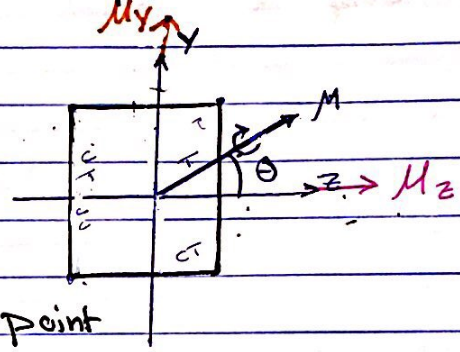
6.5 : Unsymmetric Bending

- When M is not applied on a principal axis We have to find It's components on the principal axes.

$$M_y = M \sin\theta$$
$$M_z = M \cos\theta$$



→ and to find stress at any point or Corner :-

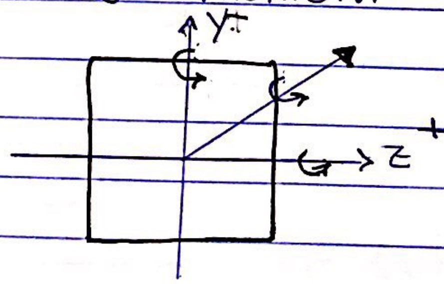
$$\sigma = \frac{M_z}{I_z} y + \frac{M_y}{I_y} z$$

Where : I_z : moment about z axis (of the cross section ex: square, triangle, ...)
I_y : ~ ~ y ~ (~ ~ ~ ~ ~)

y : ⊥ Distance between point and axis of moment on y
z : ⊥ ~ ~ ~ ~ axis of moment on z

- Sign Convention :

Take each component of the moment
→ M_z :
The direction of M_z (right hand thumb) is at z^+
and The direction of M_y (~ ~ ~) ~ ~ y^+



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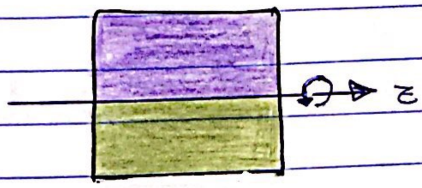
→ And for the stress : Tention +
compression −

- M_z:-

If M_z is compressing a point then It's neg
" " " tensioning " " " " pos

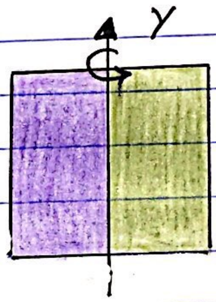


▶ Purple region is Tension so M_z is + at each point

▶ Green region is Compression so M_z is − at each point

- M_y:-

Same idea



▶ purpule region is Tension

▶ Green region is Compression

→ Orientation of the Neutral axis:-

$$\tan \alpha = \frac{I_z}{I_y} \tan \theta$$

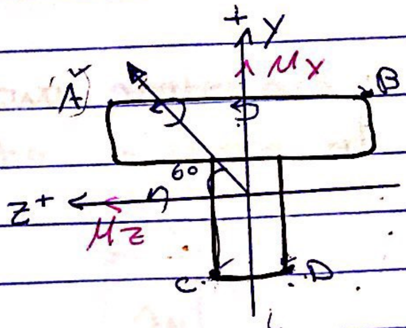
نعوض مع الاشارة

θ: + from z^+ to y^+

Ex: 6-108

$(\sigma_{allow})_t = 4\times10^6\ Pa$

$(\sigma_{allow})_c = 6\times10^6\ Pa$



$M_y = M\sin60$

$M_z = M\cos60$

find $\bar{y}$ $(\bar{y} = 0.0875)$

find I.

$I_z = (\frac{1}{12})(0.2)(0.05)^3 + (0.05)(0.2)(0.0875-0.05)^2 + (\frac{1}{12})(0.05)(0.2)^3 + (0.050)(0.2)(0.15-0.0875)^2$

$= 0.1135\times10^{-3}$

$I_y = (\frac{1}{12})(0.05)(0.2)^3 + \frac{1}{12}(0.2)(0.05)^3$

$= 35.417\times10^{-6}$

σ is Totally Tension at C

$$\sigma = \frac{M_z}{I_z}y + \frac{M_y}{I_y}z$$

$$4\times10^6 = \left(\frac{M\cos60}{0.1135\times10^{-3}}\right)(0.1625) + \left(\frac{M\sin60}{35.417\times10^{-6}}\right)(0.025)$$

$M = 21197.1\ N.m$

σ is Totally Compression at B

$$\sigma = -\frac{M_z}{I_z}y + -\frac{M_y}{I_y}z$$

$M = 3.01\ KN$ → Take the less value.

