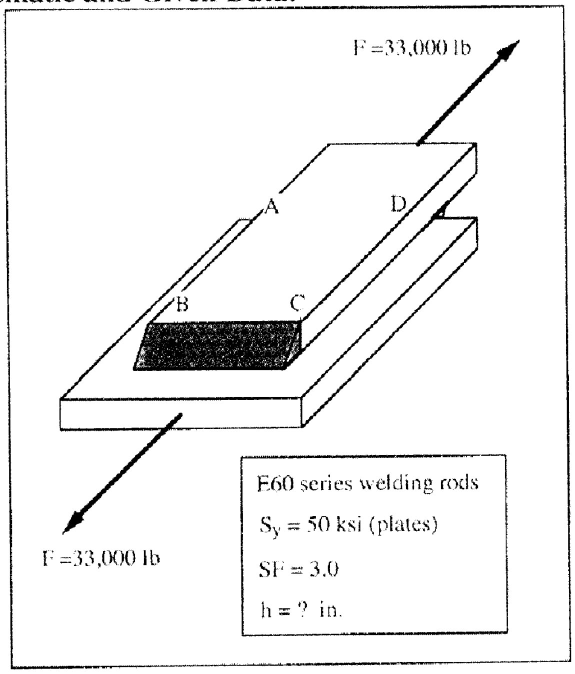
SOLUTION (11.1)

Known: Two steel plates with $S_y = 50$ ksi are joined using transverse-loaded fillet welds. Each weld is 4-inches long. E60 series welding rods are used, and good welding practice is followed. A force of 33,000 lb is applied. The safety factor is 3.0.

Find: Determine the minimum leg length that must be used.

Schematic and Given Data:



Assumptions:

1. The throat length is given by t = 0.707 h.
2. The weld efficiency is 100%.
3. The critical stress is at the minimum throat section, where the area is tL. This cross section carries the entire load F in shear.

Analysis:

1. With throat length, t = 0.707 h, the throat area, A = (0.707)(8)h = 5.66h in.^{2}
2. From Section 11.4, estimated yield strength of the weld is

   $S_y = 60 \text{ ksi} - 12 = 48 \text{ ksi}$

3. From the distortion-energy theory, $S_{ys} = (48)(0.58) = 27.84$ ksi.

4. $F = \frac{S_{ys}A}{SF}$ or $33{,}000 \text{ lb} = \frac{(27.84 \text{ ksi})(5.66h \text{ in.}^2)}{3.0}$. Thus, h = 0.63 in. ■

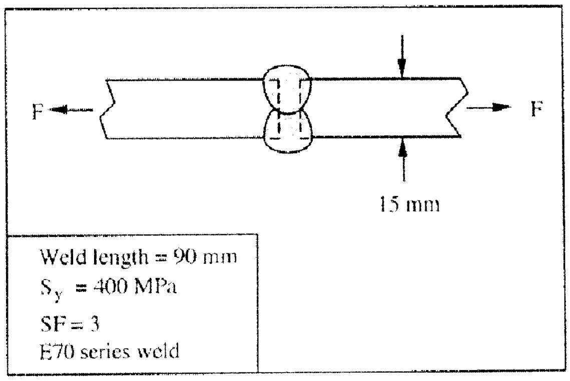
Comment: Because of assumption 3, the solution is less rigorous.

SOLUTION (11.6)

Known: Two steel plates with S_y = 400 MPa are butt welded together with E70 series welding rods. The weld length is known.

Find: Determine the maximum tensile load that can be applied to the joint with a safety factor of 3.

Schematic and Given Data:



Assumption: The weld efficiency is 100%.

Analysis:

1. From Section 11.4, the weld rod has a yield strength of

$$S_y = (70 - 12)\text{ ksi}\left(\frac{6.89\text{ MPa}}{\text{ksi}}\right) = 399.6\text{ MPa}$$

Since 399.6 < 400 the weld should yield first.

