BEARING OR CRUSHING

- Bearing Stresses (Compression Perpendicular to the Grain)
  - Allowable stresses for compression perpendicular to the grain are available from tables providing wood properties for various species and grades of lumber.
  - These allowable stresses may be modified (increased) if both of the following criteria are satisfied:
    - Bearing is applied 3 inches or more from the end of the member being stressed.
    - Bearing length is less than 6 inches.
  - When criteria are met, the allowable stresses are modified by the following factor:
    \[
    f' = \frac{0.375}{l}
    \]
    Where \( f' \) is the bearing strength in inches measured along the grain of the wood. For round washers, assume \( l \) is equal to the diameter of washer.

Bearing or Crushing

- To check for a bearing failure (crushing of wood fibers), divide the imposed load by the area of contact and compare this determined actual bearing stress to the allowable bearing stress. If the actual bearing stress exceeds the allowable bearing stress, a failure results.

<table>
<thead>
<tr>
<th>Length of bearing, in.</th>
<th>Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2</td>
<td>1.79</td>
</tr>
<tr>
<td>1</td>
<td>1.37</td>
</tr>
<tr>
<td>1 1/2</td>
<td>1.25</td>
</tr>
<tr>
<td>2</td>
<td>1.19</td>
</tr>
<tr>
<td>3</td>
<td>1.13</td>
</tr>
<tr>
<td>4</td>
<td>1.09</td>
</tr>
<tr>
<td>6 ft or more</td>
<td>1.00</td>
</tr>
</tbody>
</table>
DESIGN OF COLUMN / BRACES

- Wood members subjected to axial compression (compression parallel to the grain).
  - The capacity of a wood column is dependent on the following properties:
    - Cross-sectional area.
    - Slenderness Ratio.
    - Allowable compressive stress parallel to the grain (the basic allowable stress depends on the wood species and grade. This allowable stress may be modified depending on the slenderness ratio).

The slenderness Ratio

- The slenderness ratio is the ratio of the unsupported length \((l)\) of a member to the width \((d)\) of the face of the member under consideration. Two values of the slenderness ratio \((l/d)\) must be calculated for wood members used in construction because buckling can occur about either axis of the cross-section.
- If a column is unbraced, the controlling slenderness ratio (the larger one) will be the one determined by using the dimension of the narrower face. For wood members, \(l/d\) cannot exceed 50.

The following examples will illustrate the calculation of the slenderness ratios:

1. Unbraced Column:
   a. Slenderness ratio parallel to narrow face:
      \[
      \frac{l}{d} = \frac{72}{1.5} = 48.0
      \]
   b. Slenderness ratio parallel to wide face:
      \[
      \frac{l}{d} = \frac{72}{3.5} = 20.57
      \]
      The larger, thus controlling, slenderness ratio is 48
The slenderness Ratio

- Since the column is unbraced in both dimensions, it is intuitive that the slenderness ratio on the narrow face would control.
- Note that if the column were unbraced and 7 foot long, the controlling slenderness ratio would be 56 (over 50) and column would not be permitted without modification:
  - larger member section
  - additional lateral bracing

2. Braced Column:
   a. Slenderness ratio parallel to narrow face:
      \[
      \frac{l}{d} = \frac{108}{3.5} = 30.86
      \]
      Note: Use longest unbraced length - 9 feet
   b. Slenderness ratio parallel to wide face:
      \[
      \frac{l}{d} = \frac{192}{5.5} = 34.91
      \]
      The controlling slenderness ratio is 34.91

Wall Form Design Example

- Design forms for 14 ft high wall to be concreted at the rate of 3 ft per hour, internally vibrated. Assume the mix is made with Type I cement, with no pozzolans or admixtures, and that the temperature of concrete at placing is 60°F. Slump is 4 in. The forms will be used only once, so short-term loading stresses will apply.
- Form grade plywood sheathing \( \frac{3}{4} \) in. thick is available in 4x8-ft sheets, and 4500-lb coil ties are on hand. Framing lumber of No. 2 Douglas Fir-Larch is to be purchased as required.
**Wall Form Design Example**

### STEP 1: FIND PRESSURE.
- The concrete used for this project satisfied the conditions of Table 5-4.
- Using Table 5-4, for \( R = 3 \) ft/hr, and \( T = 60^\circ\)F, the minimum pressure for design is:
  \[
P = 600 \text{ psf}
  \]
- Then the depth of the hydrostatic load zone, for a concrete with a unit weight of 150 pcf is:

### STEP 2: SHEATHING.
- 4x8 sheets of plywood will be used. Use plywood the “strong way” (face grain parallel to plywood span). Design for uniformly spaced supports at 1-ft center-to-center.
- CHECK BENDING
  - Consider a 12-in. wide strip of plywood.
  - For continuous beams (more than three supports) the following equation is used:
  \[
l = 10.95 \sqrt{\frac{FS}{W}}
  \]
Wall Form Design Example

From Table 4-2, the bending stress for plywood is 1545 psi.

\[ f = 1.25 \times 1545 = 1930 \text{ psi} \]

From Table 4-3, the section modulus, \( S \), for ¾-in. plywood is: 0.412 in.³

Substituting in the equation:

\[ l = 10.95 \sqrt{\frac{JS}{w}} \]

\[ l = 10.95 \sqrt{\frac{(1930)(0.412)}{600}} = 10.95 \sqrt{1.33} = 12.61 \text{ in.} \]
Wall Form Design Example

- **CHECK DEFLECTION:**
  - Again considering a 12-in. width of plywood sheathing, check the maximum allowable deflection ($\Delta$) of the sheathing for \( l/360 \) of the span and 1/16 in., whichever is less.
  - From Table 4-2, the values for modulus of elasticity for plywood can be found as \( E = 1,500,000 \text{ psi} \), and Table 4-3 renders the value for the moment of inertia for plies parallel to the span as \( I = 0.197 \text{ in.}^4 \).
  - For \( \Delta = l/360 \):
    \[
    \Delta = 1.69 \frac{E_l}{w} = 1.69 \sqrt[3]{\frac{150000 \times 0.197}{600}} = 1.69 \times 7.897 = 13.35 \text{ in.}
    \]
  - For \( \Delta = 1/16 \):
    \[
    \Delta = 3.22 \frac{E_l}{w} = 3.22 \sqrt[3]{\frac{150000 \times 0.197}{600}} = 3.22 \times 4.41 = 15.22 \text{ in.}
    \]

- **CHECK ROLLING SHEAR:**
  - From Table 4-2, allowable Fs (rolling shear stress) can be found to be \( F_s = 57 \text{ psi} \), which should be multiplied by 1.25 for short-term loading. Therefore, the allowable rolling shear stress is: \( F_s = 57 \times 1.25 = 71 \text{ psi} \)
  - From Table 4-3, the value of the rolling shear constant, \( lw/Q \), can be found as 6.762.
  - Use the equation for maximum shear for a continuous plyform and solve for \( L \):
    \[
    L = \frac{F_s}{0.6w} \times \frac{71}{0.6 \times 600} \times 6.762 = 1.33 \text{ ft.} = 16.0 \text{ in.}
    \]

- **SPACING OF THE STUDS:**
  - From the above calculations, the smallest value obtained for \( l \) is 12.61 in. (bending governs), meaning that the studs CANNOT be placed any further than 12.61 inches apart.
  - We are using 8-ft.-wide plywood sheets. The sheets should have stud support at the joints. Therefore an equal-spacing of studs at 12-inches satisfies all conditions.

  : USE STUDS WITH SPACING OF 1-FT.