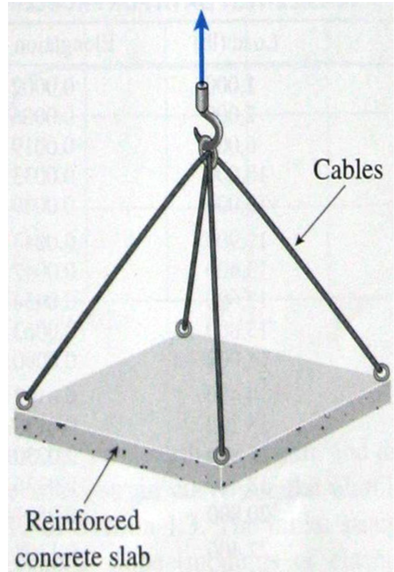
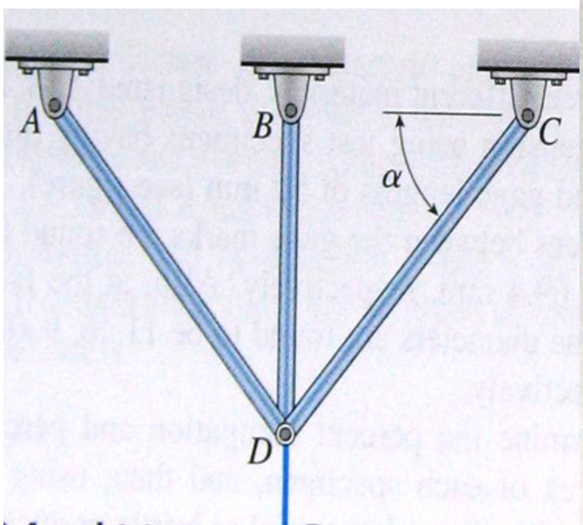
EGBE260 Week 10 Homework

1.2-12. A reinforced concrete slab 2.5 m square and 225 mm thick is lifted by four cables attached to the corners. The cables are attached to a hook at a point 1.6 m above the top of the slab. Each cable has an effective cross-sectional area A = 190 mm^2. The density of reinforced concrete is 2400 kg/m^3. Determine the tensile stress in the cables due to the weight of the concrete slab.

Answer: σ_t*=66.2 MPa.*



1.3-4. A symmetrical framework consisting of three pin-connected bars is loaded by a force P. The angle between the inclined bars and the horizontal is $\alpha = 50°$. The axial strain in the middle bar is measured as 0.0839. Determine the tensile stress in the outer bars if they are constructed of structural steel having the stress-strain diagram shown in the figure below.



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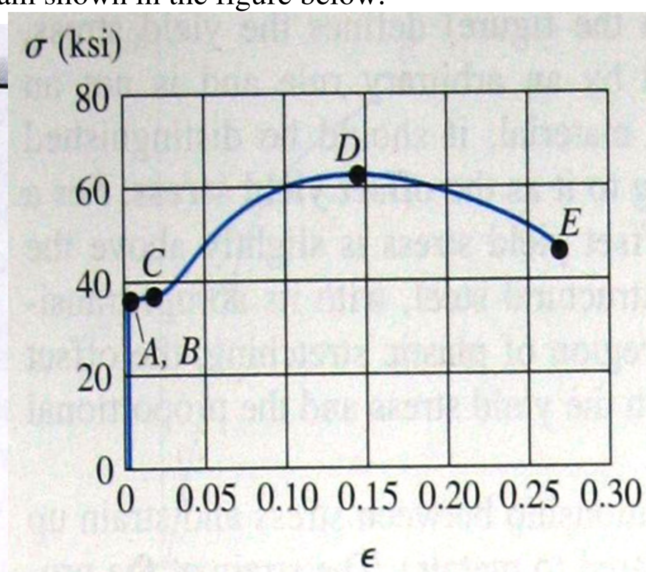
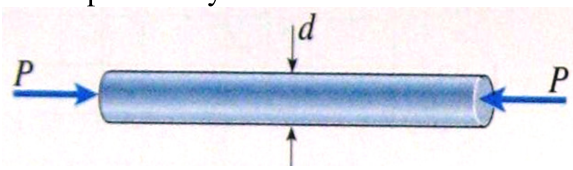


Answer: σ*=340 MPa*

1.5.1. A high-strength steel bar has diameter d = 2.25 in. The steel has modulus of elasticity E = 29 x 10^6 psi and Poisson's ratio ν = 0.30. The diameter of the bar must be less than 2.251 when it is compressed by axial forces. What is the largest compressive load that is permitted?



