

BENDING STRESS SOLUTIONS

Exercise 1:

Calculate the maximum stress that will be produced in a steel beam of rectangular cross-section when bent into the arc of a circle of radius 5 m. The depth of the beam is 6 mm, the modulus of Elasticity 210 kN/mm². Give your answer in kN/mm².

Solution:

$$\sigma_{max} = \frac{y_{max}E}{R} = \frac{3 \times 210}{5 \times 10^3} = 0.126 \text{ kN/mm}^2$$

Exercise 2:

Calculate the radius to which a steel strip of thickness 4 mm can be bent if the maximum stress acting on the material is not to exceed 100 N/mm². The material has a modulus of elasticity of 210 kN/mm².

Solution:

$$R = \frac{y_{max}E}{\sigma_{max}} = \frac{2 \times 210 \times 10^3}{100} = 4200 \text{ mm} = 4.2 \text{ m}$$

Example 3:

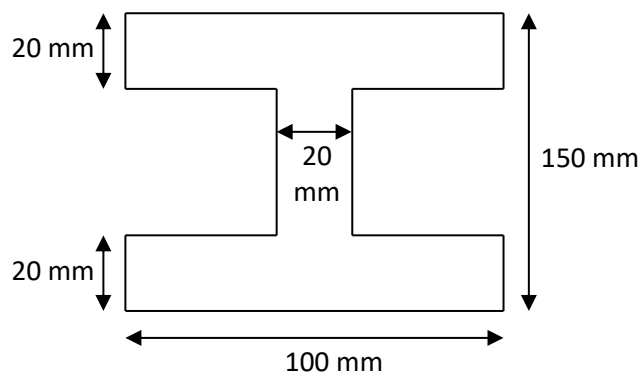
A beam of rectangular cross-section, 40 mm × 160 mm deep, is subjected to a bending of 35 kN.m. Determine the maximum bending stress in the beam material.

Solution:

$$\sigma_{max} = \frac{My_{max}}{I} = \frac{35 \times 10^3 \times 80 \times 10^{-3}}{\frac{40 \times 10^{-3} \times (160 \times 10^{-3})^3}{12}} = \frac{2800}{1.3653 \times 10^{-5}} = 205.08 \text{ MPa}$$

Example 4:

The cross-section of the idealised beam shown in the following figure has overall dimension of 100 mm × 150 mm deep with a flange and web thickness of 20 mm. Calculate the second moment of area of the section about the neutral axis. If the bending stress in the beam material is not to exceed 180 MN/m², determine the maximum bending moment in the beam.



Solution:

$$M = \frac{I\sigma_{max}}{y_{max}}$$

Where,

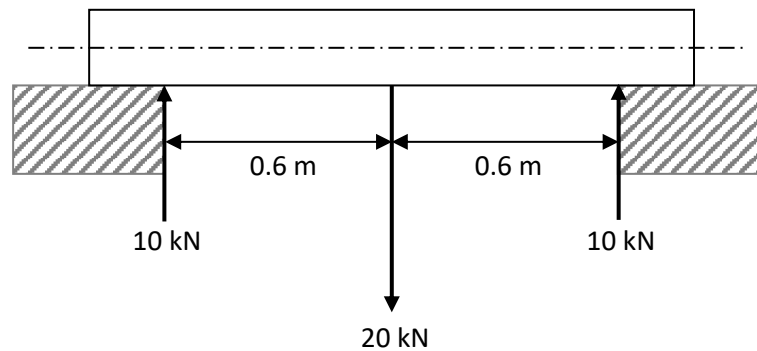
$$I = \frac{0.1(0.11 + 2 \times 0.02)^3}{12} - \frac{(0.1 - 0.02) \times 0.11^3}{12} = 1.925 \times 10^{-5} m^4$$

Therefore,

$$M = \frac{1.925 \times 10^{-5} \times 180 \times 10^6}{0.075} = 46204 Nm$$

Example 5:

A steel bar, 100 mm diameter, is used to support a pulley block. If the bar is simply supported over a span of 1.2 m, determine the maximum bending stress in the material when the pulley block is at mid-span supporting a load of 20 kN.



Solution:

$$\sigma_{max} = \frac{M_{max}y_{max}}{I}$$

With,

$$I = \frac{\pi r^4}{4} = 4.91 \times 10^{-6} m^4$$

$$M_{max} = \sum \text{moments to left of mid span}$$

$$\therefore M_{max} = 10 \times 0.6 = 6 kNm$$

Therefore,

$$\sigma_{max} = \frac{6 \times 10^3 \times 0.05}{4.91 \times 10^{-6}} = 61.12 MN/m^2$$

Example 6:

The maximum bending moment and bending stress in a beam of rectangular cross-section must not exceed 25 kN.m and 130 MN/m² respectively. What will be the minimum dimensions of the beam cross-section if the width of the beam is 2/3 of its depth?

Solution:

$$I = \frac{bd^3}{12} \text{ and } b = \frac{2}{3}d$$

$$\therefore I = \frac{2}{3}d \frac{d^3}{12} = \frac{d^4}{18}$$

From simple bending equation,

$$\sigma = \frac{My}{I}$$

Where,

$$\begin{aligned}\sigma &= 130 \text{ MN/m}^2 \\ M &= 25 \text{ kN} \\ y &= 0.5d\end{aligned}$$

Therefore,

$$130 \times 10^6 = \frac{25 \times 10^3 \times 0.5d}{\frac{d^4}{18}}$$

$$\therefore d^3 = \frac{25 \times 10^3 \times 0.5 \times 18}{130 \times 10^6} = 1.713 \times 10^{-3}$$

$$\therefore d = \sqrt[3]{1.713 \times 10^{-3}} = 120 \text{ mm}$$

And,

$$b = \frac{2}{3} \times 120 = 80 \text{ mm}$$

That is, the beam dimensions are 80 mm x 120 mm deep.