Question #78923

Compare the percentage increase in the bending moment that can be carried to produce the same maximum bending stress when a rectangular beam section is

1) Doubled in breadth, and 2) Doubled in depth.

Answer:

The maximum bending moment that can be carried by a beam is given by:

$$M = \sigma W, \tag{1}$$

where σ is a bending stress,

$W = \frac{1}{6}bh^2$ – the elastic section module of a rectangular beam section,

b and *h* are, respectively, the breadth and the depth of the cross section of a beam.

From (1) we can determine the increase in the maximum bending moment with the increase of the cross section sizing as follow:

$$\frac{M_i}{M} = \frac{\sigma W_i}{\sigma W},$$

$$\frac{M_i}{M} = \frac{b_i}{b}\left(\frac{h_i}{h}\right)^2. \tag{2}$$

The percentage increase could be determined by:

$$\varepsilon_M = \left(\frac{b_i}{b}\left(\frac{h_i}{h}\right)^2 - 1\right) \cdot 100\%. \tag{3}$$

Thus, in case 1) with doubled breadth ($b_i = 2b$, $h_i = h$) we have increase in the maximum bending moment by:

$$\varepsilon_M = \left(\frac{2b}{b}\left(\frac{h}{h}\right)^2 - 1\right) \cdot 100\% = (2-1) \cdot 100\% = 100\%.$$

In case 2) with doubled depth ($b_i = b$, $h_i = 2h$) we have increase in the maximum bending moment by:

$$\varepsilon_M = \left(\frac{b}{b}\left(\frac{2h}{h}\right)^2 - 1\right) \cdot 100\% = (4-1) \cdot 100\% = 300\%.$$