Example 8–7

Shown in Fig. 8–28 is a 15- by 200-mm rectangular steel bar cantilevered to a 250-mm steel channel using four tightly fitted bolts located at A, B, C, and D. Assume the bolt threads do not extend into the joint.

For the $F = 16$ kN load shown find

(*a*) The resultant load on each bolt

(*b*) The maximum shear stress in each bolt

(*c*) The maximum bearing stress

(*d*) The critical bending stress in the bar

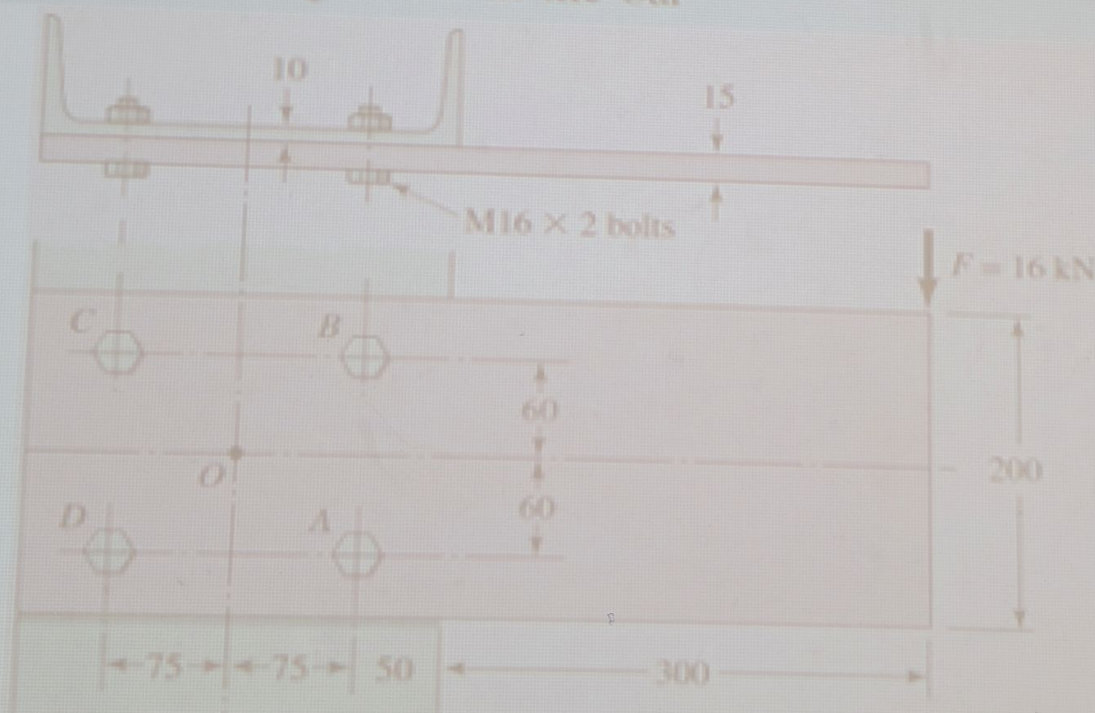

Fig. 8–28

Example 8–7 (continued)

(*a*) Point O, the centroid of the bolt group in Fig. 8–28, is found by symmetry. If a free-body diagram of the beam were constructed, the shear reaction V would pass through O and the moment reactions M would be about O. These reactions are

