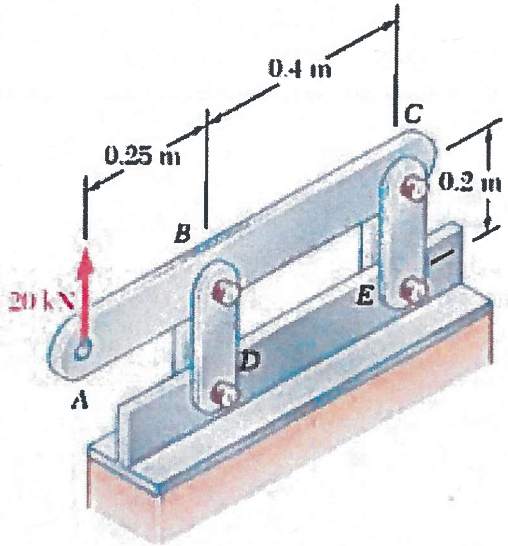


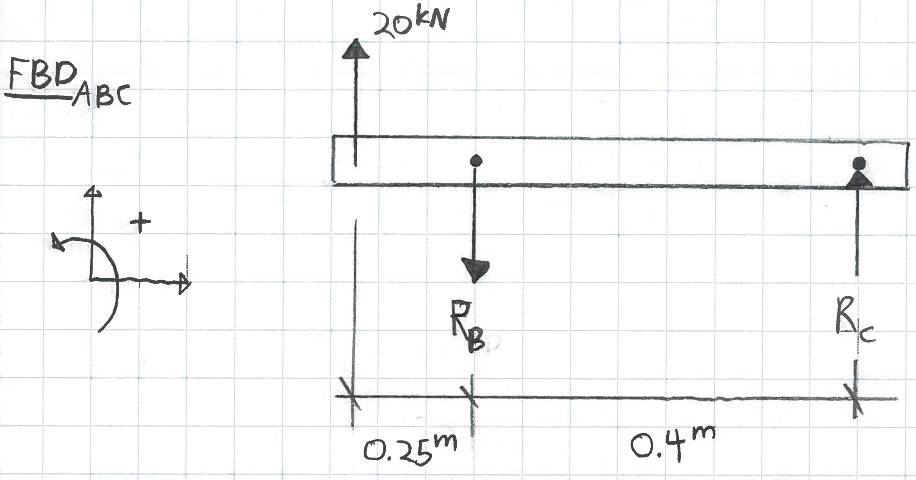
PROBLEM 1.27

For the assembly and loading of Prob. 1.7, determine (*a*) the average shearing stress in the pin at *B*, (*b*) the average bearing stress at *B* in member *BD*, (*c*) the average bearing stress at *B* in member *ABC*, knowing that this member has a 10 × 50-mm uniform rectangular cross section.

PROBLEM 1.7 Each of the four vertical links has an 8 × 36-mm uniform rectangular cross section and each of the four pins has a 16-mm diameter. Determine the maximum value of the average normal stress in the links connecting (*a*) points *B* and *D*, (*b*) points *C* and *E*.

1) Start with statics to determine the force in the pin at "B". Recognize links BD & CE are two-force members.

FBD_{ABC}



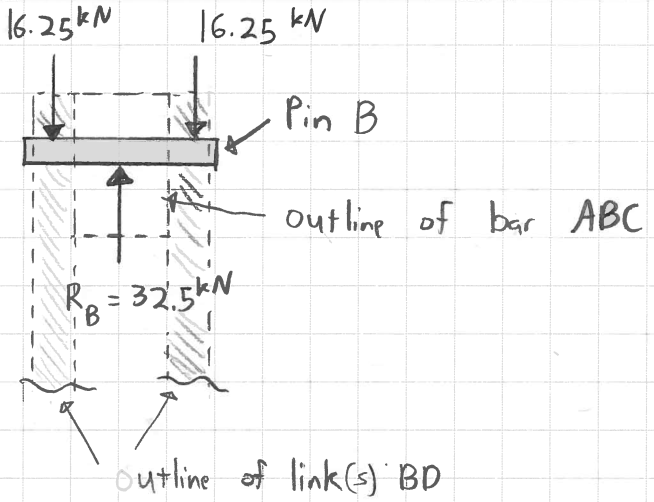
$$\overset{+}{\curvearrowleft}\sum M_C = 0; \quad R_B(0.4^m) - 20^{kN}(0.65^m) = 0$$

