Need to consider possibility of buckling in support

Material selection

achieve certain (required) buckling load while minimizing

\[ P_{\text{crit}} = \frac{\pi^2 \sigma}{L^2} \quad \text{max. mass} = \pi R^2 L E \]

anneal circular cross-section \( I = \frac{\pi R^4}{4} \)

F = \frac{M}{G M}

maximize \( E/\sigma^2 \) for highest buckling load for given mass

(Previously maximize \( \sigma/\sigma^2 \))
Re-ranking materials

<table>
<thead>
<tr>
<th></th>
<th>$\sigma_t/\sigma$</th>
<th>$E/E^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>$2.8 \times 10^3$</td>
<td>$3.3 \times 10^3$</td>
</tr>
<tr>
<td>Al</td>
<td>$1.25 \times 10^3$</td>
<td>$9.0 \times 10^3$</td>
</tr>
<tr>
<td>Ti</td>
<td>$1.88 \times 10^3$</td>
<td>$5.9 \times 10^3$</td>
</tr>
<tr>
<td>CFRP</td>
<td>$4.66 \times 10^3$</td>
<td>$3.1 \times 10^3$</td>
</tr>
<tr>
<td>Wood</td>
<td>$5.0 \times 10^3$</td>
<td>$3.7 \times 10^3$</td>
</tr>
<tr>
<td>SiC</td>
<td>$1.00 \times 10^3$</td>
<td>$4.5 \times 10^3$</td>
</tr>
</tbody>
</table>

CFRP still looks very good - high $E/E^2$

Wood might be better in welding dominated design.

Reconsider design.
Reconsider design.

\[ F_{AB} = -10 \text{ kN} \]
\[ F_{BC} = -22.4 \text{ kN} \]

BC is the largest member at highest compressive force. Only need to consider this.

Assume that it is a simply supported column.

\[ P_{\text{crit}} = \frac{\pi^2 \cdot E \cdot I}{L^2} \quad \text{given circular cross-section} \]

\[ I = \frac{\pi R^4}{4} \]

\[ \therefore P_{\text{crit}} = \frac{\pi^2 \cdot E \cdot \pi R^4}{4 \cdot L^2} \]

\[ R = \frac{P_{\text{crit}} \times 4 \cdot L^2}{\pi^3 \cdot E} = \frac{22.4 \times 10^3 \times 4 \times 5}{\pi^3 \times 70 \times 10^9} \]

\[ = 0.021 \text{ m}. \]

\[ \therefore \text{area} = \pi R^2 = 0.0014 = 14.30 \text{ mm}^2 \quad \text{(of 32 mm}^2 \text{ before)} \]

\[ \therefore \text{mass increases by} \frac{14.30}{32} = 44.7 \text{ Nm weight, weight:} \]

\[ 0.29 \times 44.7 = 13.0 \text{ kg!} \]