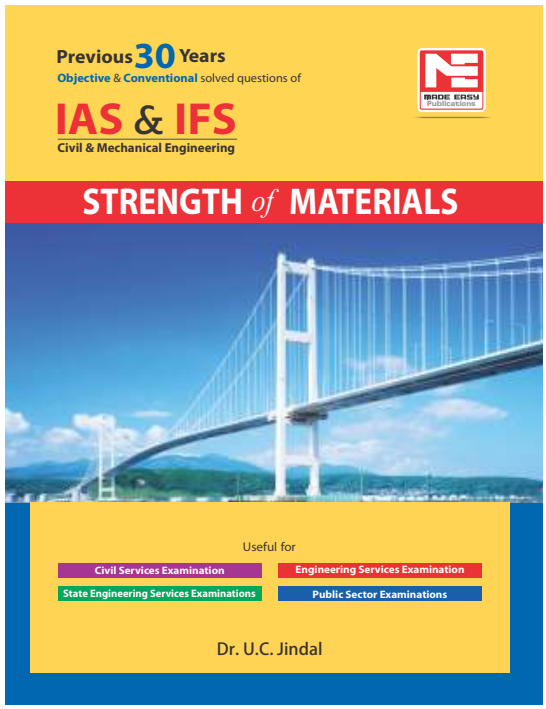

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About the Author :

Dr U.C. Jindal is former Professor and Head of the Deptt. of Mechanical Engineering, Delhi College of Engineering. He did his BE(Mech.) from Delhi University, M. Tech from IIT Kanpur and Ph.D in Experimental Stress Analysis from Delhi University. For the Last 50 years, he has been involved in teaching, research and developmental activities in the mechanics group of subjects i.e engineering mechanics, strength of materials, material science, machine design, experimental stress analysis, aircraft structures, vibrations etc. He has authored a book on MACHINE DESIGN, as a DST Project. He was recognized as Professor (Emeritus) by AICTE.

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Contents

IAS & IFS (Objective & Conventional) Previous Solved Questions

Strength of Materials

01 CHAPTER Simple Stresses in Uniform and Compound Bars

Q.1.1 A steel rod of length 300 mm and diameter 30 mm is subjected to a pull P, and the temperature rise is 100°C. If the total extension of the rod is 0.40 mm, calculate the magnitude of P. Take α for steel = 12×10^{-6}/°C and $E = 0.215 \times 10^6$ N/mm^2.

[CSE-Mains, 2011, CE : 12 Marks]

Solution:

P = Pull in N

A = Area of cross-section = $\frac{\pi}{4} \times 30^2 = 706.86$ mm^2

Extension due to pull, (assuming pull axial)

$$\delta l_1 = \frac{P}{AE} \times L = \frac{P \times 300}{706.86 \times 0.215 \times 10^6} = 1.974 \times 10^{-6} P \text{ mm}$$

δl_2 extension due to temperature change

$$= \alpha L \Delta T$$

$$= 12 \times 10^{-6} \times 300 \times 100 = 0.36$$

$$0.36 + 1.974 \times 10^{-6} P = 0.4$$

$$1.974 \times 10^{-6} P = 0.04$$

$$P = \frac{0.04 \times 10^6}{1.974} = 20263 \text{ N} = 20.263 \text{ kN}$$

Q.1.2 A metallic bar 250 mm × 100 mm × 50 mm is loaded as shown in the figure 1.1. Work out the change in volume. What should be the change that should be made in the 4 MN load in order that there should be no change in the volume of the bar.

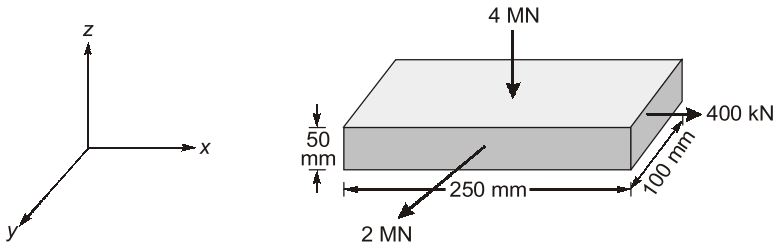

Fig. 1.1

Assume $E = 2 \times 10^5$ N/mm^2, Poisson's ratio = 0.25.

[IFS 2011, CE : 15 Marks]

Solution:

Stresses $\sigma_x = +\frac{400{,}000}{5000} = +80 \text{ MPa}$

$\sigma_y = +\frac{2\times10^6}{50\times250} = +160 \text{ MPa}$

$\sigma_z = -\frac{4\times10^6}{250\times100} = -160 \text{ MPa}$

Volumetric strain, $\varepsilon_v = \frac{\sigma_x+\sigma_y+\sigma_z}{E} - 2\nu\left(\frac{\sigma_x+\sigma_y+\sigma_z}{E}\right)$

$= \frac{80}{E} - 2\times0.25\times\frac{80}{E} = \frac{40}{E}$

Volume $= 250 \times 100 \times 50 \text{ mm}^3$

δV = change in volume $= \varepsilon_v \times V = \frac{40}{E}\times250\times100\times50$

$= \frac{50\times10^6}{E} = \frac{50\times10^6}{2\times10^5} = 250 \text{ mm}^3$

(b) For $\varepsilon_v = 0$

$\sigma_x + \sigma_y + \sigma_z - 2\nu(\sigma_x+\sigma_y+\sigma_z) = 0$

$(\sigma_x+\sigma_y)(1-2\nu) = 2\nu(\sigma_z) - \sigma_z$

$(80+160)(1-2\nu) = (2\nu-1)\sigma_z$

$240\times0.5 = (2\nu-1) = -0.5\,\sigma_z$

$120 = -\sigma_z \times 0.5$

$\sigma_z = -240 \text{ MPa}$

where in load, $P_y' = 240 \times 250 \times 100 = 6 \text{ MN}$

4 MN load should be increased to 6 MN load in same direction

So that σ_z becomes –240 N/mm^2.

Q.1.3 A crane chain having an area 7.25 cm^2 carries a load of 15 kN. It is being lowered at a uniform speed of 50 m/minute, the chain gets jammed suddenly, at that time the length of chain unwound is 12 m. Estimate the stress induced in the chain due to sudden stoppage. Neglect weight of the chain. Assume $E = 2.1 \times 10^5$ N/mm^2.

[IFS 2012, CE : 10 Marks]

Solution:

$W = 15 \text{ kN} = 15000 \text{ N}$ (∵ self weight of chain negligible)

A, chain area of cross-section $= 725 \text{ mm}^2$

Length, $L = 12000 \text{ mm}$

Volume of chain $= 12000 \times 725 = 87 \times 10^5 \text{ mm}^3$

Say, stress developed $= \sigma_i$, instantaneous in N/mm^2

Speed, $V = \frac{50}{60} = 0.833 \text{ m/s}$

Kinetic energy absorbed by chain $= \frac{mV^2}{2} = \frac{15000}{9.81}\times\frac{0.833^2}{2} = 530.5 \text{ Nm} = 530500 \text{ Nmm}$