$$\underline{\underline{R_B = 32.5^{kN}}}$$

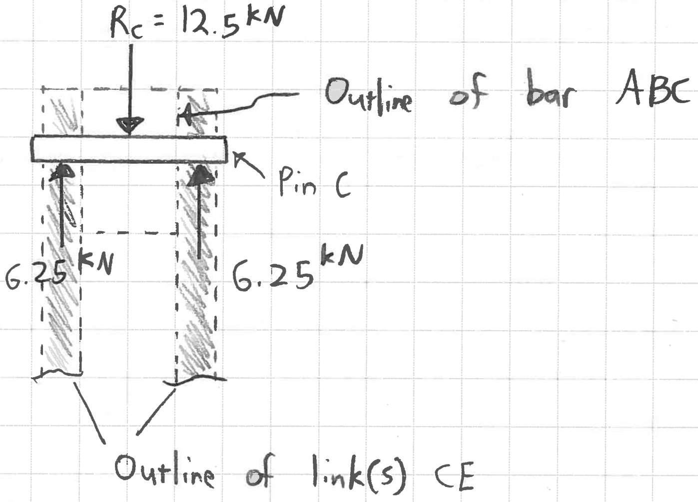
$$\overset{+}{\curvearrowleft}\sum M_B = 0; \quad -20^{kN}(0.25^m) + R_C(0.4^m) = 0$$

$$\underline{\underline{R_C = 12.5^{kN}}}$$

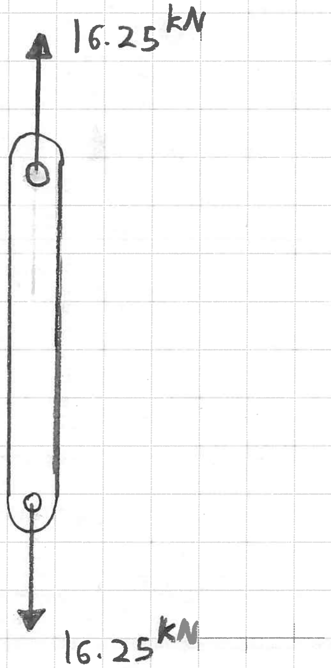
$\underline{FBD}_{\text{pin B}}$



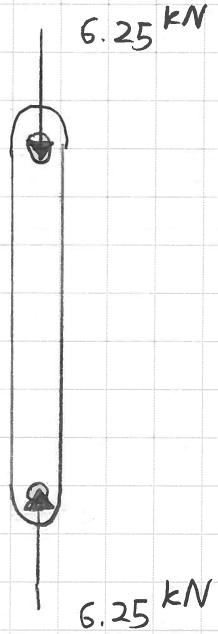
$\underline{FBD}_{\text{pin C}}$



$\underline{FBD}_{\text{link BD}}$
(one link only)

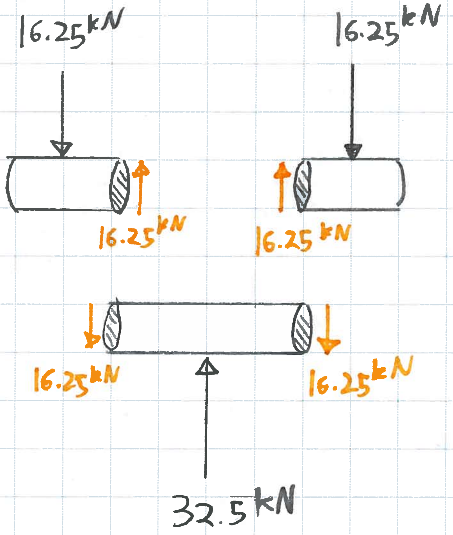


$\underline{FBD}_{\text{link CE}}$



2) SHEAR STRESS IN PIN B

Failed Pin FBD



a) So each shear plane must carry 16.25 kN

$$\tau = \frac{P}{A} = \frac{16.25 E3\ N}{201.06\ mm^2} = \underline{\underline{80.82\ MPa}}$$

b) Or, you can recognize the pin is in double shear (i.e. 2 shear planes to seperate the free body) and use:

$$\tau = \frac{P}{2A} = \frac{32.5 E3\ N}{2\,(201.06\ mm^2)} = \underline{\underline{80.82\ MPa}}$$

$$A_{pin} = \frac{\pi}{4}(16^{mm})^2 = 201.06\ mm^2$$

3) NORMAL STRESS IN LINK BD (AWAY FROM HOLES)

from free body; link BD must carry 16.25 kN

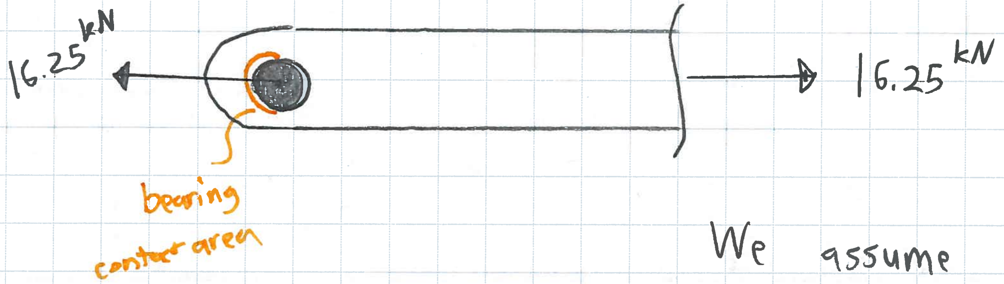
$$\sigma = \frac{P}{A} = \frac{16.25E3^{\,N}}{(8^{mm})(36^{mm})} = \underline{\underline{56.42 \text{ MPa}}} \quad \text{(Tension)}$$

