1.4 Use AS4/3501-6 carbon/epoxy composite to make the I-beam as stated in Problem 1.3. Compare its weight with that of the aluminum beam.

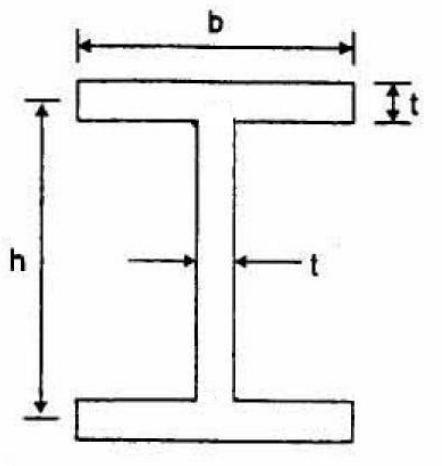

Figure 1.17 Dimensions of the cross-section of an I-beam

Solution:

Proceed in the same manner as that of problem 1.3.

(1) The expression of area moment of inertia I for a I-beam is:

$$I = \frac{t}{12}(h-t)^3 + [\frac{b}{12}t^3 + (bt)(\frac{h}{2})^2] \times 2$$

(2) First, obtain the area moment of inertia of the steel (300M) I-beam with given b, t, and h. We have

$$I_{Steel} = \frac{5}{12}(200-5)^3 + [\frac{50}{12}\cdot 5^3 + (50\cdot 5)(\frac{200}{2})^2] \times 2 = 8090573 mm^4$$

(3) For the condition $(EI)_{Composite} = (EI)_{Steel}$

we have $I_{Com} = \frac{E_{St}}{E_{Com}} I_{St} = \frac{200}{140} \times 8090573 = 11558000 mm^4$

The moment of inertia of the composite beam is given by

$$I_{Com} = \frac{5}{12}(200-5)^3 + [\frac{b}{12}\cdot 5^3 + (b\cdot 5)(\frac{200}{2})^2] \times 2$$
$$= 3089531.3 + 100020.8b = 11558000$$

Thus the width of the cross-section is obtained as $b = 84.7mm$

---- ANS

(4) Then, we compare the weights-per-unit length of these two beams.

The weights-per-unit length is defined as

$w = \rho \cdot A$, where ρ = density , and A = cross-sectional area

(i) For the composite beam

$$\rho_{Com} = 1.55(g/cm^3) = 1.55\times10^{-3}(g/mm^3)$$

$$A_{Com} = (200-5)\times5 + 2\times84.67\times5 = 1822(mm^2)$$

$$w_{Com} = \rho_{Com}\cdot A_{Com} = 1.55\times10^{-3}\times1821.7 = 2.8(g/mm)$$

(ii) Compare the weights per unit length with that of the aluminum beam

$$w_{Com} = 2.8(g/mm) < w_{Al} = 8.2(g/mm)$$

This indicates that the *AS4/3501-6 CARBON/EPOXY COMPOSITE BEAM IS MORE EFFICIENT* than the aluminum beam!

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