1.11 The rigid bar $EFG$ is supported by the truss system shown. Knowing that the member $CG$ is a solid circular rod of 0.75-in. diameter, determine the normal stress in $CG$.

Using portion $EFGCB$ as a free body,

\[ \sum F_y = 0: \quad \frac{2}{3} F_{AE} - 3600 = 0 \]

\[ F_{AE} = 6000 \text{ lb}. \]

Using beam $EFG$ as a free body,

\[ \sum M_E = 0: \quad -(4) \frac{2}{3} F_{AE} + (4) \frac{3}{5} F_{CG} = 0 \]

\[ F_{CG} = F_{AE} = 6000 \text{ lb}. \]

Cross sectional area of member $CG$:

\[ A_{CG} = \frac{\pi d^2}{4} = \frac{\pi}{4} (0.75^2) = 0.44179 \text{ in}^2 \]

Normal stress in $CG$.

\[ \sigma_{CG} = \frac{F_{CG}}{A_{CG}} = \frac{6000}{0.44179} = 13,580 \text{ psi} \]

\[ \sigma_{CG} = 13.58 \text{ ksi}. \]

1.12 The rigid bar $EFG$ is supported by the truss system shown. Determine the cross-sectional area of member $AE$ for which the normal stress in the member is 15 ksi.

Using portion $EFGCB$ as a free body,

\[ \sum F_y = 0: \quad \frac{2}{3} F_{AE} - 3600 = 0 \]

\[ F_{AE} = 6000 \text{ lb} = 6.00 \text{ kips} \]

Stress in member $AE$:

\[ \sigma_{AE} = 15 \text{ ksi} \]

\[ \sigma_{AE} = \frac{F_{AE}}{A_{AE}} \]

\[ A_{AE} = \frac{F_{AE}}{\sigma_{AE}} = \frac{6.00}{15} = 0.400 \text{ in}^2 \]
Problem 1.15

The wooden members $A$ and $B$ are to be joined by plywood splice plates that will be fully glued on the surfaces in contact. As part of the design of the joint, and knowing that the clearance between the ends of the members is to be 6 mm, determine the smallest allowable length $L$ if the average shearing stress in the glue is not to exceed 700 kPa.

There are four separate areas that are glued. Each of these areas transmits one half the 15 kN load. Thus

$$F = \frac{1}{2} P = \frac{1}{2} (15) = 7.5 \text{ kN} = 7500 \text{ N}$$

Let $l$ = length of one glued area and $W = 75 \text{ mm} = 0.075 \text{ m}$ be its width.

For each glued area,

$$A = lw$$

Average shearing stress:

$$\tau = \frac{F}{A} = \frac{F}{lw}$$

The allowable shearing stress is $\tau = 720 \times 10^3 \text{ Pa}$

Solving for $l$,

$$l = \frac{F}{\tau W} = \frac{7500}{(720 \times 10^3)(0.075)} = 0.142857 \text{ m} = 142.85 \text{ mm}$$

Total length $L$:

$$L = l + \text{(gap)} + l = 142.85 + 6 + 142.85$$

$$L = 292 \text{ mm}$$

Problem 1.16

When the force $P$ reached 1600 lb, the wooden specimen shown failed in shear along the surface indicated by the dashed line. Determine the average shearing stress along that surface at the time of failure.

Area being sheared:

$$A = (3 \text{ in})(0.6 \text{ in}) = 1.8 \text{ in}^2$$

Force:

$$P = 1600 \text{ lb}$$

Shearing stress:

$$\tau = \frac{P}{A} = \frac{1600}{1.8} = 889$$

$$\tau = 889 \text{ psi}$$
Problem 1.23

1.23 A 6-mm-diameter pin is used at connection C of the pedal shown. Knowing that $P = 500$ N, determine (a) the average shearing stress in the pin, (b) the nominal bearing stress in the pedal at C, (c) the nominal bearing stress in each support bracket at C.

