Compression Members (revisited)

- designed for strength & stresses
- designed for serviceability & deflection
- need to design for stability
  - ability to support a specified load without sudden or unacceptable deformations

Effect of Length (revisited)

- long & slender
- short & stubby

Critical Stresses (revisited)

- when a column gets stubby, crushing will limit the load
- real world has loads with eccentricity
**Bracing (revisited)**

- bracing affects shape of buckle in one direction
- both should be checked!

**Wood Columns**

- slenderness ratio $= \frac{L}{d_{\text{min}}} = \frac{L}{d_1}$
  - $d_1$ = smaller dimension
  - $\ell / d \leq 50$ (max)

\[
f_c = \frac{P}{A} \leq F'_c
\]

- where $F'_c$ is the allowable compressive strength parallel to the grain
- bracing common

---

**Allowable Wood Stress**

\[
F'_c = F_c \left( C_D \right) \left( C_M \right) \left( C_t \right) \left( C_F \right) \left( C_p \right)
\]

- where:
  - $F_c$ = compressive strength parallel to grain
  - $C_D$ = load duration factor
  - $C_M$ = wet service factor (1.0 dry)
  - $C_t$ = temperature factor
  - $C_F$ = size factor
  - $C_p$ = column stability factor

**Strength Factors**

- wood properties and load duration, $C_D$
  - short duration
    - higher loads
  - normal duration
    - $> 10$ years

- stability, $C_p$
  - combination curve - tables

\[
F'_c = F^*_c C_p = \left( F_c C_D \right) C_p
\]
**C_p Charts**

**Procedure for Analysis**

1. calculate $L_e/d_{\min}$
   - KL/d each axis, choose largest
2. obtain $F_c$
   - compute $F_{cE} = \frac{0.822E'_{\min}}{\left(\frac{L_e}{d}\right)^2}$
     - where $E'_{\min} = E_{\min}(C_M)(C_T)(C_i)$
3. compute $F_c^* \approx F_c C_D$
4. calculate $F_{cE}/F_c^*$ and get $C_p$ (chart)
5. calculate $F_c' = F_c^* C_p$

**Procedure for Analysis (cont’d)**

6. compute $P_{\text{allowable}} = F_c' \cdot A$
   - or find $f_{\text{actual}} = P/A$
7. is $P \leq P_{\text{allowable}}$? (or $f_{\text{actual}} \leq F_c'$?)
   - yes: OK
   - no: overstressed & no good

**Procedure for Design**

1. guess a size (pick a section)
2. calculate $L_e/d_{\min}$
   - KL/d each axis, choose largest
3. obtain $F_c$
   - compute $F_{cE} = \frac{0.822E'_{\min}}{\left(\frac{L_e}{d}\right)^2}$
     - where $E'_{\min} = E_{\min}(C_M)(C_T)(C_i)$
4. compute $F_c^* \approx F_c C_D$
5. calculate $F_{cE}/F_c^*$ and get $C_p$ (chart)
Procedure for Design (cont’d)

6. calculate \( F'_c = F''_c C_p \)
7. compute \( P_{\text{allowable}} = F'_c A \)
   - or find \( f_{\text{actual}} = P/A \)
8. is \( P \leq P_{\text{allowable}} \)  \( \text{or } f_{\text{actual}} \leq F'_c \) ?
   - yes: OK
   - no: pick a bigger section and go back to step 2.

