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**SOLUTION (10.31)**

**Known:** Three SAE class 9.8 steel bolts with a specified safety factor are used to attach a bracket of known geometry that supports a known vertical load.

**Find:** Determine an appropriate bolt size.

**Schematic and Given Data:** See Figure 10.32 of the textbook. The safety factor,  $SF = 10$ .

**Assumptions:**

1. The clamped members are rigid and do not deflect with load.
2. The load tends to rotate the bracket about point A.
3. The shear loads are carried by friction.

**Design Analysis:**

1. With the assumption of rigid clamped members and shear loads carried by friction, the eccentricity of the applied load has no effect on bolt loading. With the bracket tending to rotate about point A, the strain (and hence the load) imposed upon the two bolts D is four times that imposed upon bolt E. Let  $F_D$  and  $F_E$  denote the tensile loads carried by bolts D and E. Summation of moments about point A for the *design overload* of  $24 \text{ kN}(10) = 240 \text{ kN}$  gives

$$\begin{aligned} 500(240) &= 100F_E + 400F_D + 400F_D \\ &= 25F_D + 400F_D + 400F_D \end{aligned}$$

or

$$F_D = 145.45 \text{ kN}$$

2. Class 9.8 steel has a proof strength of 650 MPa. Hence the required tensile stress area is

$$A_t = \frac{145,450}{650} = 224 \text{ mm}^2$$

Reference to Table 10.2 indicates the required thread size to be  $M20 \times 2.5$ .

**Comments:**

1. Because of appearance, and to provide additional safety, a larger bolt size might be selected.
2. As in Sample Problem 10.2, the bolt size required is independent of  $k_b$ ,  $k_c$ , and  $F_i$ , *except* for the fact that  $F_i$  must be large enough to justify the assumption that shear forces are transmitted by friction. With an assumed coefficient of friction of 0.4 and an initial tension (after considering tightening variations and initial relaxation) of at least  $0.55S_pA_t$ , compare the available shear friction force (using 16-mm bolts) with the applied shear overload:

$$\begin{aligned}\text{Available friction force} &= (3 \text{ bolts})(0.55S_pA_t)f \\ &= 3(0.55)(650 \text{ MPa})(245 \text{ mm}^2)(0.4) \\ &= 105,105 \text{ N}\end{aligned}$$

which represents a margin of safety with respect to the 24-kN applied overload, plus the rotational tendency caused by the overload eccentricity. The second effect is dealt with in Sample Problem 10.5.