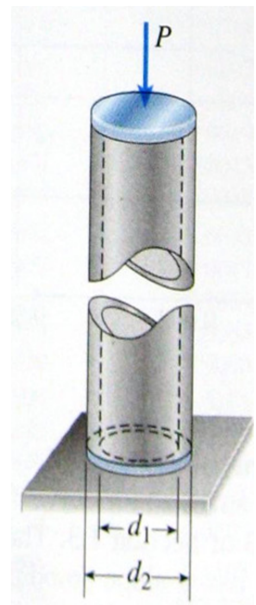
Answer: P_{max} *= 171 k.*

1.5.7. A hollow bronze cylinder is compressed by a force P. The cylinder has inner diameter d1=1.85 in, outer diameter d2 = 2.15 in, and modulus of elasticity E = 16,000 ksi. When the force P increases from 0 to 35 k, the outer diameter of the cylinder increases by 0.0017 in.

a) Determine the increase in the inner diameter

b) Determine the increase in the wall thickness

c) Determine Poisson's ratio

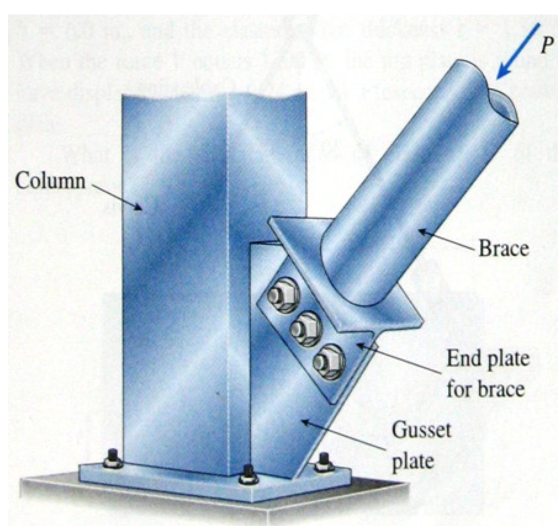


Answers: a) $\Delta d_1 = 0.0015$ *in, b)* $\Delta t = 0.00012$ *in, c)* $\nu = 0.34$

1.6-1. A bolted connection between a vertical column and a diagonal brace is shown below. The connection consists of three 5/8 in bolts that join two ¼ in plates. The compressive load P carried by the brace equals 5.5 k.

Determine the following quantities:

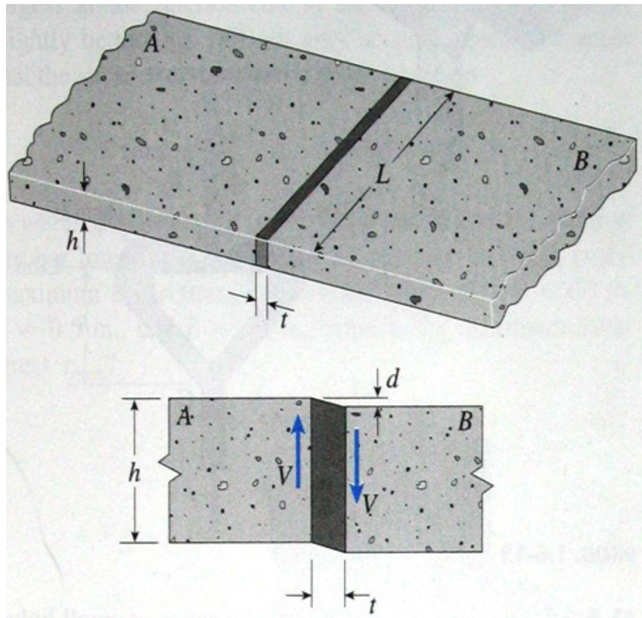
a) The average shear stress in the bolts
b) The average bearing stress between the plates and the bolts