![Diagram of the pedal and pin connections]

---

(a) $\tau_{\text{pin}} = \frac{C}{A_{\text{pin}}} = \frac{\frac{1}{2}C}{\frac{\pi}{4}d^2} = \frac{2C}{\pi d^2} = \frac{(2)(1300)}{(\pi(6\times10^{-3}))^2} = 23.0 \times 10^6 \text{ Pa}$

$\tau_{\text{pin}} = 23.0 \text{ MPa}$

(b) $\sigma_b = \frac{C}{A_b} = \frac{C}{(6\times10^{-3})(9\times10^{-3})} = 24.1 \times 10^6 \text{ Pa}$

$\sigma_b = 24.1 \text{ MPa}$

(c) $\sigma_b = \frac{\frac{1}{2}C}{A_b} = \frac{C}{2d} = \frac{1300}{(2)(6\times10^{-3})(5\times10^{-3})} = 21.7 \times 10^6 \text{ Pa}$

$\sigma_b = 21.7 \text{ MPa}$

Draw free body diagram of ACD.

Since ACD is a 3-force member, the reaction at C is directed toward point E, the intersection of the lines of action of the other two forces.

From geometry, $CE = \sqrt{300^2 + 125^2} = 325$ mm.

$\Sigma F_y = 0$: $\frac{125}{325}C - P = 0$ \[ C = \frac{325}{125}P = (2.6)(500) = 1300 \text{ N} \]

---

The free body diagram is not fully drawn in the image, but the description indicates the forces and reactions acting on the pedal and pin connection.
1.31 Two wooden members of uniform rectangular cross section are joined by the simple glued scarf splice shown. Knowing that \( P = 11 \text{ kN} \), determine the normal and shearing stresses in the glued splice.

\[
\begin{align*}
\theta &= 90^\circ - 45^\circ = 45^\circ \\
P &= 11 \text{ kN} = 11 \times 10^3 \text{ N} \\
A_0 &= (150)(75) = 11.25 \times 10^3 \text{ mm}^2 = 11.25 \times 10^{-3} \text{ m}^2 \\
\sigma &= \frac{P \cos^2 \theta}{A_0} = \frac{(11 \times 10^3 \cos^2 45^\circ)}{11.25 \times 10^{-3}} \\
&= 4.89 \times 10^3 \text{ Pa} \\
\tau &= \frac{P \sin 2\theta}{2A_0} = \frac{(11 \times 10^3 \sin 90^\circ)}{2(11.25 \times 10^{-3})} \\
&= 4.89 \times 10^3 \text{ Pa} \\
\sigma &= 489 \text{ kPa} \\
\tau &= 489 \text{ kPa}
\end{align*}
\]

1.32 Two wooden members of uniform rectangular cross section are joined by the simple glued scarf splice shown. Knowing that the maximum allowable tensile stress in the glued splice is 560 kPa, determine (a) the largest load \( P \) that can be safely applied, (b) the corresponding shearing stress in the splice.

\[
\begin{align*}
\theta &= 90^\circ - 45^\circ = 45^\circ \\
A_0 &= (150)(75) = 11.25 \times 10^3 \text{ mm}^2 = 11.25 \times 10^{-3} \text{ m}^2 \\
\sigma &= 560 \text{ kPa} = 560 \times 10^3 \text{ Pa} \\
\sigma &= \frac{P \cos^2 \theta}{A_0} \\
\sigma &= \frac{(560 \times 10^3 \cos^2 45^\circ)}{} \\
&= 12.60 \times 10^3 \text{ N} \\
P &= 12.60 \text{ kN} \\
\tau &= \frac{P \sin \theta \cos \theta}{A_0} = \frac{(12.60 \times 10^3 \sin 45^\circ \cos 45^\circ)}{11.25 \times 10^{-3}} \\
&= 560 \times 10^3 \text{ Pa} \\
\tau &= 560 \text{ kPa}
\end{align*}
\]
Problem 1.43

1.43 The two wooden members shown, which support a 16-kN load, are joined by plywood splices fully glued on the surfaces in contact. The ultimate shearing stress in the glue is 2.5 MPa and the clearance between the members is 6 mm. Determine the required length \( L \) of each splice if a factor of safety of 2.75 is to be achieved.