Specific Column Charts

<table>
<thead>
<tr>
<th>Nominal Area (in²)</th>
<th>6</th>
<th>8</th>
<th>10</th>
<th>12</th>
<th>14</th>
<th>16</th>
<th>18</th>
<th>20</th>
<th>22</th>
<th>24</th>
<th>26</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 x 4</td>
<td>12.25</td>
<td>11.1</td>
<td>7.28</td>
<td>4.94</td>
<td>3.50</td>
<td>2.63</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 x 6</td>
<td>19.25</td>
<td>17.4</td>
<td>14.1</td>
<td>11.4</td>
<td>7.76</td>
<td>5.51</td>
<td>4.14</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 x 8</td>
<td>25.35</td>
<td>22.9</td>
<td>15.1</td>
<td>10.2</td>
<td>7.26</td>
<td>6.46</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 x 8</td>
<td>30.35</td>
<td>27.6</td>
<td>34.8</td>
<td>20.9</td>
<td>16.9</td>
<td>13.4</td>
<td>10.7</td>
<td>8.71</td>
<td>7.17</td>
<td>6.53</td>
<td></td>
</tr>
<tr>
<td>6 x 10</td>
<td>52.25</td>
<td>47.6</td>
<td>63.0</td>
<td>36.1</td>
<td>29.2</td>
<td>23.1</td>
<td>18.5</td>
<td>15.0</td>
<td>13.4</td>
<td>11.3</td>
<td></td>
</tr>
<tr>
<td>8 x 8</td>
<td>56.25</td>
<td>54.0</td>
<td>51.5</td>
<td>48.1</td>
<td>43.5</td>
<td>38.0</td>
<td>32.3</td>
<td>27.4</td>
<td>23.1</td>
<td>19.7</td>
<td>16.6</td>
</tr>
<tr>
<td>8 x 10</td>
<td>71.25</td>
<td>68.4</td>
<td>65.3</td>
<td>61.0</td>
<td>55.1</td>
<td>48.1</td>
<td>41.0</td>
<td>34.7</td>
<td>29.3</td>
<td>24.9</td>
<td>21.4</td>
</tr>
<tr>
<td>8 x 12</td>
<td>86.25</td>
<td>82.8</td>
<td>79.0</td>
<td>73.5</td>
<td>66.7</td>
<td>58.2</td>
<td>49.6</td>
<td>42.0</td>
<td>35.4</td>
<td>32.0</td>
<td>26.0</td>
</tr>
<tr>
<td>10 x 10</td>
<td>90.35</td>
<td>88.4</td>
<td>85.9</td>
<td>83.0</td>
<td>73.0</td>
<td>67.0</td>
<td>60.5</td>
<td>54.0</td>
<td>48.4</td>
<td>44.4</td>
<td>39.5</td>
</tr>
<tr>
<td>10 x 12</td>
<td>109.25</td>
<td>107</td>
<td>104</td>
<td>100</td>
<td>95.6</td>
<td>89.1</td>
<td>81.2</td>
<td>72.6</td>
<td>64.0</td>
<td>56.1</td>
<td>48.9</td>
</tr>
<tr>
<td>10 x 14</td>
<td>128.25</td>
<td>126</td>
<td>122</td>
<td>118</td>
<td>112</td>
<td>105</td>
<td>95.3</td>
<td>85.3</td>
<td>75.1</td>
<td>65.9</td>
<td>57.5</td>
</tr>
<tr>
<td>12 x 12</td>
<td>132.25</td>
<td>130</td>
<td>128</td>
<td>125</td>
<td>122</td>
<td>117</td>
<td>111</td>
<td>104</td>
<td>95.6</td>
<td>85.9</td>
<td>78.3</td>
</tr>
<tr>
<td>14 x 14</td>
<td>182.25</td>
<td>180</td>
<td>178</td>
<td>170</td>
<td>172</td>
<td>168</td>
<td>163</td>
<td>156</td>
<td>148</td>
<td>139</td>
<td>129</td>
</tr>
<tr>
<td>16 x 16</td>
<td>240.25</td>
<td>238</td>
<td>226</td>
<td>234</td>
<td>230</td>
<td>226</td>
<td>222</td>
<td>216</td>
<td>208</td>
<td>200</td>
<td>190</td>
</tr>
</tbody>
</table>

*Load capacity in kips for solid-sawn sections of No. 1 grade Douglas fir-larch with no adjustment for moisture or load duration conditions.

Timber Construction by Code

- light-frame
  - light loads
  - 2x’s
  - floor joists – 2x6, 2x8, 2x10, 2x12 typical at spacings of 12”, 16”, 24”
  - normal spans of 20-25 ft or 6-7.5 m
  - plywood spans between joists
  - stud or load-bearing masonry walls
  - limited to around 3 stories – fire safety

Design of Columns with Bending

- satisfy
  - strength
  - stability
- pick
  - section
**Design**

- **Wood**

\[
\left( \frac{f_c}{F_c'} \right)^2 + \frac{f_{bx}}{F_{bx}' \left( 1 - \frac{f_c}{F_{cEx}} \right)} \leq 1.0
\]

() term – magnification factor for \( P-\Delta \)

\( F'_{bx} \) – allowable bending strength

**Design Steps Knowing Loads**

1. assume limiting stress
   - buckling, axial stress, combined stress
2. solve for \( r, A \) or \( S \)
3. pick trial section
4. analyze stresses
5. section ok?
6. stop when section is ok