Answers: a) $\tau = 5980$ *psi, b)* $\sigma_b = 11{,}730$ *psi*

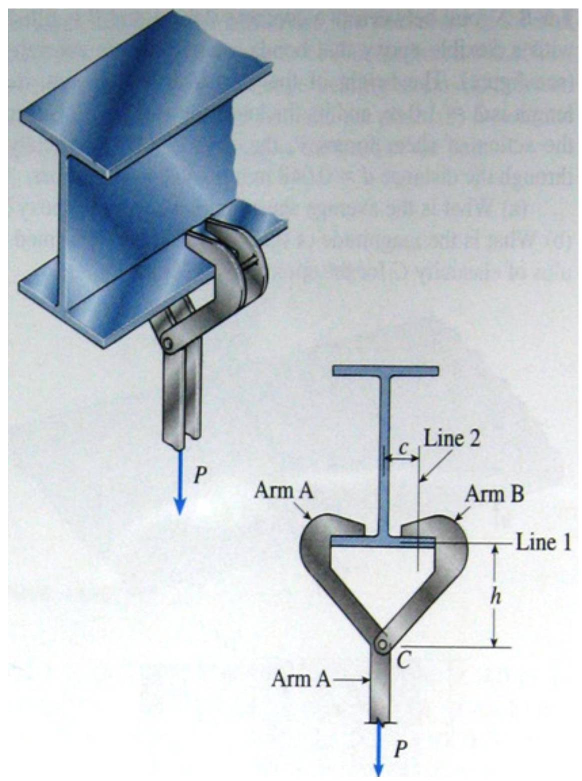
1.6-8. A joint between two concrete slabs A and B is filled with a flexible epoxy that bonds securely to the concrete. The height of the joint is h = 100 mm, its length is 1.0 m, and its thickness is t = 12 mm. Under the action of shear forces V, the slabs displace vertically through the distance d = 0.048 mm relative to each other.
a) What is the average shear strain in the epoxy?
b) What is the magnitude of the forces V if the shear modulus of elasticity for the epoxy is G=960 MPa?

Answers: $\gamma = 0.004$, *b)* $V = 384$ *kN*



1.6-13. The clamp shown below is used to support a load hanging from the lower flange of a steel beam. The clamp consists of two arms (A and B) jointed by a pin at C. The pin has diameter d = 0.5 in. Because arm B straddles arm A, the pin is in double shear. Line 1 in the figure defines the line of action of the resultant horizontal force H acting between the lower flange of the beam and arm B. The vertical distance from this line to the pin is h = 10.0 in. Line 2 defines the line of action of the resultant vertical force V acting between the flange and arm B. The horizontal distance from this line to the centerline of the beam is c = 4.0 in. The force conditions between arm A and the lower flange are symmetrical with those given for arm B.
Determine the average shear stress in the pin at C when the load P = 4000 lb.

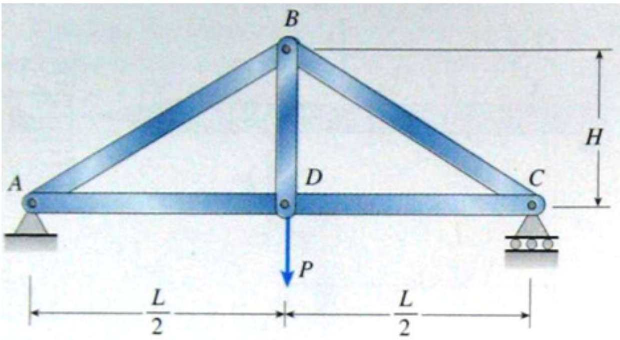
Answer: $\tau = 5490$ *psi*



2.2-8. The pin-connected truss shown in the figure has a span L = 6.0 m and height H = 1.5 m. The truss is constructed of steel bars, each having cross-sectional area A = 3000 mm^2 and modulus of elasticity E = 200 GPa. Load P acts vertically at the midpoint D.

a) If P = 120 kN, what is the horizontal displacement of joint C?

b) What is the maximum permissible load P_{max} if the displacement of joint C is limited to 2.0 mm?

