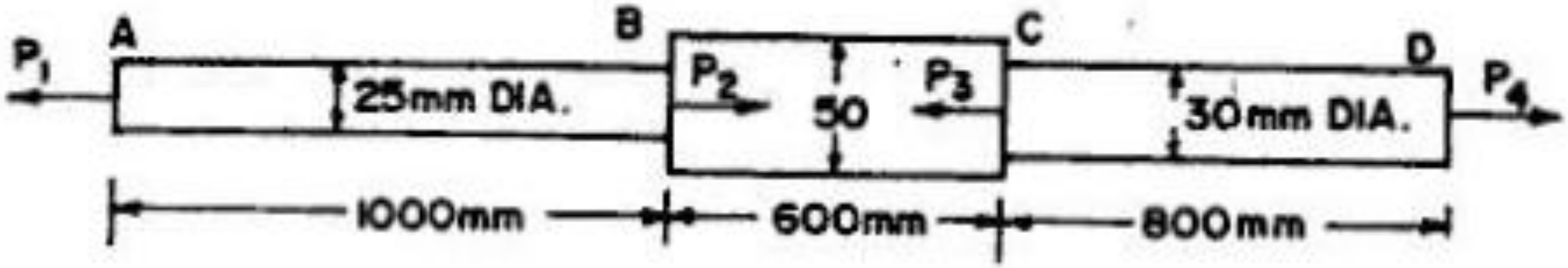
MECHANICAL ENGINEERING SCIENCE

Dr. Mantesh B Khot

Department of Mechanical Engineering

NUMERICALS

A member ABCD is subjected to point loads P_1, P_2, P_3 and P_4 as shown in figure below. Calculate the force P_2 necessary for equilibrium if P_1 = 10 kN, P_3 = 40 kN and P_4 = 16 kN. Taking modulus of elasticity as 2.05×10^5 N/mm^2, determine the total elongation of the member.



NUMERICALS

Solution:

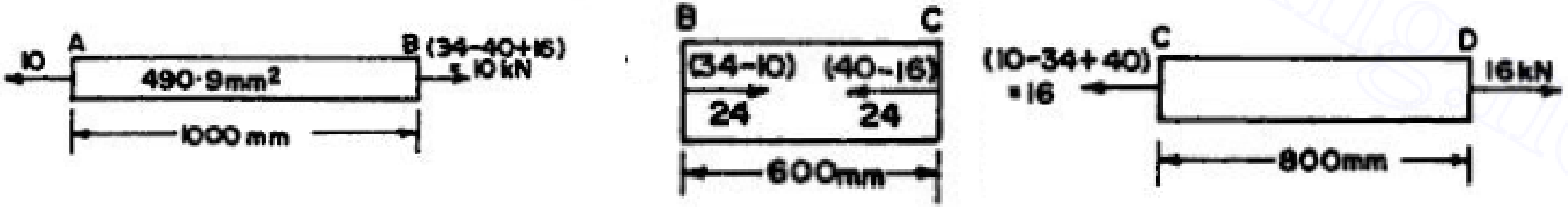
For the equilibrium of the bar,

$$P_1 + P_3 = P_2 + P_4$$

or $$10 + 40 = P_2 + 16 \text{ , From which } P_2 = 34 \text{ kN } (\rightarrow)$$

Now from Eq. 2.14, $\Delta = \frac{1}{E} \Sigma \frac{PL}{A}$

The free body diagrams for the three portions of the bar are shown



NUMERICALS

Solution:

$$A_1 = \frac{\pi}{4}(25)^2 = 490.9\ \text{mm}^2\ ;\ A_2 = \frac{\pi}{4}(50)^2 = 1963.5\ \text{mm}^2\ ;\ A_3 = \frac{\pi}{4}(30)^2 = 706.9\ \text{mm}^2$$

$$\Delta_1 = \frac{10 \times 1000 \times 1000}{490.9 \times 2.05 \times 10^5} = 0.099 \quad \text{(elongation)}$$