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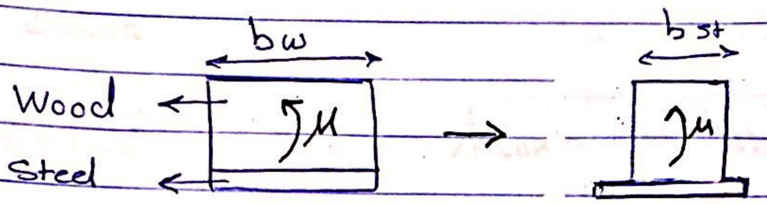
6.6 Composite Beams:

→ If you have a piece of two materials you can transform it to a piece of one material.

$E_{st} > E_{wood}$



$b_{st} = n\, b_w$ ⤳ where $n = \dfrac{E_w}{E_{st}}$ $\quad \dfrac{\text{mat}①}{\text{mat}②}$

- after finding new b and n find $\bar{y}$ (Neutral axis) and I_{NA}
- and you can use $\sigma = \dfrac{Mc}{I}$ to find stress

If you wand to find σ at apoint but in wood use

$$\underset{\text{old mat (1)}}{\underline{\sigma_w}} = n\, \underset{\text{new mat (2)}}{\underline{\sigma_{st}}}$$

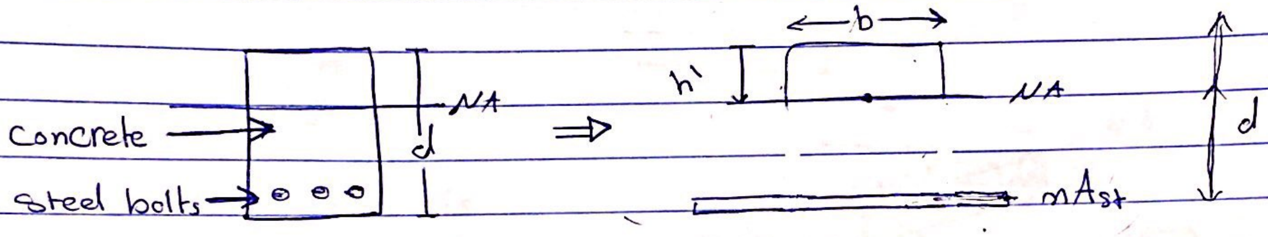
6.7: Reinforced Concrete Beams

$$n = \frac{E_{st}}{E_{conc}}$$

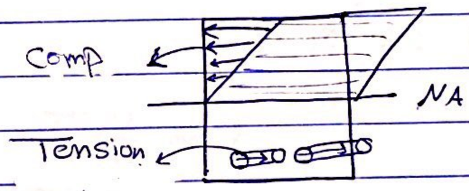
Transformed Area : $A_{con} = n A_{st}$

Equation to find h': (Distance from top to N.A)

$\rightarrow \frac{b}{2} h'^2 + n A_{st} h' - n A_{st} d = 0$



Sketch of stress:



$\Sigma \bar{y} A = 0$

Ch7. Transverse Shear

7.1+2 : Shear in straight members and shear formula.

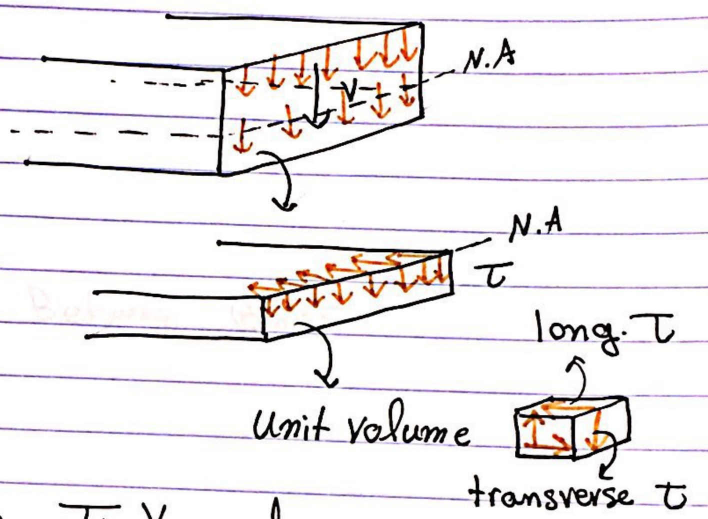
Shear → longtudinal shear

Shear → transverse shear

- Shear stress at the top = 0

$$\tau = \frac{VQ}{It}$$

and τ_{max} is at the N.A.



