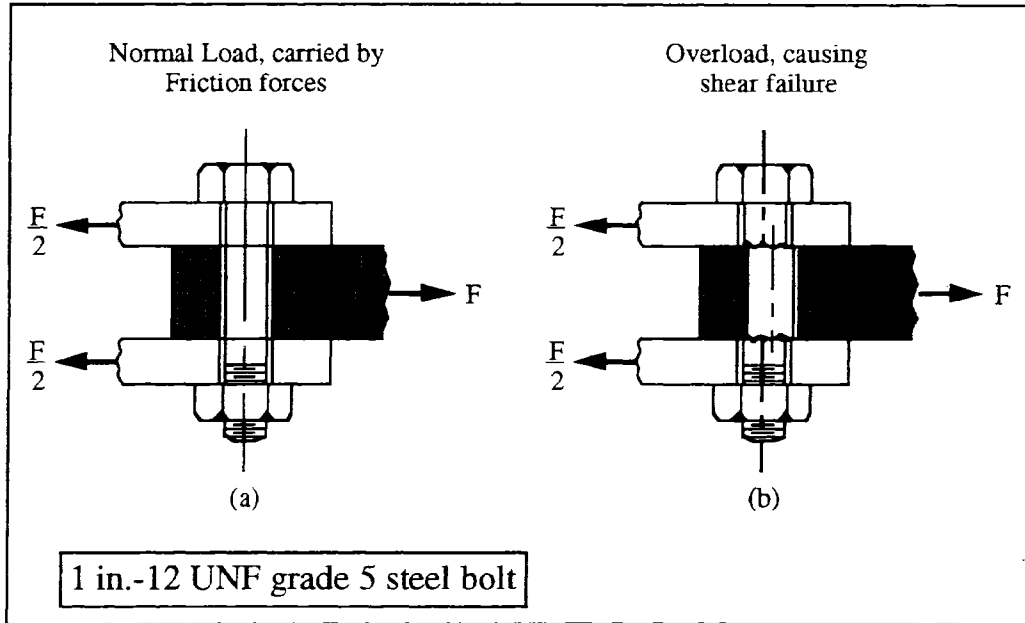


### SOLUTION (10.30)

**Known:** A known steel bolt clamps three steel plates and is loaded in double shear.

**Find:** Determine the force capacity of the joint.

#### Schematic and Given Data:



#### Assumptions:

1. The bolt is tightened to its full proof load; that is,  $F_i = S_p A_t$ .
2. The bolt fails in double shear.
3. The bolt and plates have adequate strength to prevent other failure modes.
4. The wrench-torque variation is roughly  $\pm 30$  percent.
5. There is a 10 percent initial loss in tension during the first few weeks of service.

#### Analysis:

1. For 1 in.-12 UNF grade 5 steel bolt, Table 10.1 gives  $A_t = 0.663 \text{ in.}^2$ , and Table 10.4 shows that  $S_p = 85 \text{ ksi}$ . Therefore, the initial tension is:

$$\begin{aligned} F_i &= S_p A_t \\ &= 85,000(0.663) \\ &= 56,355 \text{ lb} \end{aligned}$$

With  $\pm 30\%$  torque-wrench variation and 10% initial tension loss during the first few weeks of service, a conservative assumption of working value of  $F_i$  is about 35,500 lb.

2. The coefficient for semi-polished steel is approximately 0.3, and for sand or grit-blasted steel approximately 0.5. For this case, a friction of 0.4 is assumed. Therefore, the force required to slip each of two interface =  $35,500 \times 0.4 = 14,200 \text{ lb}$ .

Hence, the value of  $F$  required to overcome friction is in the range of 28,000 lb.

3. For the two shear planes involved, the larger value of force that can be transmitted through the bolt itself is  $F = 2 S_{ys} A$ , where  $A =$  the area of the bolt at the shear plane =  $\pi(1)^2/4 = 0.785 \text{ in.}^2$  and  $S_{ys} = 0.58 S_y = 0.58(92) = 53 \text{ ksi}$ . Thus, for yielding of the two shear planes,

$$F = 2(53,000)(0.785) = 83,210 \text{ lb}$$

4. The estimated 83,210 lb would increase the shear stress to the shear yield strength over the entire cross section of the shear planes. A further increase in load would cause total shear yield failure. The estimated load for complete failure is, ■

$$F = 2AS_{us}, \text{ where from Eq. (10.16), } S_{us} \approx 74 \text{ ksi}$$

$$\text{Therefore, } F = 2(0.785)(74 \times 10^3) = 116,180 \text{ lb}$$

