بخش ۱-۶: تنش مجاز:

همه مسائل مقاومت مصالح را می توان به دو نوع زیر تقسیم بندی کرد:

۱) تحلیل: هندسه، متریال و بارها از پیش تعریف شده است . وظیفه شما محاسبه تنش و اطمینان از آن است که:

$$\sigma < \sigma_{allowable}$$ (مجاز)

۲- طراحی: بارها و تنش های مجاز معلوم هستند. وظیفه شما انتخاب متریال و یا هندسه مناسب است.

تعاریف:

□$\sigma_{allowable(مجاز)} = \sigma_{failure\ (شکست)} / F.S.$

F.S. = Safety Factor= ضریب اطمینان

(ضریب اطمینان بسته به نوع کاربرد معمولا بین ۲-۸ است.)

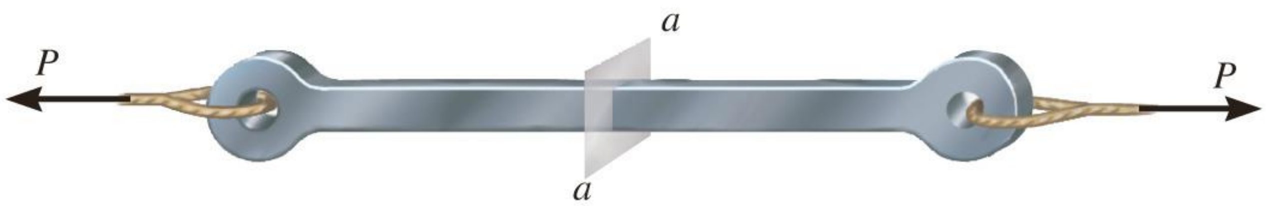
□$\sigma_{failure(شکست)} =$ تنش شکست

(معمولا تنش شکست را برابر استحکام تسلیم ماده σ_y در نظر میگیرند).

بنابراین:

• مساحت $= P/ \sigma_{allowable(مجاز)}$

مثال:



(a)

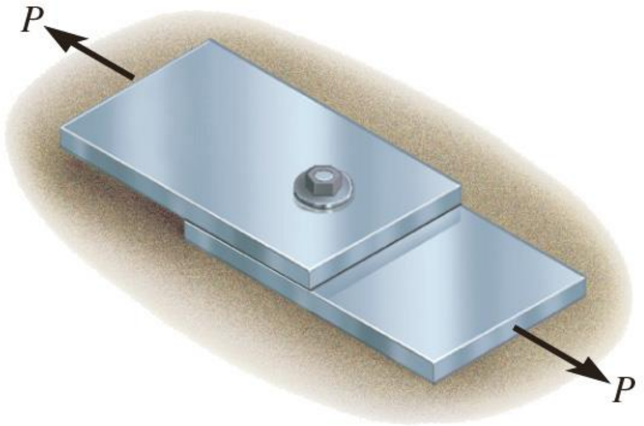
$P = 10K$ lbs

$\sigma allow = 10$ ksi

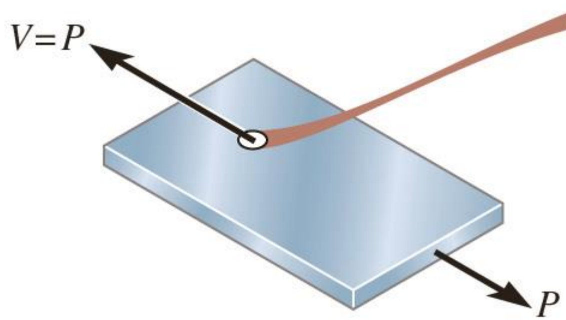
پس:

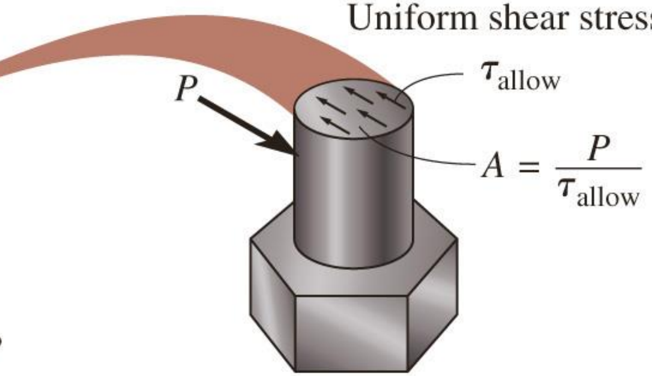
$A = 1$ in^2

(b)