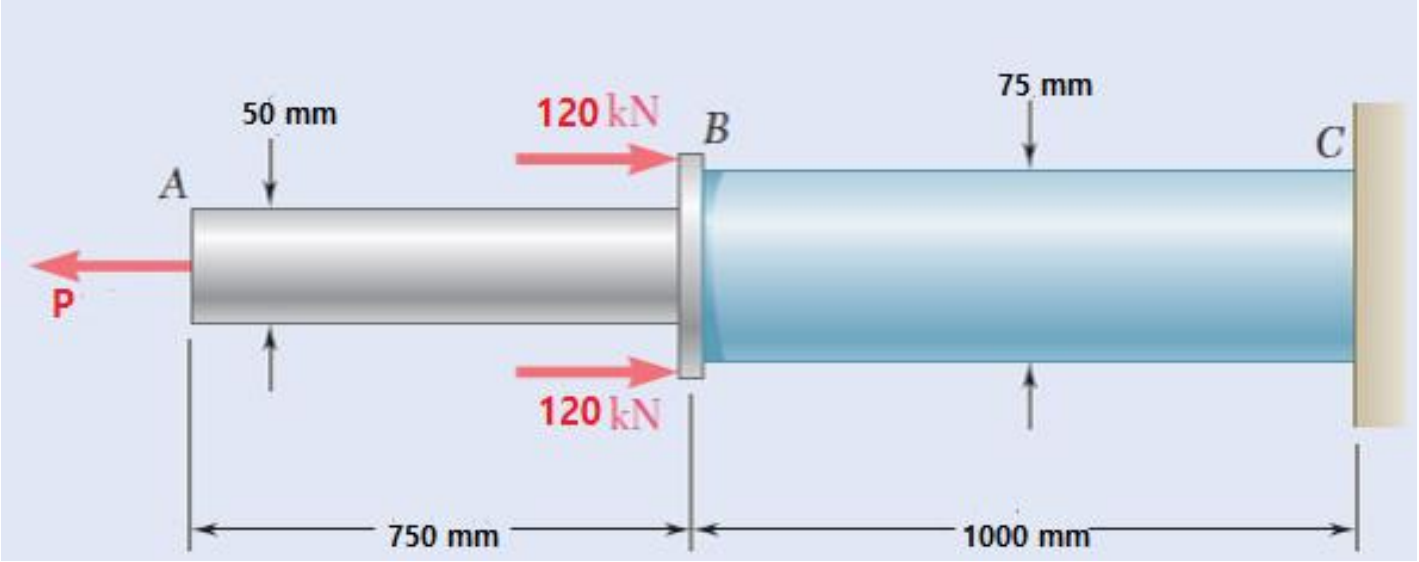
$$\Delta_2 = \frac{24 \times 1000 \times 600}{1963.5 \times 2.05 \times 10^5} = 0.036 \quad \text{(contraction)}$$

$$\Delta_3 = \frac{16 \times 1000 \times 800}{706.9 \times 2.05 \times 10^5} = 0.088 \quad \text{(elongation)}$$

Total $\quad \Delta = \Delta_1 - \Delta_2 + \Delta_3 = 0.099 - 0.036 + 0.088 = \mathbf{0.151}\ \ \mathbf{mm.}$

NUMERICALS

Two solid cylindrical rods AB and BC are welded together at B and loaded as shown. Determine the magnitude of the force P for which the tensile stress in rod AB has the same magnitude as the compressive stress in rod BC.



NUMERICALS

Solution:

$$\sigma_{AB} = \frac{P}{A_{AB}} = \frac{P}{\frac{\pi}{4}(50\times10^{-3})^2} = 509.3P$$

$$\sigma_{BC} = \frac{2(120)-P}{A_{BC}} = \frac{240-P}{\frac{\pi}{4}(75\times10^{-3})^2} = 54324 - 226.35P$$