4) NORMAL STRESS IN LINK AT PIN B

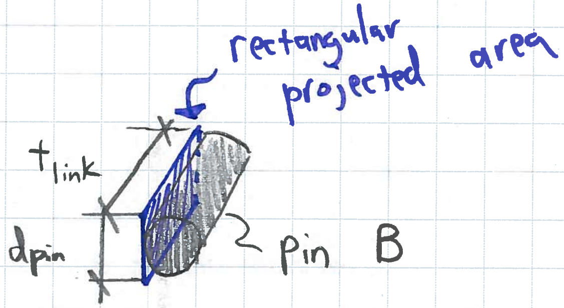
$$\sigma = \frac{16.25E3^{\,N}}{(\underset{t_{link}}{8^{mm}})(\underset{w_{link}}{36^{mm}} - \underset{d_{pin}}{16^{mm}})} = \underline{\underline{101.56 \text{ MPa}}} \quad \text{(Tension)}$$

5) BEARING STRESS IN LINK AT PIN B

This is the stress between the pin & the link.



We assume →



a) So,

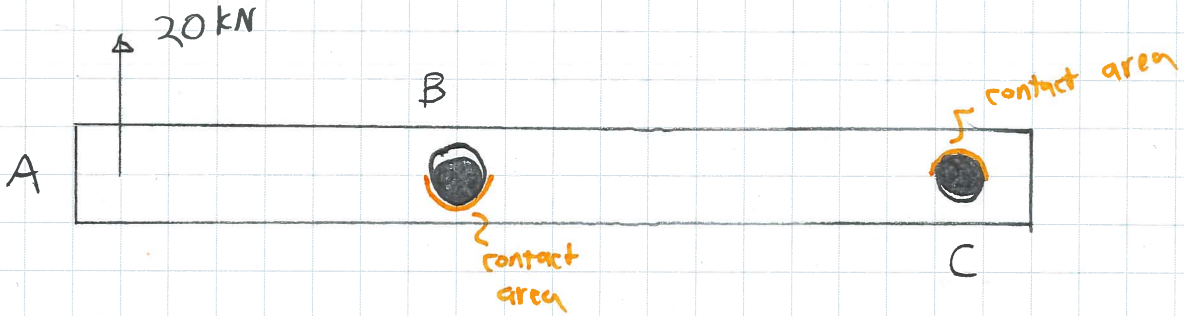
$$\sigma_{bearing} = \frac{16.25E3^{\ N}}{(\underset{\underset{d_{pin}}{\nearrow}}{16^{mm}})(\underset{\underset{t_{link}}{\uparrow}}{8^{mm}})} = \underline{\underline{126.95\ MPa}}$$

(Bearing is Compression)

b) Or, you can recognize that the 32.5 kN force on bar ABC is shared by to links at B. Thus,

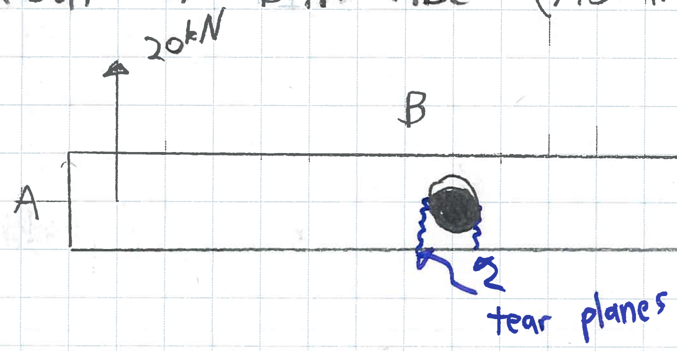
$$\sigma_{bearing} = \frac{32.5E3^{\ N}}{(2\ links)(16^{mm})(8^{mm})} = \underline{\underline{126.95\ MPa}}$$

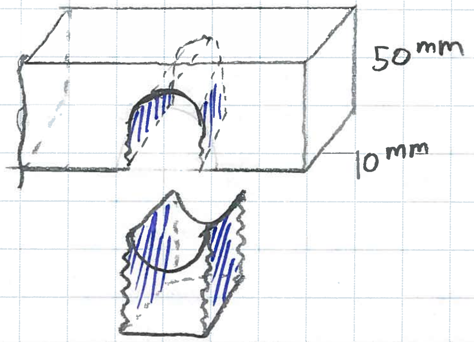
6) BEARING STRESS IN BAR ABC AT B



$$\sigma_{bearing} = \frac{32.5E3^{N}}{\underset{\overset{\nearrow}{t_{bar}}}{(10^{mm})}\underset{\overset{\uparrow}{d_{pin}}}{(16^{mm})}} = \underline{\underline{203.13 \quad MPa}}$$

7) TEAR OUT OF BAR ABC (ASSUMING PIN IS CENTERED)





$$\sigma_{tear} = \frac{32.5E3^{N}}{\underset{\overset{\nearrow}{t_{bar}}}{(10\ mm)}\underset{\overset{\uparrow}{h_{hole}}}{\left(\frac{50^{mm}}{2}\right)}(2\ planes)} = \underline{\underline{65 \quad MPa}}$$