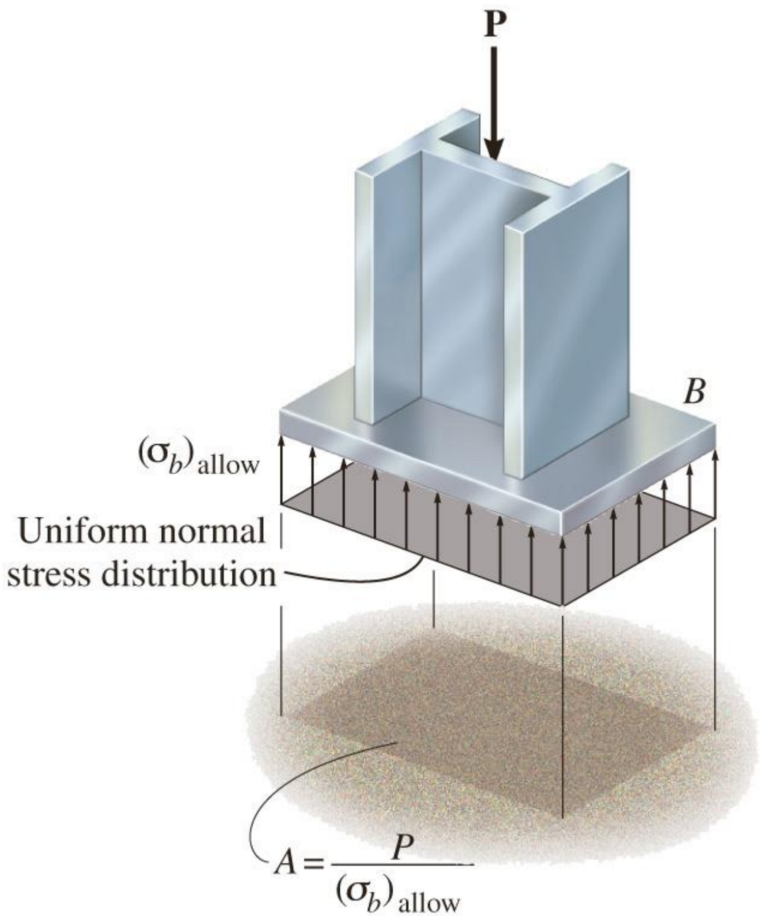
(a)





(b)

(c)


P
B
$(\sigma_b)_{allow}$
Uniform normal
stress distribution
$A = \frac{P}{(\sigma_b)_{allow}}$

EXAMPLE 1.14

The suspender rod is supported at its end by a fixed-connected circular disk as shown in Fig. 1–27*a*. If the rod passes through a 40-mm-diameter hole, determine the minimum required diameter of the rod and the minimum thickness of the disk needed to support the 20-kN load. The allowable normal stress for the rod is $\sigma_{\text{allow}} = 60$ MPa, and the allowable shear stress for the disk is $\tau_{\text{allow}} = 35$ MPa.

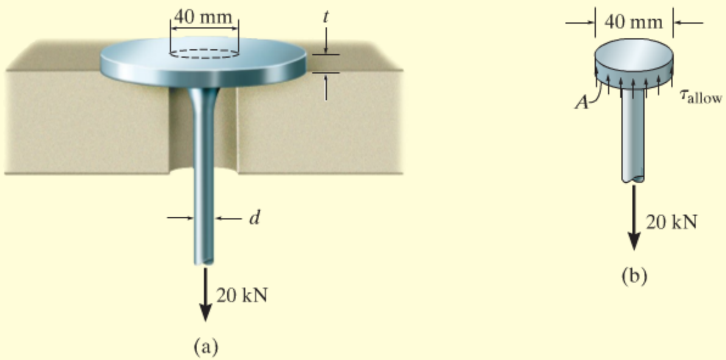


Fig. 1–27

SOLUTION

Diameter of Rod. By inspection, the axial force in the rod is 20 kN. Thus the required cross-sectional area of the rod is