$$V = 16\text{ kN} \qquad M = 16(300 + 50 + 75) = 6800\text{ N}\cdot\text{m}$$

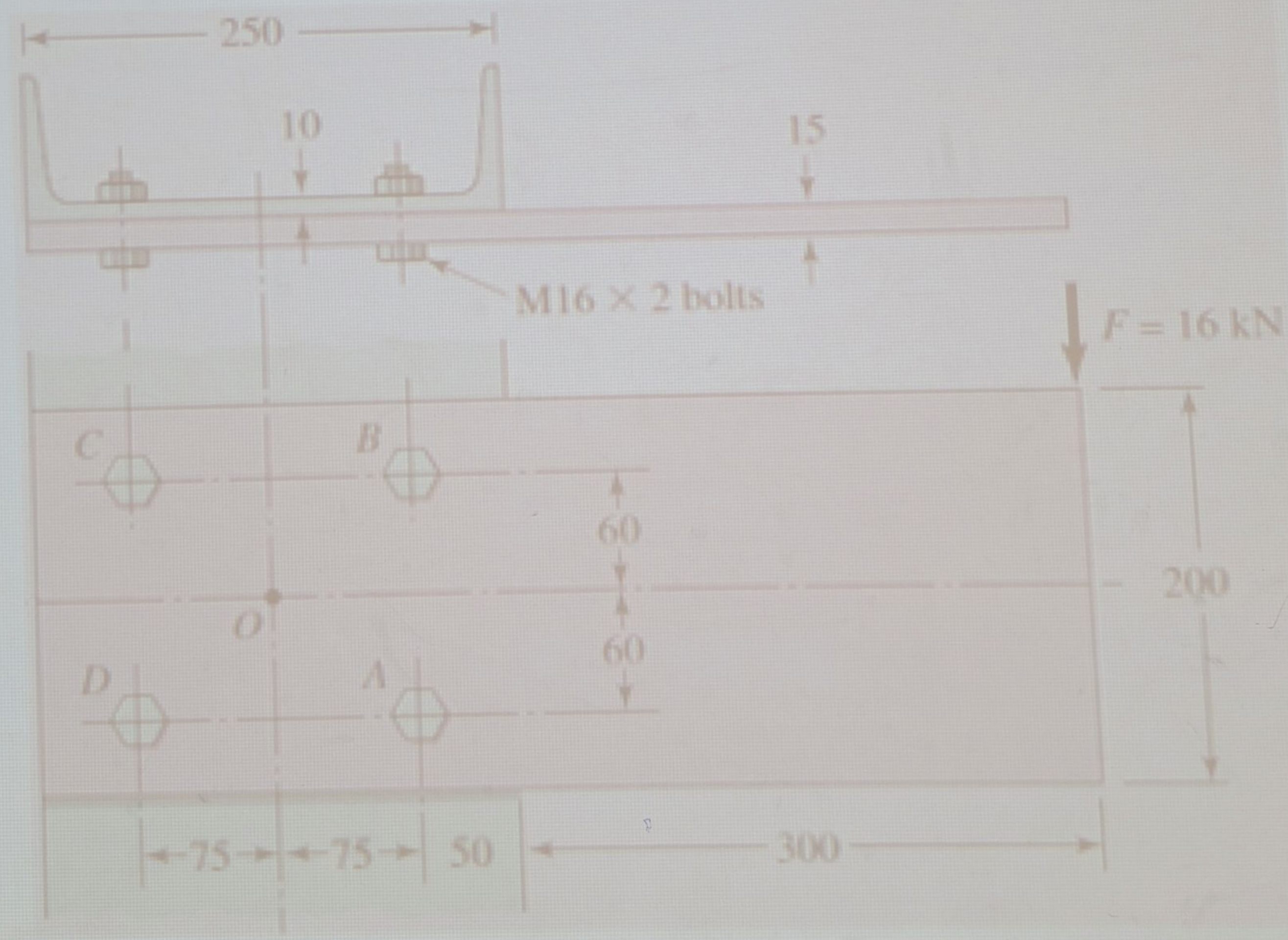

Fig. 8–28

Example 8–7 (continued)

In Fig. 8–29, the bolt group has been drawn to a larger scale and the reactions and resultants are shown. The distance from the centroid to the center of each bolt is