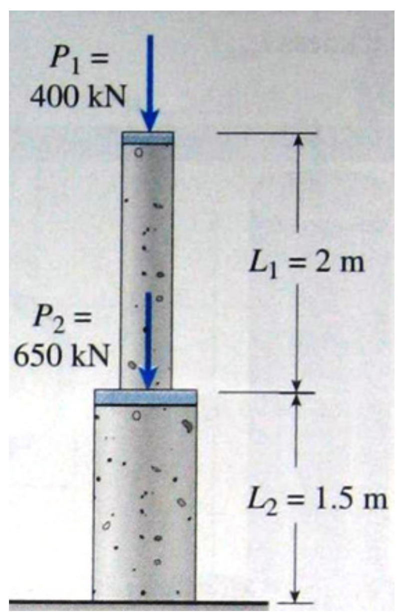


Answer: a), δ_C *= 1.20 mm, b)* P_{max} *= 200 kN*

2.3-4. A reinforced concrete pedestal (E = 25 GPa) having dimensions L_1 = 2 m and L_2 = 1.5 m is shown below. The loads applied to the pedestal are P_1 = 400 kN and P_2 = 650 kN. Under the action of these loads, the maximum permissible shortening of the pedestal is 1.0 mm. Let A_1 and A_2 represent the cross-sectional areas of the upper and lower parts, respectively.

a) If the area A_2 is three times the area A1, what is the minimum permissible area A_1?

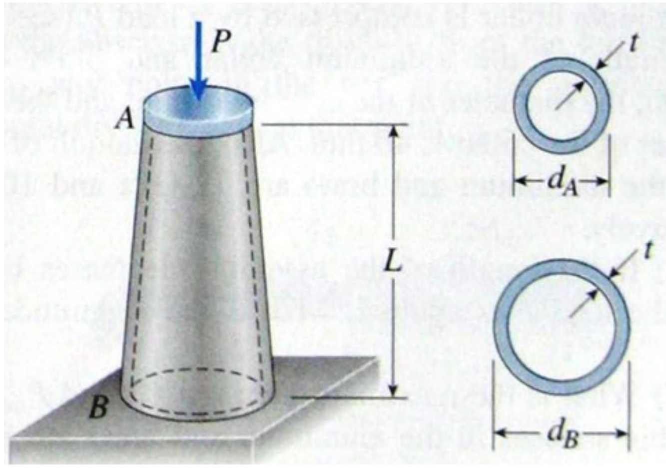
b) If the areas A_1 and A_2 are such that the compressive stresses in both parts of the pedestal are the same, what is the minimum permissible area A_1?



Answers: a) A_1 *= 53,000* mm^2*, b)* A_1 *= 56,000* mm^2

2.3-16. A tapered aluminum post AB of hollow circular cross section and length L is compressed by load P. The outside diameters of the top and bottom are d_A and d_B respectively, and the wall thickness is t. Describe the shortening of the post in terms of P, L, E, t, d_B, and d_A.

Answer: $\delta = \dfrac{PL}{\pi E t (d_B - d_A)} \ln\left(\dfrac{d_B - t}{d_A - t}\right)$

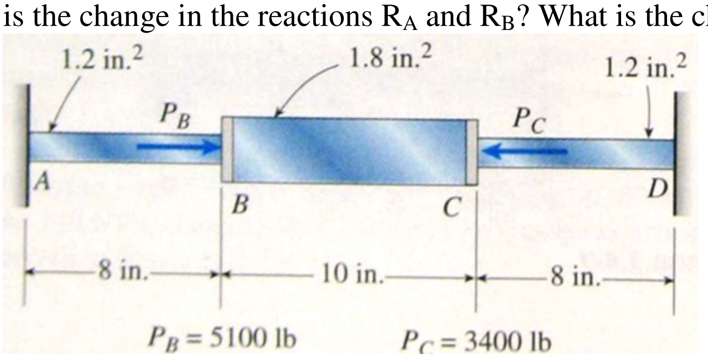


2.4-9. The fixed-end bar ABCD consists of three prismatic segments, as shown in the figure. The end segments have cross-sectional area $A_1 = 1.2\ in^2$ and length $L_1 = 8$ in. The middle segment has cross-sectional area $A_2 = 1.8\ in^2$ and length $L_2 = 10$ in. Loads P_B and P_C are equal to 5100 lb and 3400 lb, respectively.

a) Determine the reactions R_A and R_B.

b) Determine the compressive axial force in the middle segment of the bar

c) If the length and cross sectional area of each of the three segments are doubled in value, what is the change in the reactions R_A and R_B? What is the change in the force F?

