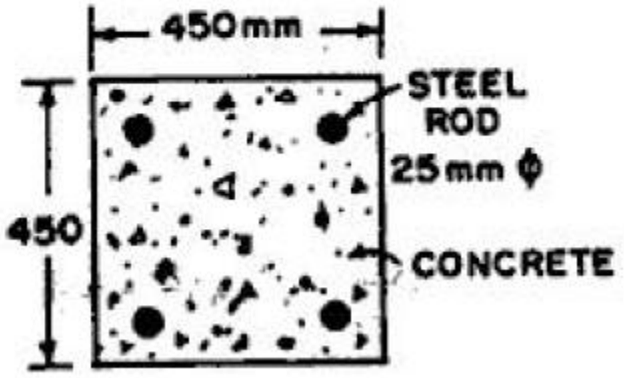
MECHANICAL ENGINEERING SCIENCE

Dr. Mantesh B Khot

Department of Mechanical Engineering

NUMERICALS

A reinforced concrete column 450 mm×450 mm has four steel rods of 25 mm diameter embedded in it. Determine the stresses in steel and concrete when total load on the column is 1000 kN. Take moduli of elasticity for steel and concrete as 205 MPa and 13.6 KN/mm^2 respectively.



NUMERICALS

Solution

$$\text{Total area of column} = 450 \times 450$$

$$= 202500 \text{ mm}^2$$

$$\text{Area of steel rods} = 4\left(\frac{\pi}{4}25^2\right)$$

$$= 1963.5 \text{ mm}^2$$

$$\therefore \quad \text{Area of concrete, } A_c = 202500 - 1963.5$$

$$= 200536.5 \text{ mm}^2$$

$$\text{From equilibrium, } p_s A_s + p_c A_c = 1000 \times 10^3 \quad \text{...}(i)$$

NUMERICALS

From compatibility, $\frac{p_s}{E_s} = \frac{p_c}{E_c}$

or $$p_s = p_c \cdot \frac{E_s}{E_c} = p_c \frac{205}{13.6} = 15.074\, p_c \quad \text{...(2)}$$

Substituting this value of p_s in (1) we get

$\therefore$ $15.074\, p_c\,(1963.5) + p_c\,(200536.5) = 1000 \times 10^3$

From which, $p_c = \mathbf{4.345\ N/mm^2}$

Hence $p_s = 15.074 \times 4.345 = \mathbf{65.501\ N/mm^2}$

Now, average compressive stress $= \frac{1000 \times 10^3}{202500} = 4.938\ \text{N/mm}^2$

$\therefore$ Average load carried by concrete $= 4.938 \times 200536.5 \times 10^{-3} = 990.3$ kN

Actual load carried by concrete $= 4.345 \times 200536.5 \times 10^{-3} = 871.3$ kN

A concrete column of 37.5 cm2 cross-section, reinforced with steel rods having a total cross-sectional area 7.5 cm2 carries a load of 800 kN as shown in Figure a. If *E* for steel is 15 times greater than that of concrete, calculate the loads in steel, and concrete.

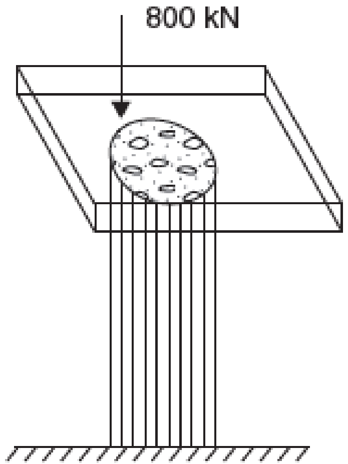


Figure a: Concrete Column

Solution:

$$E_{steel} = 15E_{concrete};$$

$$A_{concrete} = (37.5 - 7.5)\ \text{cm}^2 = 30\ \text{cm}^2;\ \text{and}\ A_{steel} = 7.5\ \text{cm}^2$$

Contraction in both the steel and concrete will be same.

$$\delta l_{steel} = \delta l_{concrete}\ \text{also,}\ \in_{steel} = \in_{concrete}$$

and load, $P = P_{steel} + P_{concrete}$

Since, $\in_{steel} = \in_{concrete}$

$$\frac{\sigma_{steel}}{E_{steel}} = \frac{\sigma_{concrete}}{E_{concrete}} \Rightarrow \frac{P_{steel}}{A_{steel}E_{steel}} = \frac{P_{concrete}}{A_{concrete}E_{concrete}}$$

or $$P_{steel} = \frac{A_{steel}E_{steel}}{A_{concrete}E_{concrete}} \times P_{concrete} = \frac{7.5 \times 15E_{concrete}}{30 \times E_{concrete}} \times P_{concrete}$$

or $$P_{steel} = 3.75\ P_{concrete}$$

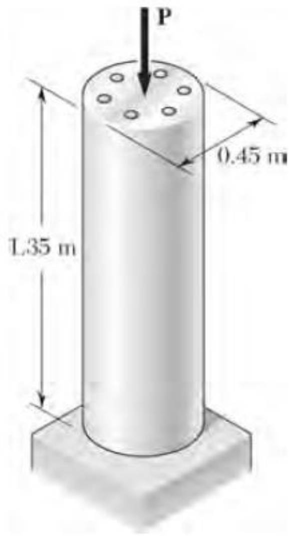
$$P = P_{\text{steel}} + P_{\text{concrete}} = 3.75\, P_{\text{concrete}} + P_{\text{concrete}} = 4.75\, P_{\text{concrete}}$$

$$P_{\text{concrete}} = \frac{P}{4.75} = \frac{800}{4.75} = 168.42\text{kN}$$

$$P_{\text{steel}} = 800 - 168.42 = 631.58 \text{ kN}$$

1. An axial force of 200 kN is applied to the assembly shown by means of rigid end plates. Determine (a) the normal stress in the aluminum shell, (b) the corresponding deformation of the assembly.

*2. The 1.35 m concrete post is reinforced with six steel bars, each with a 28 mm diameter. Knowing that Youngs Modulus of steel is 200 GPa Youngs Modulus of concrete is 29 GPa. Determine the normal stresses in the steel and in the concrete when a 1560 kN axial centric force **P** is applied to the post.*



THANK YOU

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