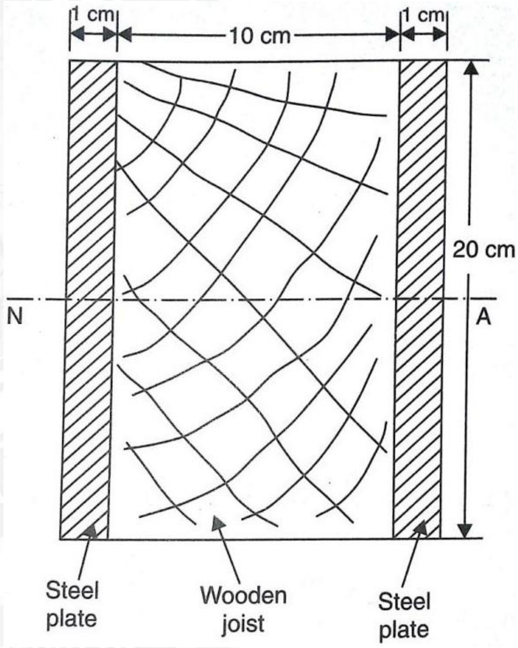
3.6. COMPOSITE BEAMS (FLITCHED BEAMS)

A beam made up of two or more different materials assumed to be rigidly connected together and behaving like a single piece is known as a composite beam or a wooden flitched beam. The strain at the common surface will be same for both materials. Also the total moment of resistance will be equal to the sum of the moments of individual sections.

Problem 3.6.1. a flitched beam consist of a wooden joist 10cm wide and 20cm deep strengthed by two steel plates 10mm thick and 20cm deep. If the max stress in the wooden joist is 7 N/mm^2. Find the corresponding max stress attained in steel. Find also the moment of resistance of the composite section. Take youngs modulus for steel = 2×10^5 N/mm^2 and for wood = 1×10^4 N/mm^2



Given

Let width of wooden joist b_2 = 10cm

Depth of wooden joist d_2 = 20cm

Width of one steel plate b_1 = 1cm

Depth of one steel plate d_1 = 20cm

Number of steel plate = 2

Max stress in wood σ_2 = 7N/mm^2

E for steel $E_1 = 2\times 10^5$ N/mm^2

E for wood $E_2 = 1\times 10^4$ N/mm^2

Solution:

M.O.I. of wooden joist about N.A.

$$I_2 = b_2 d_2^2 /12 = 6666.66 cm^4$$

M.O.I of two steel plates about N.A

$$I_2 = 2\times b_1 d_1^3 = 1333.33\times 10^4\ mm^4$$

Now using $\sigma_{1/E_1} = \sigma_{2/E_2}$

$$\sigma_1 = 20\times 7 = \mathbf{140\ N/}mm^2$$

Total moment M = $M_1 + M_2$

Where $M_1 = \frac{\sigma 1}{y} \times I_1$

$$= \frac{140}{100} \times 1333.33\times 10^4$$

$$= 18666.620 \text{ Nm}$$

$$M_2 = \frac{\sigma_2}{y} \times I_2$$

$$= \frac{7}{100} \times 6666.66 \times 10^4 \text{ N mm}$$

$$= 4666.662 \text{ Nm}$$

$$M = M_1 + M_2$$

$$= 18666.620 + 4666.662$$

$$= \mathbf{23333.282 \ Nm}$$

IMPORTANT TERMS

Shear force	Adding of vertical forces from right side to the consider point of the beam Symbol: Downward force = + ve Upward force = - ve	**Diagram:** Point load (W) = vertical line (upward force = downward line Downward force = upward line) UVL (w) – Inclined line UVL (w) – parabolic curve Cantilever Beam : +ve side SSB : + ve or – ve OHB : + ve or – ve
Bending moment	Adding of bending moment from right side to the consider point of the beam. Symbol: Clockwise direction = - ve Anticlockwise direction = +ve CLB : free end = 0 SSB : Both end = 0 OHB : Both end = 0	**Diagram:** Point load (W) – Inclined line (upward force = downward line Down force = upward line UVL (w) – parabolic curve UVL (w) – Cubic Curve Cantilever Beam : - ve side SSB : + ve OHB : + ve or – ve
Cantilever Beam	Adding of vertical forces	PL = add only W UDL = Add (Force x distance) UDL acting point = midpoint = $l/2$ UVL = add ($wl/2$) UVL acting point from small end = $2l/3$ UVL acting point from big end = $l/3$
SSB	Step 1: To find reaction forces at two support (R_A, R_B) Take moment about A = 0 to find Reaction R_B Sum of upward force = downward force; to find reaction R_A	

OHB	Same procedure as SSB SF with Reaction & without reaction calculate	**Maximum bending moment** at shear force become zero (SF = 0) **Point of contrafluxture** act at Bending moment become zero (BM = 0)
BENDING STRESS IN BEAM		
Bending Equation	$\frac{M}{I} = \frac{\sigma_{max}}{y_{max}} = \frac{E}{R}$ Based on type of beam with support to find M which is available in **IV unit table**	$M = Bending\ Moment$ $I = Moment\ of\ Inertia$ $\sigma = Bending\ stress$ $y = distance\ of\ Neutral\ axis$ $E = Youngs\ modulus$ $R = Bending\ radius$
Section Modulus	$Z = \frac{I}{y}$ $= \frac{bd^2}{6}\ for\ Rectangular\ section$ $= \frac{1}{6D}(BD^3 - bd^3)\ hollow\ Rect$	$= \frac{\pi d^3}{32}\ for\ circular\ section$ $= \frac{\pi}{32D}(D^4 - d^4)\ hollow\ circlr$
For Unsymmetrical section	Step1: to find C.G of the section in y direction = $\bar{y}$ but max value of y is used in bending eqn. Step2: to find Moment of inertia of the section = I Step3: from Moment eqn to find unknown value	
Moment of resistance of a section	$M = \sigma\ x\ Z$	
Composite beam(Flitched beams)	Strain remains same $e_1 = e_2 = \frac{\sigma 1}{E_1} = \frac{\sigma 2}{E_2}$	
Modular Ratio	$= \frac{E_1}{E_2}$	