▸ Difference between $\tau = \frac{V}{A}$ and Shear formula $\tau = \frac{VQ}{It}$

$\tau = \frac{V}{A}$ Calculates Avg shear stress in the cross section

$\tau = \frac{VQ}{It}$ ~ shear stress in a specefic point or Area

Now : what's t and Q :-

Q : Moment of Area above or under point

t: width of cross sectional area at where τ is measured.

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7.3: Shear flow in Built up Members.

Shear flow $q = \frac{VQ}{I}$

q: is the loading measured as a force per unit length

You can relate shear flow and shear stress

$$\tau = \frac{q}{t}$$

→ Now:

$$F = \frac{S \times q}{n}$$

spacing Between Bolts

Strength of each nail

n: number of nails crossing the Area Boundry (see page 382 in Book)

▶ to find shear stress in each Bolt

$$\tau = \frac{F}{A} = \frac{S \times q}{n \times A}$$

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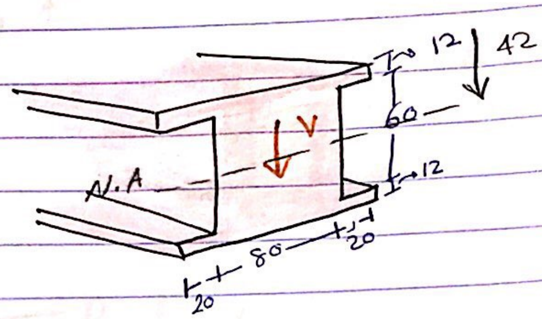
Examples solved on Ch 7:

7.14 $V_{max} = ?$



$\tau_{all} = 40\ MPa$

$\tau_{all} = \frac{VQ}{It}$

→ Q_{max} is at N.A

• $t = 80\ mm$

• $I = 2\left(\frac{1}{12}(120)(12)^3 + (12)(120)(36)^2\right) + \left(\frac{1}{12}\right)(80)(60)^3$

$= 5207040\ mm^4 = 5207040 \times 10^{-12}\ m^4$

$= 5.20704 \times 10^{-6}\ m^4$

• $Q = \Sigma \bar{y}A = (0.036)(0.012)(0.12) + \left(\frac{0.03}{2}\right)(0.08)(0.03)$

$= 8.784 \times 10^{-5}$

$40\mu = \frac{V(8.784 \times 10^{-5})}{(5.20704 \times 10^{-6})(0.08)}$

$V = 189691.8\ N$

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7.41

$P = 12\ kN$

$S = ??$ if $F_{max} = 1.5\ kN$

$$F = \frac{q \times S}{n}$$

$$S = \frac{nF}{q}$$

$$q_{max} = \frac{V_{max} Q_{max}}{I} =$$

Q_{max} (Around N.A)

$$Q = (112.5)(0.025)(0.1)$$

$$Q = 2.8125 \times 10^{-4}$$

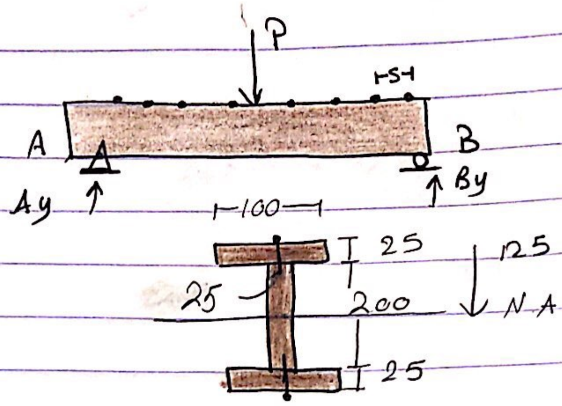
$$\text{So} \quad q_{max} = \frac{(6k)(2.8125)(10^{-4})}{(8.0208)(10^{-5})}$$

$$= 21039.048\ N/m$$

$$S = \frac{(1)(1.5 \times 10^3)}{(21039.048)}$$

$$S = 0.071296\ m$$

$$= 71.296\ mm$$



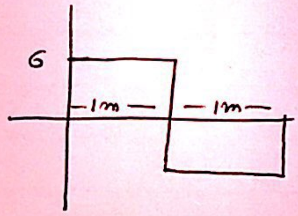
To find V_{max}:

• Reactions :

$\Sigma M_A = 0 \quad : \quad -P(1) + (B_y)(2) = 0$

$B_y = 6\ KN = A_y$

• So $V_{max} = 6\ KN$



$$I = 2\left[\frac{1}{12}(0.1)(0.025)^3 + (0.1)(0.025)(0.1125)^2\right] + \left(\frac{1}{12}\right)(0.025)(0.200)^3$$

$$I = 8.0208 \times 10^{-5}$$

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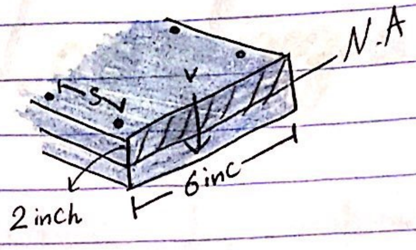
7-33