2. With the assumed 100% efficiency, the maximum tensile load that can be applied is

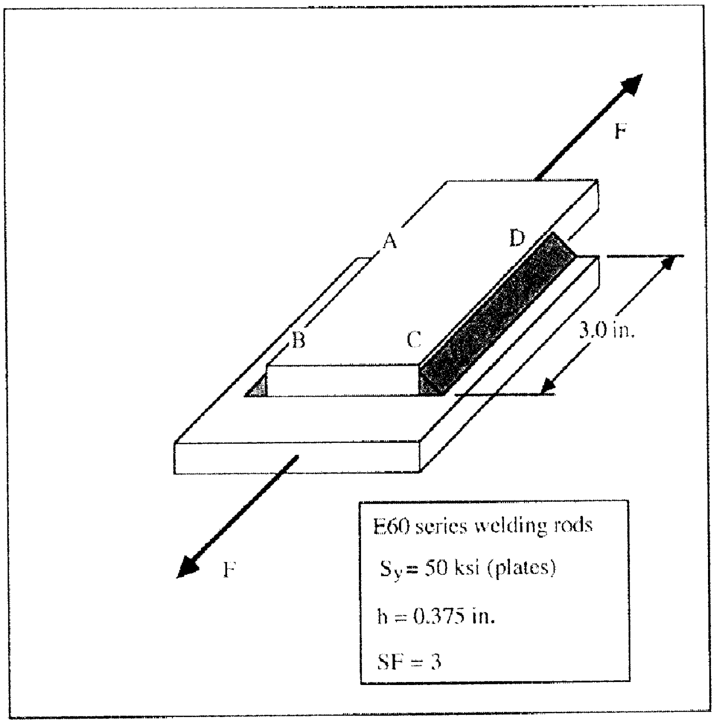
$$F = \frac{S_y A}{SF} = \frac{(399.6 \times 10^6\text{ N/m}^2)(0.015\text{ m})(0.09\text{ m})}{3} = 179.8\text{ kN}$$ ■

SOLUTION (11.9)

Known: Two steel plates are joined using 3/8 in. parallel-loaded fillet welds. The yield strength, S_y, and the length of the welds are known. The safety factor is 3.

Find: Determine the maximum tensile load that can be applied.

Schematic and Given Data:

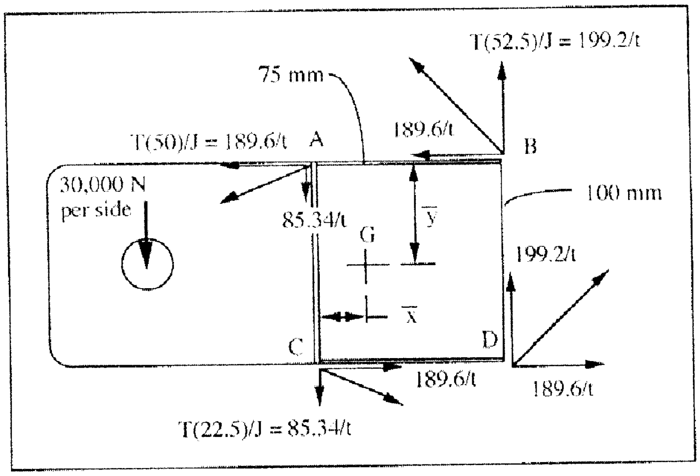


Assumptions:
1. The throat length is given by t = 0.707 h.
2. The weld efficiency is 100%.

Analysis:
1. With t = 0.707 h, the throat area = (0.707)(3/8)(6) = 1.59 in.^{2}.
2. From Section 11.4, the yield strength of the weld material is $S_y = 60 - 12 = 48$ ksi.
3. Using the distortion energy theory, $S_{sy} = 0.58\, S_y = 0.58(48) = 27.8$ ksi.
4. Thus, $F = S_{sy}A/SF = (27{,}800)(1.59)/3 = 14{,}700$ lb. ■

Analysis:

1.



2. Calculating the center of gravity, G, of the weld-segment.

$$\bar{x} = \frac{\Sigma A_i x_i}{\Sigma A} = \frac{100\,t\,(0) + 75\,t\,(37.5) + 75\,t\,(37.5)}{250\,t} = 22.5 \text{ mm}$$

$\bar{y} = 50$ mm (by symmetry)

3. The polar moment of inertia of the weld pattern about G is the polar moment of inertia of one vertical plus the two horizontal welds.

$$J = J_v + 2J_h = \frac{100^3 t}{12} + 100\,t(22.5^2 + 0) + 2\left[\frac{75^3 t}{12} + 75t\,(50^2 + 15^2)\right]$$

$J = 613{,}020t \text{ mm}^4$

4. $T = (30{,}000 \text{ N})(55 \text{ mm} + 22.5 \text{ mm}) = 2.325 \times 10^6$ N·mm

Torsional stress components are shown in the above figure at A, B, C, and D.

