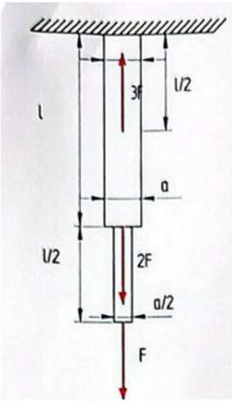
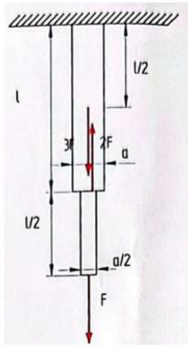
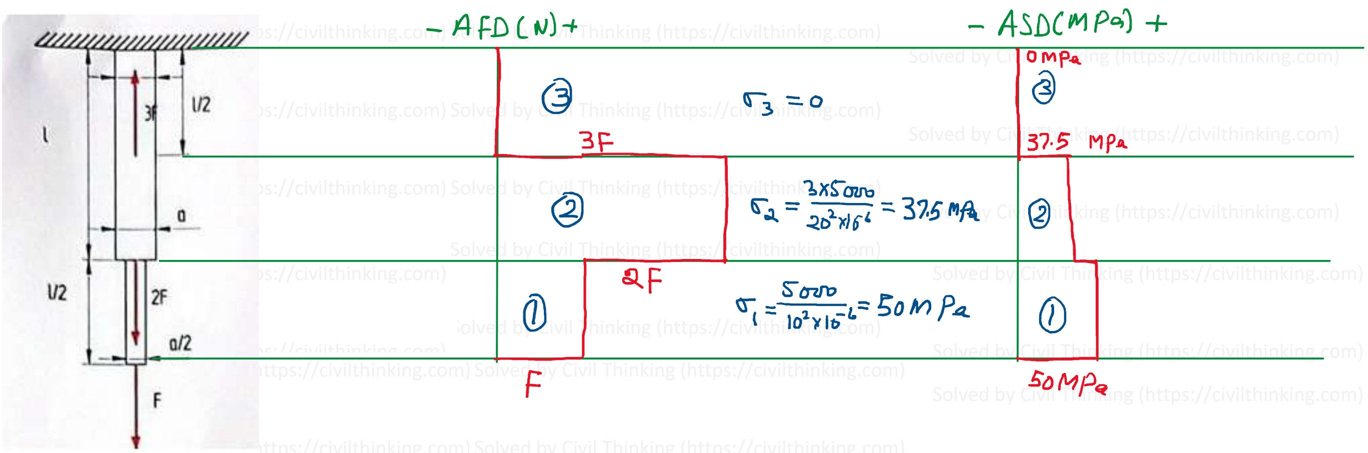
Solid Mechanics: Axial Load Diagram, Axial Stress Diagram: Problem 4 solution

Draw a graph of tensile or compressive forces and stresses and calculate the total deformation of a square steel bar with the given data l=4m b=20mm F=5000N and E=210 GPa for the following cases:







$$\delta L_{Total} = \frac{F_1L_1}{A_1E_1} + \frac{F_2L_2}{A_2E_2} + \frac{F_3L_3}{A_3E_3}$$

$$= \frac{F\,L/2}{\left(\frac{a}{2}\right)^2 \times E} + \frac{3F\cdot L/2}{a^2 E} + 0$$

$$= \frac{FL}{a^2E}\left[\frac{1/2}{1/4} + \frac{3/2}{1}\right]$$

$$\simeq 0.000833\ m = 0.83\ mm$$

$$\left(\frac{5\,000\times4}{20^2\times10^{-6}\times210\times10^9}\right)\times\left(\frac{\frac{1}{2}}{\frac{1}{4}}+\frac{\frac{3}{2}}{1}\right)$$

0.000 833 333 33

$$\delta L_{Total} = \frac{\sigma_1L_1}{E_1} + \frac{\sigma_2L_2}{E_2} + \frac{\sigma_3L_3}{E_3}$$

$$= \frac{\sigma_1\frac{L}{2}}{E} + \frac{\sigma_2\frac{L}{2}}{E} + 0$$

$$= \frac{L}{2E}(\sigma_1+\sigma_2)$$

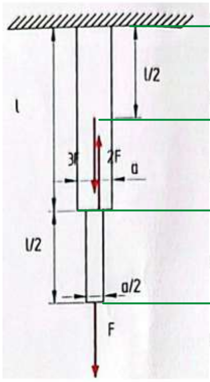
$$= \frac{4}{2\times210\times10^9}(50+37.5)\times10^6$$

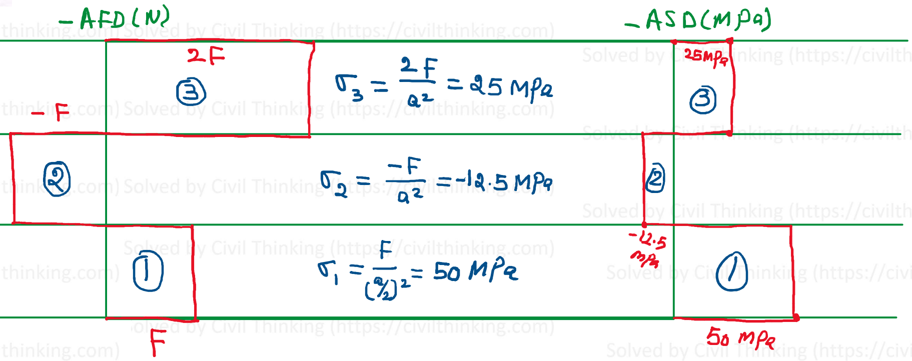
$$= 0.000833\ m = 0.83\ mm$$

$$\left(\frac{4}{2\times210\times10^9}\right)\times(50+37.5)\times10^6$$

0.000 833 333 33

l=4m b=20mm F=5000N and E=210 GPa





$$\Delta L_{Total} = \Delta L_1 + \Delta L_2 + \Delta L_3$$

$$= \frac{\sigma_1 L_1}{E} + \frac{\sigma_2 L_2}{E} + \frac{\sigma_3 L_3}{E} \quad \text{[Using ASD]}$$

$$= \frac{1}{E}\left[\sigma_1 \frac{L}{2} + \sigma_2 \frac{L}{2} + \sigma_3 \frac{L}{2}\right]$$

$$= \frac{L}{2E}\left[\sigma_1 + \sigma_2 + \sigma_3\right]$$

$$= \frac{4}{2 \times 210 \times 10^9}\left[50 + (-12.5) + 25\right] \times 10^6$$

$$\simeq 0.000595\,m \simeq 0.6\ mm$$

$$\Delta L_{Total} = \Delta L_1 + \Delta L_2 + \Delta L_3 = \frac{F_1 L_1}{A_1 E} + \frac{F_2 L_2}{A_2 E} + \frac{F_3 L_3}{A_3 E}$$

$$= \frac{1}{E}\left[\frac{F_1 L_1}{A_1} + \frac{F_2 L_2}{A_2} + \frac{F_3 L_3}{A_3}\right]$$

$$= \frac{1}{E}\left[\frac{FL}{2(a/2)^2} + \frac{-FL}{2a^2} + \frac{2FL}{2a^2}\right]$$

$$= \frac{FL}{2a^2 E}\left[\frac{1}{1/4} - \frac{1}{1} + \frac{2}{1}\right]$$

$$\simeq 0.000595 \simeq 0.6\ mm$$

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