HOMEWORK SOLUTION
MER214: STRENGTH OF MATERIAL

PROBLEM 6.32 | THE BUILT-UP WOODEN BEAM SHOWN IS SUBJECTED TO A VERTICAL SHEAR OF 8 kN. KNOWING THAT NAILS ARE SPACED LONGITUDINALLY EVERY 60mm AT A AND EVERY 25mm AT B, DETERMINE THE SHEARING FORCE IN THE NAILS (a) AT A, (b) AT B. (GIVEN: $I_x = 1.504 \times 10^9 mm^4$)

GIVEN:
1. BUILT UP I-BEAM WITH MOMENT OF INERTIA OF $1.504 \times 10^9 mm^4$
2. NAILS AT POINTS "A" AND "B".
3. AT "A" NAILS ARE SPACED EVERY 60mm LONGITUDINALLY
4. AT "B" NAILS ARE SPACED EVERY 25mm LONGITUDINALLY
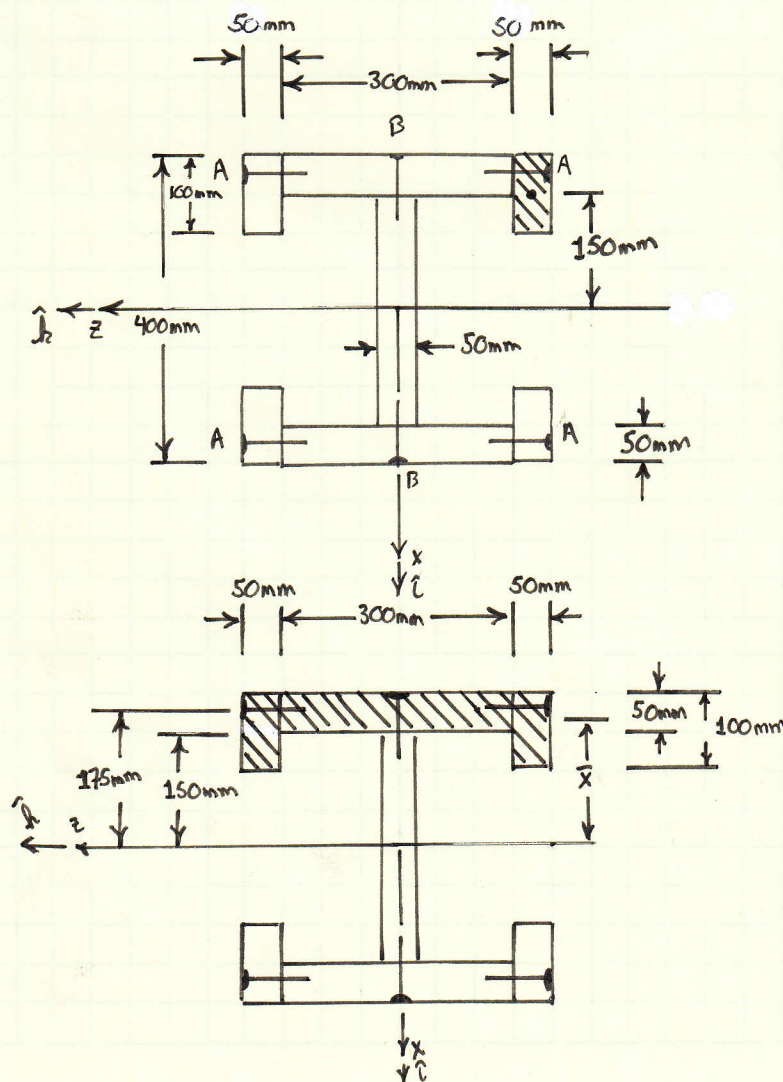
ASSUMPTIONS:
1. THE MATERIAL IS LINEARLY ELASTIC
2. DEFORMATIONS ARE SMALL

FIND:
1. SHEAR FORCE IN THE NAILS AT "A".
2. SHEAR FORCE IN THE NAILS AT "B".

FIGURE:

(a)

(b)

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SOLUTION:

STARTING WITH THE SHADED REGION IN FIGURE @, THE EXPRESSION FOR THE SHEAR FLOW IS GIVEN BY

$$q = \frac{V \cdot Q}{I} \qquad \text{①}$$

$$Q = \bar{x} \cdot A = (150mm) \cdot (50mm)(100mm) = 750(10^3) mm^3 \qquad \text{②}$$

$$\Rightarrow q = \frac{8(10^3)N \cdot 750(10^3)mm^3}{1.504 \times 10^9 mm^4} = 3.989 \frac{N}{mm} \qquad \text{③}$$

THE ALTERNATIVE EXPRESSION FOR THE SHEAR FLOW IS

$$q = 3.989 \frac{N}{mm} = \frac{\text{SHEAR FORCE IN A NAIL}}{\text{SPACING}} = \frac{F_s}{60mm}$$

$$\boxed{F_s = 239.4 \, N} \qquad \text{FOR NAILS AT "A"} \qquad \text{④}$$

NOW CONSIDER THE SHADED REGION IN FIGURE ⓑ

$$Q = \sum \bar{Y}_i A_i = 2 \cdot (150mm)(100mm)(50mm) + (175mm)(50mm)(300mm)$$

$$= 4.125(10^6) mm^3$$

$$q = \frac{8(10^3)N \cdot 4.125(10^6)mm^3}{1.504(10^9)mm^4} = 21.94 \frac{N}{mm}$$

$$q = 21.94 \frac{N}{mm} = \frac{F_s}{25mm}$$

$$F_s = (21.94 \frac{N}{mm}) \cdot (25 \cdot mm) = \boxed{548.5 \, N} \qquad \text{FOR NAILS AT "B"}$$

SUMMARY:

IN THIS PROBLEM THE DEFINATIONS OF SHEAR FLOW USED TO START THE PROBLEM IS RELATED TO THE SHEAR STRESS ON THE AXIAL SURFACE. THE SECOND DEFINATION OF SHEAR FLOW RELATES TO THE SPACING OF THE NAILS AXIALLY. THESE TWO SHEAR FLOWS ARE ACTUALLY PERPENDICULAR TO EACH OTHER.