$s = 6$ inch



$V = 600$ lb

$F = \dfrac{q \times s}{n}$

$F = \dfrac{q \times 6}{2}$ ~ 2 rows

$$q = \frac{VQ}{I} = \frac{600 \overbrace{\left((1)(2)(6)\right)}^{in^3}}{\left(\frac{1}{12}\right)(6)(4)^3 \; in^4} = 225 \text{ lb/in}$$

$F = \dfrac{(225)(6)}{2} = 675$ lb

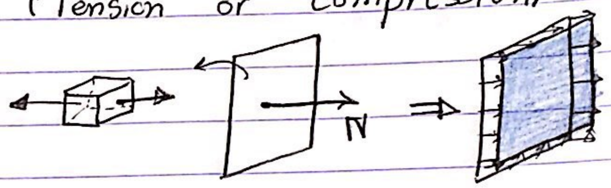
Ch8. Combined Loadings.

→ 8.2 : State of stress caused by combined Loadings.

In this section you will have to find the Combined state of stress at a point so Remember:

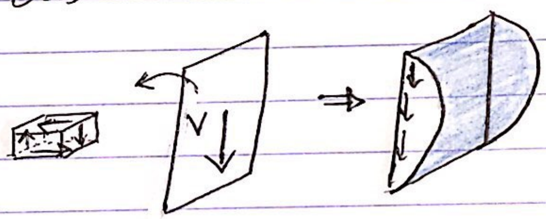
Normal force: → It Does a normal stress (Tension or compression)

$$\sigma = \frac{N}{A}$$



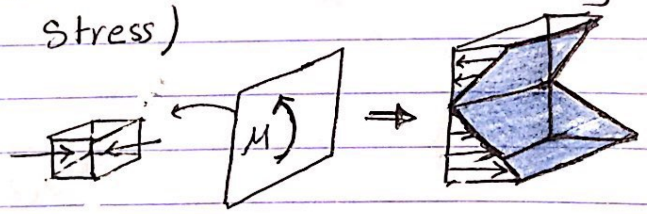
Shear force: → It Does a shear stress

$$\tau = \frac{VQ}{It}$$



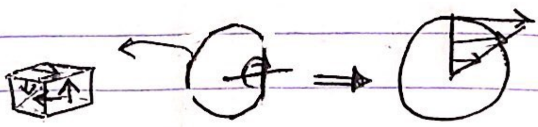
Bending Moment: → It Does a stress (Bending stress)

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



Torsional Moment: → It Does a shear stress

$$\tau = \frac{Tc}{J}$$



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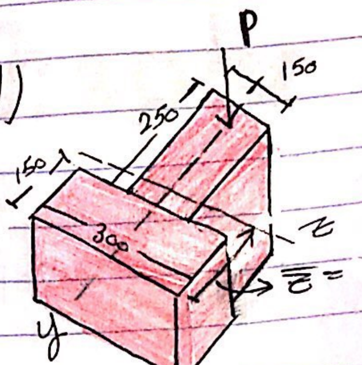
8-27

$\sigma_{all} = 6$ MPa (for wood)

$P_{max} = ?$

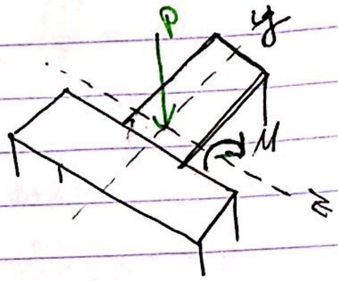


mm

location of $\bar{z}$:

$$\bar{z} = \frac{(0.075)(0.15)(0.3) + (0.3\ )(0.3\ )(0.15)}{(0.3\ )(0.15) + (0.15)(0.3)} = 1 \quad \text{mm}$$

0.044



Moving P:

$$M = (P)\left(\frac{4\ 0 - 187.5}{1000}\right)$$

$M = 0.2125\ P$

There are two stresses

$$\sigma_{all} = \sigma_P + \sigma_M$$

$$= \frac{P}{A} + \frac{(M)c}{I}$$

$$= \frac{P}{(0.3)(0.15) + (0.15)(0.3)} + \frac{(0.2125P)(0.2625)}{I_z}$$

Finding $I_z = 1.5609 \times 10^{-3}$

$$6 \times 10^6 = 11.11\,P + 35.736\,P$$

$P = 128$ kN

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