$$r = \sqrt{(60)^2 + (75)^2} = 96.0\ \text{mm}$$

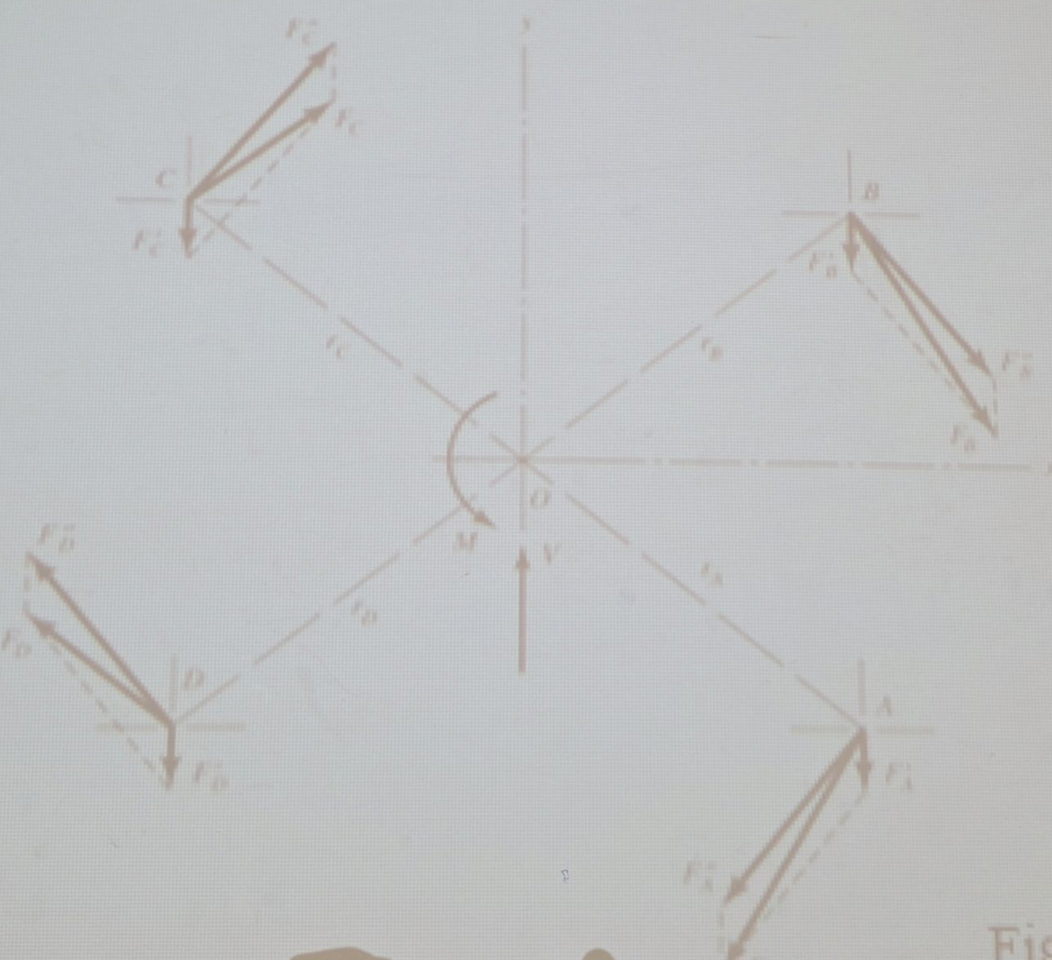

Fig. 8–29

Example 8–7 (continued)

The resultants are found as follows. The primary shear load per bolt is

$$F' = \frac{V}{n} = \frac{16}{4} = 4 \text{ kN}$$

Since the r_n are equal, the secondary shear forces are equal, and Eq. (8–57) becomes

$$F'' = \frac{Mr}{4r^2} = \frac{M}{4r} = \frac{6800}{4(96.0)} = 17.7 \text{ kN}$$

The primary and secondary shear forces are plotted to scale in Fig. 8–29 and the resultants obtained by using the parallelogram rule. The magnitudes are found by measurement (or analysis) to be

$$F_A = F_B = 21.0 \text{ kN} \qquad \text{Answer}$$

$$F_C = F_D = 14.8 \text{ kN} \qquad \text{Answer}$$

Example 8–7 (continued)

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$$F_C = F_D = 14.8 \text{ kN} \qquad \text{Answer}$$

Example 8–7 (continued)

(*b*) Bolts A and B are critical because they carry the largest shear load. The problem stated to assume that the bolt threads are not to extend into the joint. This would require special bolts. If standard nuts and bolts were used, the bolts would need to be 46 mm long with a thread length of $L_T = 38$ mm. Thus the unthreaded portion of the bolt is $46 - 38 = 8$ mm long. This is less than the 15 mm for the plate in Fig. 8–28, and the bolts would tend to shear along the minor diameter at a stress of $\tau = F/A_s = 21.0(10)^3/144 = 146$ MPa. Using bolts not extending into the joint, or shoulder bolts, is preferred. For this example, the body area of each bolt is $A = \pi(16^2)/4 = 201.1\ \mathrm{mm}^2$, resulting in a shear stress of

$$\tau = \frac{F}{A} = \frac{21.0(10)^3}{201.1} = 104\ \text{MPa} \qquad \text{Answer}$$