$$A = \frac{P}{\sigma_{\text{allow}}}; \qquad \frac{\pi}{4}d^2 = \frac{20(10^3)\text{ N}}{60(10^6)\text{ N/m}^2}$$

so that

$$d = 0.0206 \text{ m} = 20.6 \text{ mm} \qquad \textit{Ans.}$$

Thickness of Disk. As shown on the free-body diagram in Fig. 1–27*b*, the material at the sectioned area of the disk must resist *shear stress* to prevent movement of the disk through the hole. If this shear stress is *assumed* to be uniformly distributed over the sectioned area, then, since $V = 20$ kN, we have

$$A = \frac{V}{\tau_{\text{allow}}}; \qquad 2\pi(0.02 \text{ m})(t) = \frac{20(10^3)\text{ N}}{35(10^6)\text{ N/m}^2}$$

$$t = 4.55(10^{-3}) \text{ m} = 4.55 \text{ mm} \qquad \textit{Ans.}$$

EXAMPLE 1.15

The shaft shown in Fig. 1–28*a* is supported by the collar at *C*, which is attached to the shaft and located on the right side of the bearing at *B*. Determine the largest value of *P* for the axial forces at *E* and *F* so that the bearing stress on the collar does not exceed an allowable stress of $(\sigma_b)_{allow} = 75$ MPa and the average normal stress in the shaft does not exceed an allowable stress of $(\sigma_t)_{allow} = 55$ MPa.

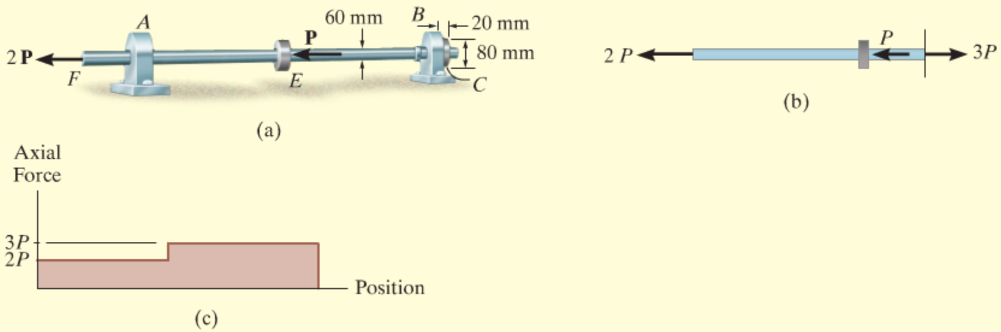


Fig. 1–28

SOLUTION

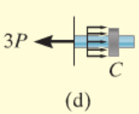
To solve the problem we will determine *P* for each possible failure condition. Then we will choose the *smallest* value. Why?

Normal Stress. Using the method of sections, the axial load within region *FE* of the shaft is 2*P*, whereas the *largest* axial force, 3*P*, occurs within region *EC*, Fig. 1–28*b*. The variation of the internal loading is clearly shown on the normal-force diagram, Fig. 1–28*c*. Since the cross-sectional area of the entire shaft is constant, region *EC* is subjected to the maximum average normal stress. Applying Eq. 1–11, we have

$$A = \frac{P}{\sigma_{allow}}; \qquad \pi(0.03 \text{ m})^2 = \frac{3P}{55(10^6)\text{ N/m}^2}$$

$$P = 51.8 \text{ kN} \qquad \textit{Ans.}$$

Bearing Stress. As shown on the free-body diagram in Fig. 1–28*d*, the collar at *C* must resist the load of 3*P*, which acts over a bearing area of $A_b = [\pi(0.04 \text{ m})^2 - \pi(0.03 \text{ m})^2] = 2.199(10^{-3}) \text{ m}^2$. Thus,



$$A = \frac{P}{\sigma_{allow}}; \qquad 2.199(10^{-3}) \text{ m}^2 = \frac{3P}{75(10^6)\text{ N/m}^2}$$

$$P = 55.0 \text{ kN}$$

By comparison, the largest load that can be applied to the shaft is $P = 51.8$ kN, since any load larger than this will cause the allowable normal stress in the shaft to be exceeded.

NOTE: Here we have not considered a possible shear failure of the collar as in Example 1.14.