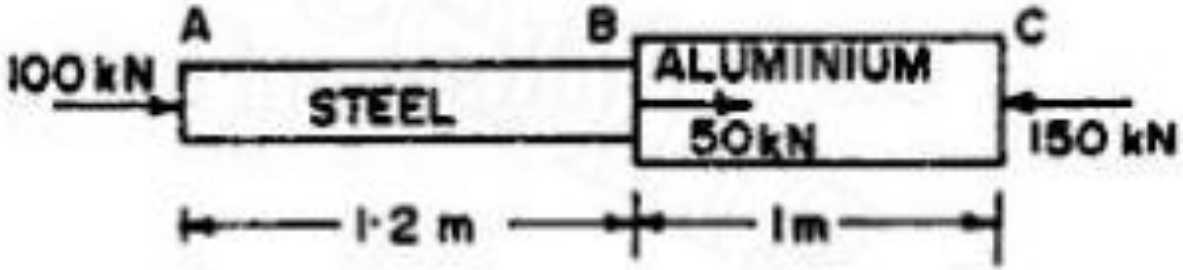
Equating both the stresses,

$509.39P = 54324 - 226.35P$

$=> P = 73.84kN$

NUMERICALS

A member ABC is formed by connecting a steel bar of 20 mm diameter to an aluminium bar of 30 mm diameter and is subjected to forces as shown in figure below. Determine the total deformation of the bar, taking E for aluminium as 0.7×10^5 N/mm^2 and that for steel as 2×10^5 N/mm^2



NUMERICALS

Solution:

$$\therefore \quad \Delta = \Sigma \frac{PL}{AE} = \frac{P_1 L_1}{A_1 E_1} + \frac{P_2 L_2}{A_2 E_2}$$

Portion AB

Force $P_1 = 100$ kN (or $150 - 50 = 100$ kN), compressive;

$L_1 = 1200$ mm

$A_1 = \frac{\pi}{4}(20)^2 = 314.16 \text{ mm}^2$

$E_1 = 2 \times 10^5 \text{ N/mm}^2$

$$\therefore \quad \Delta_1 = \frac{100 \times 10^3 \times 1200}{314.16 \times 2 \times 10^5} \approx 1.91 \text{ mm (contraction)}$$

Portion BC

Force $P_2 = 100 + 50 = 150$ kN; $L_2 = 1000$ mm

$A_2 = \frac{\pi}{4}(30)^2 = 706.86$; $E_2 = 0.7 \times 10^5 \text{ N/mm}^2$

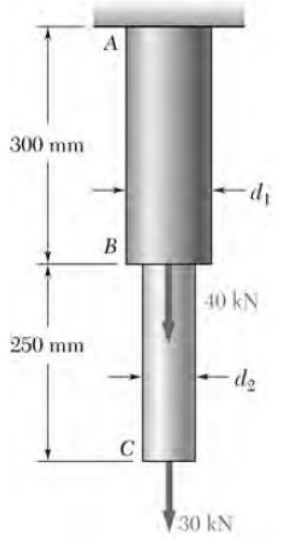
$$\Delta_2 = \frac{150 \times 10^3 \times 1000}{706.86 \times 0.7 \times 10^5} = 0.303 \text{ mm (contraction)}$$

$$\therefore \text{ Total } \Delta = \Delta_1 + \Delta_2 = 1.91 + 0.303 = \mathbf{2.213 \text{ mm}} \text{ (contraction)}$$

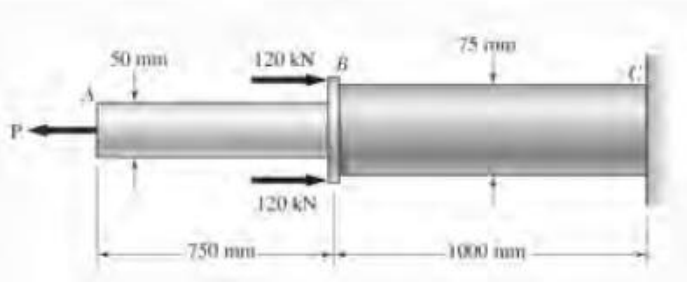
MECHANICAL ENGINEERING SCIENCE

STRESS AND STRAIN

1. *Two solid cylindrical rods AB and BC are welded together at B and loaded as shown. Knowing that the average normal stress must not exceed 175 MPa in rod AB and 150 MPa in rod BC, determine the smallest allowable values of d1 and d2.*



2. Two solid cylindrical rods AB and BC are welded together at B and loaded as shown. Determine the magnitude of the force P for which the tensile stress in rod AB is twice the magnitude of the compressive stress in rod BC.



THANK YOU

Dr. Mantesh B Khot
Department of Mechanical Engineering
mahanteshbk@pes.edu
+91 87 2202 4584