Example 8–7 (continued)

(*c*) The channel is thinner than the bar, and so the largest bearing stress is due to the pressing of the bolt against the channel web. The bearing area is $A_b = td = 10(16) = 160\ \text{mm}^2$. Thus the bearing stress is

$$\sigma = -\frac{F}{A_b} = -\frac{21.0(10)^3}{160} = -131\ \text{MPa} \qquad \text{Answer}$$

Example 8–7 (continued)

(*d*) The critical bending stress in the bar is assumed to occur in a section parallel to the y axis and through bolts A and B. At this section the bending moment is

$$M = 16(300 + 50) = 5600\ \text{N} \cdot \text{m}$$

The second moment of area through this section is obtained by the use of the transfer formula, as follows:

$$I = I_{\text{bar}} - 2(I_{\text{holes}} + \bar{d}^2 A)$$

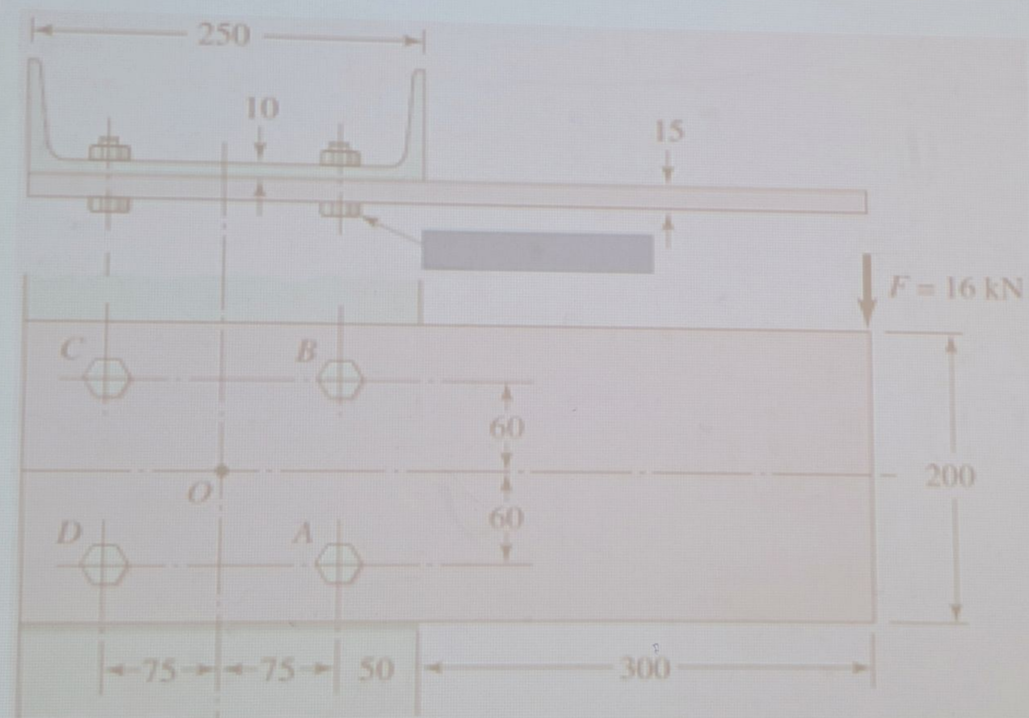
$$= \frac{15(200)^3}{12} - 2\left[\frac{15(16)^3}{12} + (60)^2(15)(16)\right] = 8.26(10)^6\ \text{mm}^4$$

Then

$$\sigma = \frac{Mc}{I} = \frac{5600(100)}{8.26(10)^6}(10)^3 = 67.8\ \text{MPa} \qquad \text{Answer}$$

Example 3 – Eccentrically Loaded Bolted Connection Design

The Figure shows a 15 by 200-mm rectangular steel bar cantilevered to a 250 mm steel channel using four tightly fitted bolts located at A, B, C, and D.
The joint is subject to an eccentric load of 16 KN as shown.
You are the engineer. Specify ISO bolt and tightening load for the application.



Sample Problem 1

Specify a bolt pattern for 4 bolts and determine the size of the bolts.

Problem 8–79