Direct shear adds a downward vector of $\frac{V}{A} = \frac{30{,}000 \text{ N}}{(250 \text{ mm})t} = \frac{120}{t}$ at each location.

Thus, the highest resultant stress is at C.

5. At C, $\tau = \frac{1}{t}\sqrt{189.6^2 + (85.34 + 120)^2} = \frac{280.9}{t}$

6. From Section 11.4, $S_y = S_u - 12$ ksi $= 60 - 12 = 48$ ksi. From the distortion-energy theory,

$S_{ys} = 0.58\,S_y = 0.58(48) = 27.84 \text{ ksi} = (27.84 \text{ ksi})\left(\frac{6.89 \text{ MPa}}{\text{ksi}}\right) = 191.9 \text{ MPa}$

7. $\frac{280.9}{t} = \frac{S_{ys}}{SF} = \frac{191.9}{3}$; $t = 4.39$ mm

$h = \frac{t}{0.707} = \frac{4.39}{0.707} = 6.21$ mm

Conservatively we use h = 7 mm. ■

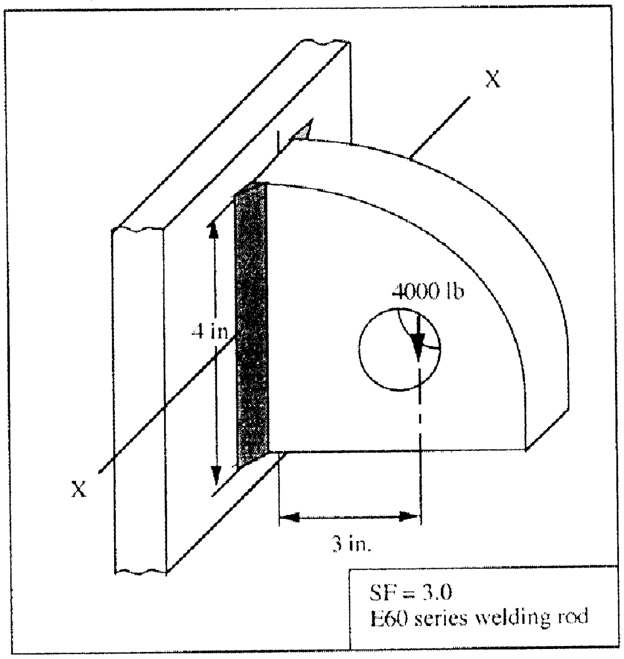
Comment: For calculating transverse shear and axial stress, the throat dimension t is assumed to be in a 45° orientation. But the throat dimension t is assumed to be in the plane of the weld pattern when computing torsional stresses. Also, for calculating the weld dimension h, t is assumed to be in a 45° plane. This simplification although not theoretically correct is justified for most engineering applications.

SOLUTION (11.14)

Known: A bracket supports a 4000 lb load. A fillet weld extends for the full 4 in. lengtl on both sides. Series E60 welding rod is used. The safety factor is 3.0.

Find: Calculate the minimum weld size required.

Schematic and Given Data:



Assumptions:

1. The throat length is given by t = 0.707 h.
2. The weld efficiency is 100%.

Analysis:

1. The stress due to direct shear is given by:

$$\tau = \frac{V}{A} = \frac{4000\text{ lb}}{8t} = \frac{500}{t}$$

2. The stress due to bending is given by:

$\sigma = \frac{Mc}{I}$ where

$M = (3\text{ in.})(4000\text{ lb}) = 12{,}000\text{ lb.in}$

$$I = 2\left(\frac{L^3t}{12}\right) = 2\left(\frac{4^3t}{12}\right) = 10.67t\text{ in.}^4;\ c = 2\text{ in. Therefore, } \sigma = \frac{12{,}000(2)}{10.67\,t} = \frac{2249.3}{t}$$

3. Vectorally adding σ and τ: Resultant stress $= \frac{1}{t}\sqrt{500^2 + 2249.3^2} = \frac{2304}{t}$

4. From Section 11.4 in the text, $S_y = 60 - 12 = 48$ ksi. Using the distortion-energy theory, $S_{ys} = 0.58\ S_y = 0.58(48) = 27.84$ ksi

5. $\frac{2304}{t} = \frac{S_{ys}}{SF} = \frac{27,840}{3.0}$; $t = 0.25$ in.

6. Since $t = 0.707\ h$, $h = \frac{t}{0.707} = \frac{0.25}{0.707} = 0.35$ in. ■