Kurdistan Region
Salahaddin University-Erbil
College of Engineering
Mechanic & Mechatronics Engineering Department

Strength of Materials

For Second Stage Students
In Mechanic & Mechatronics Dept.

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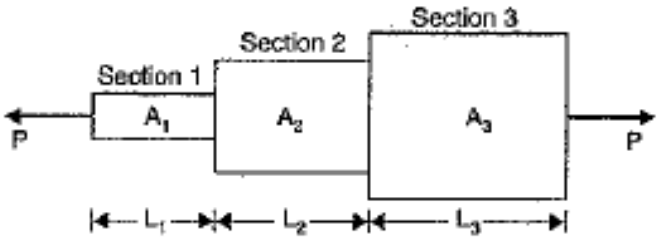
ANALYSIS OF BARS OF VARYING SECTIONS

A bar of different length and different diameters as shown in figure. This rod is subjected to an external load P.



Though each section is subjected to the same axial load P, yet the stress, strains and change in length will be different. The total change in length will be obtained by adding the changes in length of individual section.

Let:

P = axial load , **L1** = length of section 1, **A1** = cross-sectional area of section 1

L2, A2 = length and cross-sectional area of section 2

L3, A3 = length and cross-sectional area of section 3

E = young's modulus or modulus of elasticity for the bar or rod material.

Then the stress for section 1,

$$\sigma_1 = \frac{\text{Load}}{\text{Area section 1}} = \frac{P}{A1}$$

Similarly, the stresses for section 2 and section 3 are given as,

$$\sigma_2 = \frac{\text{Load}}{\text{Area section 2}} = \frac{P}{A2}$$

$$\sigma_3 = \frac{\text{Load}}{\text{Area section 3}} = \frac{P}{A3}$$

Strain for section 1 equal to, $\varepsilon_1 = \frac{\sigma 1}{E} = \frac{P}{A1 * E}$

Similarly, the strains of section 2 and section 3 are,

$\varepsilon_2 = \frac{\sigma 2}{E} = \frac{P}{A2 * E}$,,,, $\varepsilon_3 = \frac{\sigma 3}{E} = \frac{P}{A3 * E}$

But strain in section 1 equal to,

$$\varepsilon_1 = \frac{\delta L1}{L1} \quad ,,, \quad \delta L1 = \varepsilon_1 * L1$$

$$\delta L1 = \frac{P * L1}{A1 * E}$$

Change of the length for section 2 and section 3

$$\delta L2 = \frac{P*L2}{A2*E} \quad ,,,, \quad \delta L3 = \frac{P*L3}{A3*E}$$

Total change in the length of the bar or rod, when the young's modulus of different section is same

$$\text{Total } \delta L = \delta L1 + \delta L2 + \delta L3 = \frac{P*L1}{A1*E} + \frac{P*L2}{A2*E} + \frac{P*L3}{A3*E} = \frac{P}{E} * \left[\frac{L1}{A1} + \frac{L2}{A2} + \frac{L3}{A3}\right]$$

If the young's modulus of different section is different, then total change in length of the rod equal to,

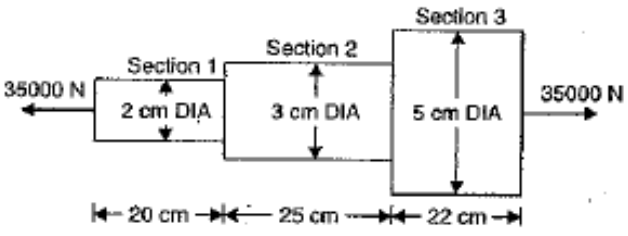
$$\text{Total } \delta L = \delta L1 + \delta L2 + \delta L3 = \frac{P*L1}{A1*E1} + \frac{P*L2}{A2*E2} + \frac{P*L3}{A3*E3} =$$

$$p * \left[\frac{L1}{E1*A1} + \frac{L2}{E2*A2} + \frac{L3}{E3*A3}\right]$$

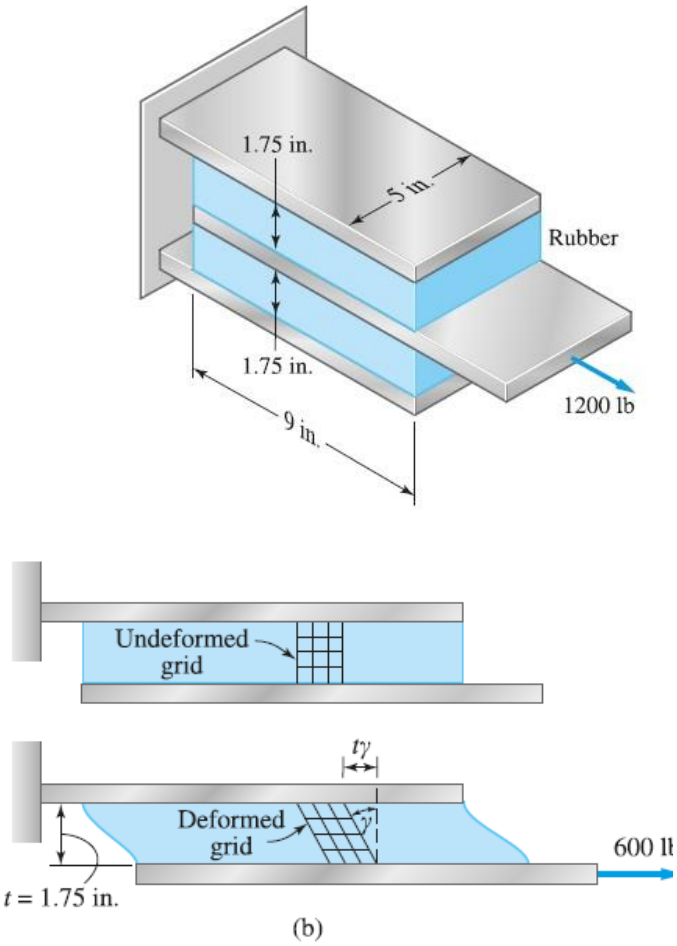
Problem 4. An axial pull of 35000 N is acting on a bar consisting of three length as shown in figure. If the young's modulus = 2.1 * 10^5 N/mm^2, determine:

1- Stresses in each section and

2- Total extension of the bar (δL).



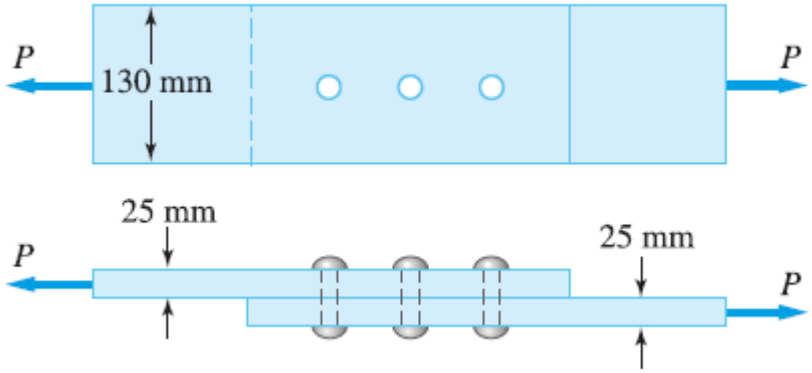
Problem 5. Two 1.75-in.-thick rubber pads are bonded to three steel plates to form the shear mount shown in Fig. Find the displacement of the middle plate when the 1200-lb load is applied. Consider the deformation of rubber only. Use E = 500 psi and μ = 0.48 for rubber.



(b)

Problem 6. The lap joint is connected by three 20-mm-diameter rivets. Assuming that the axial load P = 50 kN is distributed equally among the three rivets, find

(a) the shear stress in a rivet;
(b) the bearing stress between a plate and a rivet; and
(c) the maximum average tensile stress in each plate.

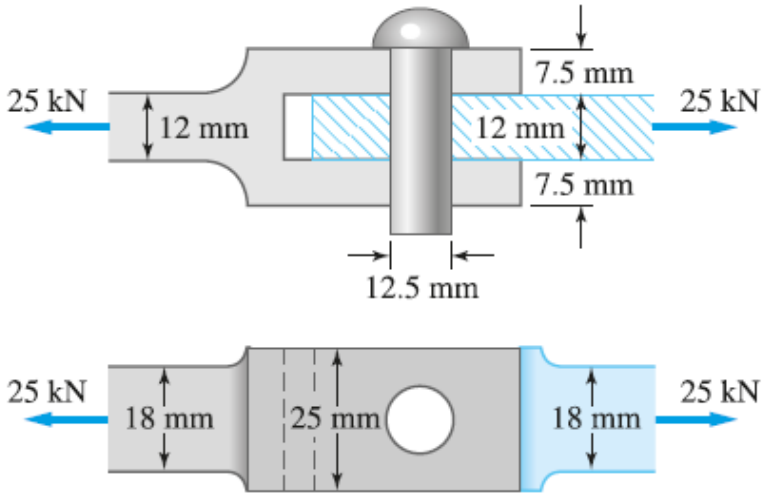


Problem 7. For the joint shown in the figure, calculate

(a) the largest bearing stress between the pin and the members;

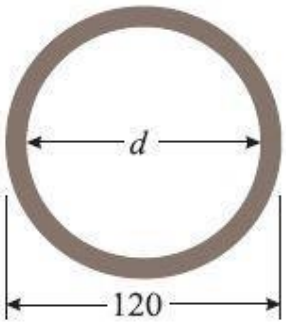
(b) the average shear stress in the pin; and

(c) the largest average normal stress in the members.



Problem 8: A hollow steel tube 3.5 m long has external diameter of 120 mm. in order to determine the internal diameter, the tube subjected to a tensile load of 400 kN and extension was measured to be 2 mm. if the modulus of elasticity for the tube material is 200 Gpa, determine the internal diameter of the tube.

Solution:



Problem 9: The plate welded to the end of the I-beam is fastened to the support with four 10-mm-diameter bolts (two on each side). Assuming that the load is equally divided among the bolts, determine the normal and shear stresses in a bolt.