ES120 Spring 2018 – Section 1 Notes

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Problem 1:

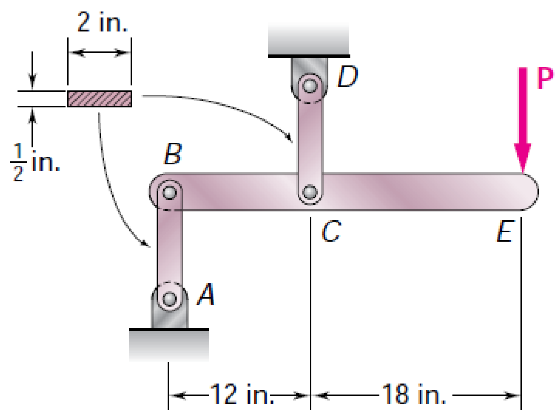

Figure 1

Each of the steel links AB and CD is connected to a support and to member BCE by 1-in.-diameter steel pins acting in single shear. Knowing that the ultimate shearing stress is 30 ksi for the steel used in the pins and that the ultimate normal stress is 70 ksi for the steel used in the links, determine the allowable load P if an overall factor of safety of 3.0 is desired. (Note that the links are not reinforced around the pin holes.)

Solution 1

Use member BCE as free body.

$$\Sigma M_B = 0: \quad 12F_{CD} - 30P = 0 \Rightarrow P = \frac{2}{5}F_{CD} \tag{1}$$

$$\Sigma M_C = 0: \quad 12F_{AB} - 18P = 0 \Rightarrow P = \frac{2}{3}F_{AB} \tag{2}$$

Both links have the same area, pin diameter and material. Therefore, they have the same ultimate load.
Failure by pin in single shear

$$A = \frac{\pi}{4}d^2 = 0.7854\text{in}^2 \tag{3}$$

$$F_u = \tau_u A = (30)(0.7854) = 23.562 \text{ kips} \tag{4}$$

Failure by tension in link

$$A = (b-d)t = (2-1)\frac{1}{2} = 0.5 \text{ in}^2 \tag{5}$$

$$F_u = \sigma_u A = (70)(0.5) = 35 \text{ kips} \tag{6}$$

Ultimate load for link and pin is the smaller.

$$F_u = 23.562 \text{ kips} \tag{7}$$

Allowable values of F_{CD} and F_{AB}

$$F_{all} = \frac{F_u}{\text{Factor of Safety}} = \frac{23.562}{3.0} = 7.854 \text{ kips} \tag{8}$$

Allowable load for structure is teh smaller of $\frac{2}{3}F_{all}$ and $\frac{2}{5}F_{all}$.

$$P = \frac{2}{5}(7.854) \tag{9}$$

$$\boxed{P = 3.14 \text{ kips}} \tag{10}$$

Problem 2:

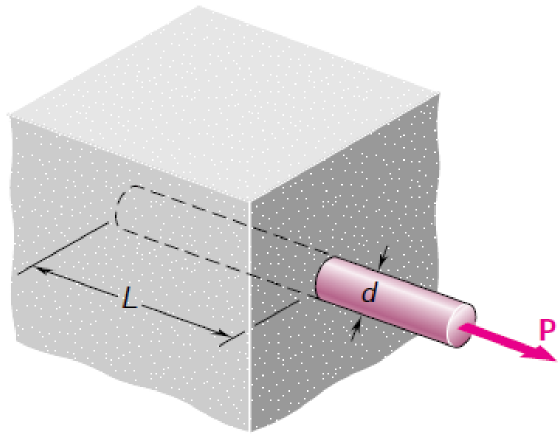

Figure 2

A force P is applied as shown to a steel reinforcing bar that has been embedded in a block of concrete. Determine the smallest length L for which the full allowable normal stress in the bar can be developed. Express the result in terms of the diameter d of the bar, the allowable normal stress σ_{all} in the steel, and the average allowable bond stress τ_{all} between the concrete and the cylindrical surface of the bar. (Neglect the normal stresses between the concrete and the end of the bar.)

Solution 2

For the shear we know that the area in which it is action on is

$$A = \pi d L \tag{11}$$

And thus the reaction force from the shear will be the same as P where

$$P = \tau_{all} A = \tau_{all} \pi d L \tag{12}$$

As for the tensile stress the area will be the cross section of the rod, namely,

$$A = \frac{\pi}{4} d^2 \tag{13}$$

Similarly, the reaction force from the normal stress must balance p such that:

$$P = \sigma_{all} A = \sigma_{all} (\frac{\pi}{4} d^2) \tag{14}$$

Therefore equating both of the above we obtain:

$$\tau_{all} \pi d L = \sigma_{all} \frac{\pi}{4} d^2 \tag{15}$$

Which when solving for L we obtain:

$$\boxed{L = \frac{\sigma_{all} d}{4 \tau_{all}}} \tag{16}$$