375h = P_{4\text{fail}}/\sigma_{ut}^{WC}\)                                                | \(h\) = minimum cross-section height that is necessary to support the applied compressive load  \\
\(P_{4\text{fail}}\) = compressive failure load  \\
\(\sigma_{ut}^{WC}\) = 3000 psi [1] (ultimate compressive stress for the basswood parallel to the grain) |
| Double Shear Failure of the Member/Gusset Adhesive Bond | \(P_{5_{\text{shear}}} = t_{ut}^{WS} (2A^*)\)                                               | \(P_{5_{\text{shear}}}\) = compressive failure load  \\
t_{ut}^{WS} = 1087.6952 psi [2] (ultimate shear failure stress for the basswood parallel to the grain – average of values given)  \\
A^* = area of the gusset plate/member adhesive load |
| Quadruple Shear Failure of the Member/Gusset Bond | \(A_{3} = P_{6_{\text{shear}}}/t_{ut}^{WS}\)                                                   | \(A_{3}\) = total area associated with shear failure on four surfaces  \\
\(P_{6_{\text{shear}}}\) = compressive failure load  \\
t_{ut}^{WS} = 467.1801 psi [3] (ultimate shear failure stress for the basswood parallel to grain – average of values given) |
<table>
<thead>
<tr>
<th>Member Label</th>
<th>Member Type</th>
<th>Axial Load (lb)</th>
<th>&quot;h&quot; Dimension (in.)</th>
<th>Failure Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>7</td>
<td>Tension</td>
<td>213.426</td>
<td>0.04747</td>
<td>Tensile Fracture</td>
</tr>
<tr>
<td>8</td>
<td>Compression</td>
<td>21.35</td>
<td>0.0221</td>
<td>Global Buckling</td>
</tr>
<tr>
<td>9</td>
<td>Compression</td>
<td>90.938</td>
<td>0.15416</td>
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<td>Tension</td>
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<tr>
<td>12</td>
<td>Compression</td>
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<td>0.15416</td>
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