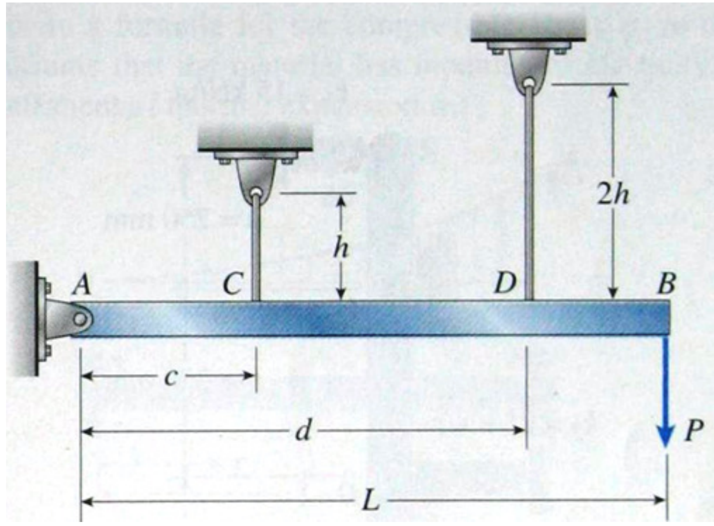


Answers: a) R_A = 2100 lb, to the left, b) F = 3000 lb (compression)

2.4-14. A rigid bar AB of length L = 1600 mm is hinged to a support at A and supported by two vertical wires attached at points C and D. Both wires have the same cross-sectional area (A = 16 mm^2) and both are made of the same material (E = 200 GPa). The wire at C has length h = 0.4 m and the wire at D has length twice that amount. The horizontal distances are c = 0.5 m and d = 1.2 m.

a) Determine the tensile stresses σ_C and σ_D in the wires due to the load P = 970 N acting at end B of the bar.

b) Find the downward displacement $\delta_B$at end B of the bar.



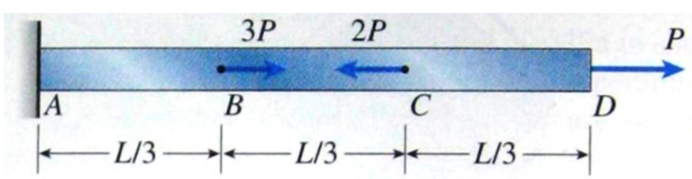
Answers: a) σ_C = 50.0 MPa, σ_D = 60.0 MPa, b) δ_B = 0.32 mm

2.7-5. The bar ABC shown below is loaded by a force P acting at end C and by a force Q acting at the midpoint B. The bar has constant axial rigidity EA.

a) Determine the strain energy U1 of the bar when the force P acts alone (Q=0).

b) Determine the strain energy U2 when the force Q acts alone (P = 0).

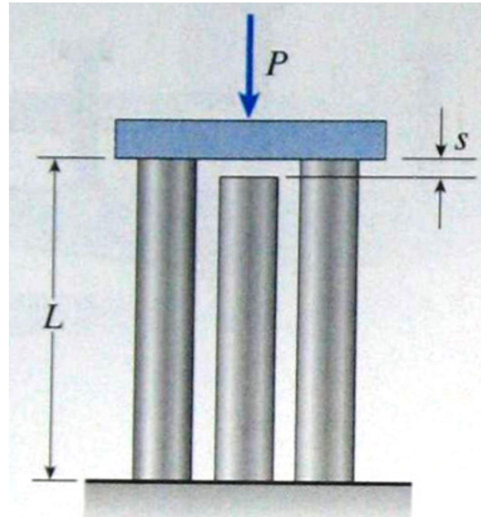
c) Determine the strain energy U when the forces P and Q act simultaneously upon the bar.



Answers: c) $U = P^2L/2EA + PQL/2EA + Q^2L/4EA$

2.7-10. A compressive load P is transmitted through a rigid plate to three magnesium-alloy bars that are identical, except that initially the middle bar is slightly shorter than the other bars. The dimensions and properties of the assembly are as follows: length L = 1.0 m, cross sectional area of each bar A = 3000 mm2, E = 45 GPa, and the gap s = 1.0 mm.

a) Calculate the load P1 required to close the gap.
b) Calculate the downward displacement of the rigid plate when P = 400 kN.
c) Calculate the total strain energy U of the three bars when P = 400 kN.
d) Explain why the strain energy U is not equal to Pδ/2.



Answers: a) $P_1 = 270$ *kN, b)* $\delta = 1.321$ *mm, c)* $U = 37.1$ *in-lb.*