There are 4 separate areas of glue. Each glue area must transmit 8 kN of shear load.

\[
P = 8 \text{ kN} = 8 \times 10^3 \text{ N}
\]

Required ultimate load.

\[
P_u = (F.S.) P = (2.75)(8 \times 10^3) = 22 \times 10^3 \text{ N}
\]

Required length of each glue area.

\[
P_u = \tau_u A = \tau_u l w
\]

\[
l = \frac{P_u}{\tau_u w} = \frac{22 \times 10^3}{(2.5 \times 10^6)(0.125)} = 70.4 \times 10^{-3} \text{ m}
\]

Length of splice:

\[
L = 2l + c = (2)(70.4 \times 10^{-3}) + 0.006 = 0.1468 \times 10^{-3} \text{ m}
\]

\[
L = 146.8 \text{ mm}
\]

Problem 1.44

1.44 For the joint and loading of Prob. 1.43, determine the factor of safety, knowing that the length of each splice is \( L = 180 \text{ mm} \).

1.43 The two wooden members shown, which support a 16-kN load, are joined by plywood splices fully glued on the surfaces in contact. The ultimate shearing stress in the glue is 2.5 MPa and the clearance between the members is 6 mm. Determine the required length \( L \) of each splice if a factor of safety of 2.75 is to be achieved.

There are 4 separate areas of glue. Each glue area must transmit 8 kN of shear load.

\[
P = 8 \text{ kN} = 8 \times 10^3 \text{ N}
\]

Length of splice. \( L = 2l + c \) where \( l = \text{length of glue} \) and \( c = \text{clearance} \).

\[
l = \frac{1}{2}(L - c) = \frac{1}{2}(0.180 - 0.006) = 0.087 \text{ m}
\]

Area of glue.

\[
A = lw = (0.087)(0.125) = 10.875 \times 10^{-3} \text{ m}
\]

Ultimate load.

\[
P_u = \tau_u A = (2.5 \times 10^6)(10.875 \times 10^{-3}) = 27.1875 \times 10^3 \text{ N}
\]

Factor of safety.

\[
F.S. = \frac{P_u}{P} = \frac{27.1875 \times 10^3}{8 \times 10^3} \quad \text{F.S.} = 3.40
\]
Problem 1.65

1.65 Two wooden members of 70 × 110-mm uniform rectangular cross section are joined by the simple glued scarf splice shown. Knowing that the maximum allowable shearing stress in the glued splice is 500 kPa, determine the largest axial load \( P \) that can be safely applied.

\[
A_o = (0.070 \text{ m})(0.110 \text{ m}) = 7.7 \times 10^{-3} \text{ m}^2
\]

\[
\theta = 90^\circ - 20^\circ = 70^\circ
\]

\[
\tau = \frac{P}{A_o \sin \theta \cos \theta}
\]

\[
P = \frac{A_o \tau}{\sin \theta \cos \theta} = \frac{(7.7 \times 10^{-3})(500 \times 10^3)}{\sin 70^\circ \cos 70^\circ} = 11.98 \times 10^3 \text{ N}
\]

\[P = 11.98 \text{ kN}\]
Problem 1.66

The 2000-lb load can be moved along the beam $BD$ to any position between stops at $E$ and $F$. Knowing that $\sigma_{\text{all}} = 6$ ksi for the steel used in rods $AB$ and $CD$, determine where the stops should be placed if the permitted motion of the load is to be as large as possible.

Permitted member forces:

$AB: (F_{AB})_{\text{max}} = \sigma_{\text{all}} A_{AB} = (6)(\frac{\pi}{4})(\frac{3}{2})^2$

$= 1.17810 \text{ kips}$

$CD: (F_{CD})_{\text{max}} = \sigma_{\text{all}} A_{CD} = (6)(\frac{\pi}{4})(\frac{5}{2})^2$

$= 1.84078 \text{ kips}$

Use member $BEFD$ as a free body.

$P = 2000 \text{ lb} = 2.000 \text{ kips}$

$\sum M_D = 0$:

$-(60)F_{AB} + (60 - x_E)P = 0$

$60 - x_E = \frac{60 F_{AB}}{P} = \frac{(60)(1.17810)}{2.000}$

$x_E = 35.343$ in.

$\sum M_B = 0$:

$60 F_{CD} - x_P = 0$

$x_F = \frac{60 F_{CD}}{P} = \frac{(60)(1.84078)}{2.000}$

$x_F = 55.2$ in.