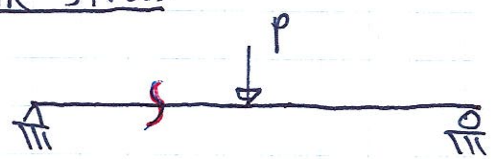
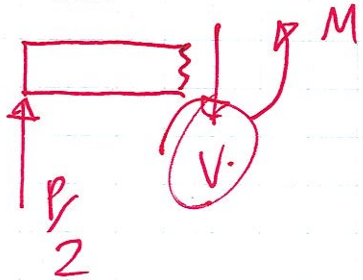
# Topic: SHEAR STRESS IN BEAMS



## SHEAR STRESS

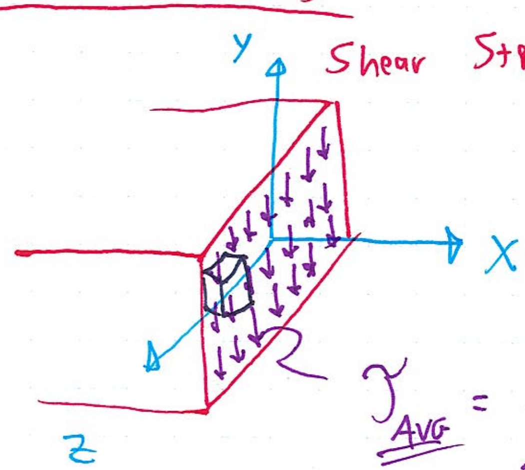



## INTERNAL FORCES




## INTERNAL STRESSES

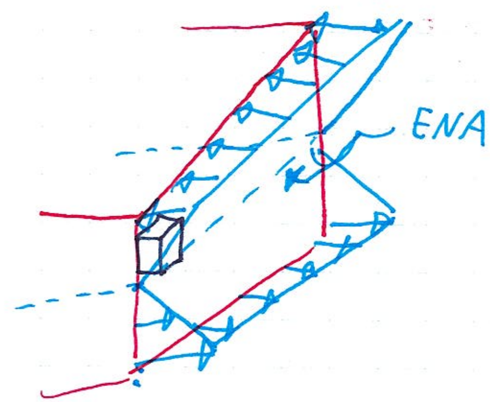
Shear Stress




$$\tau_{AVG} = \frac{V}{A}$$

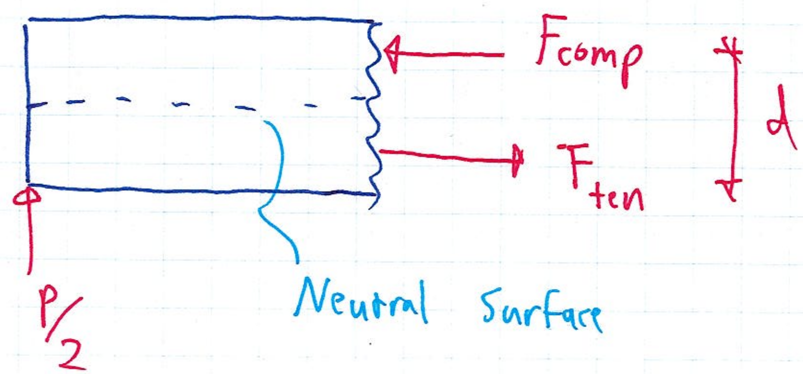
+

Bending Stress



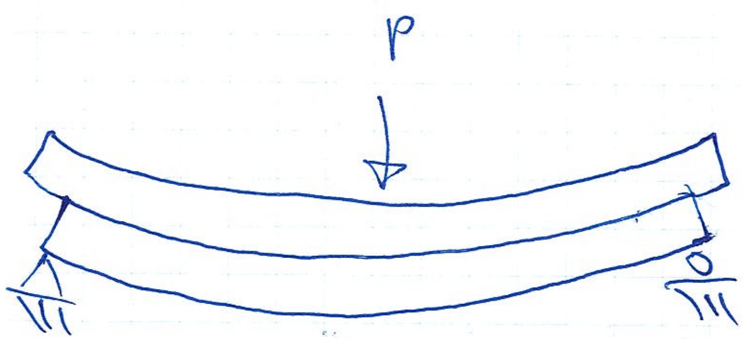

$$\sigma_x = \frac{-My}{I}$$

WE CAN ALSO REPRESENT THE MOMENT, M, W/ A COUPLE

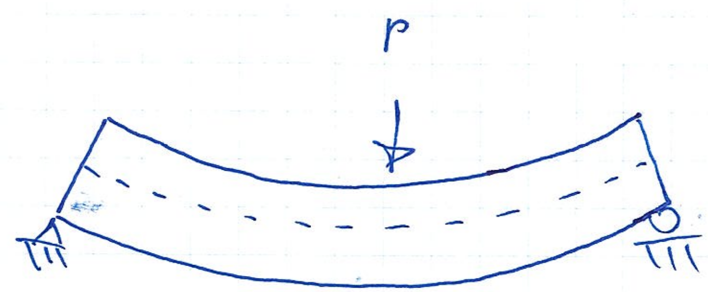



$$M = (F_{comp} \text{ or } F_{ten})\, d$$

IF WE LET THESE SECTION SLIP ⇒ PLANE SECTIONS DO NOT REMAIN PLANE

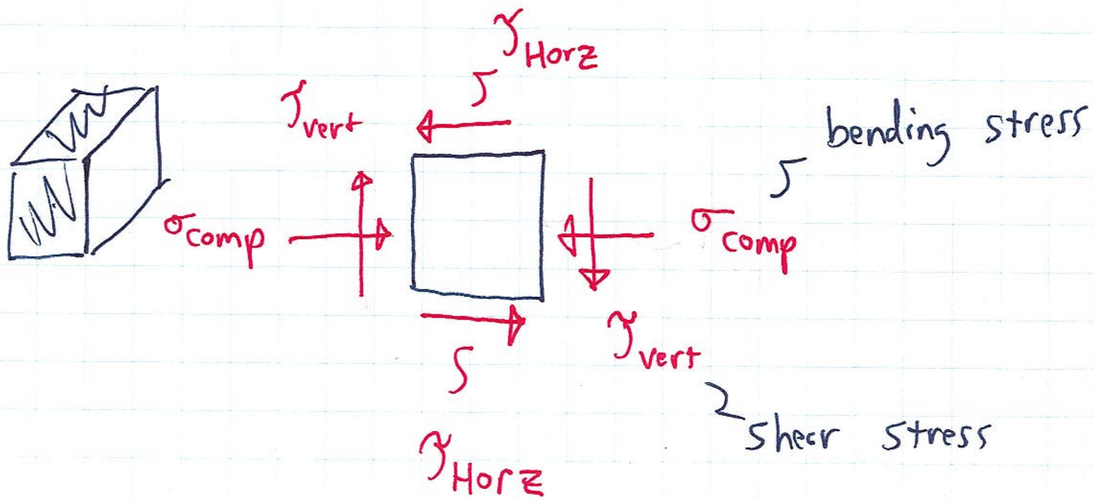



VS.




YOU CANNOT DEVELOP THE SAME MOMENT. SO THERE EXIST SOME SHEAR ALONG THE BEAM IN THE HORIZONTAL DIRECTION.

DIFF. STRESS BLOCK



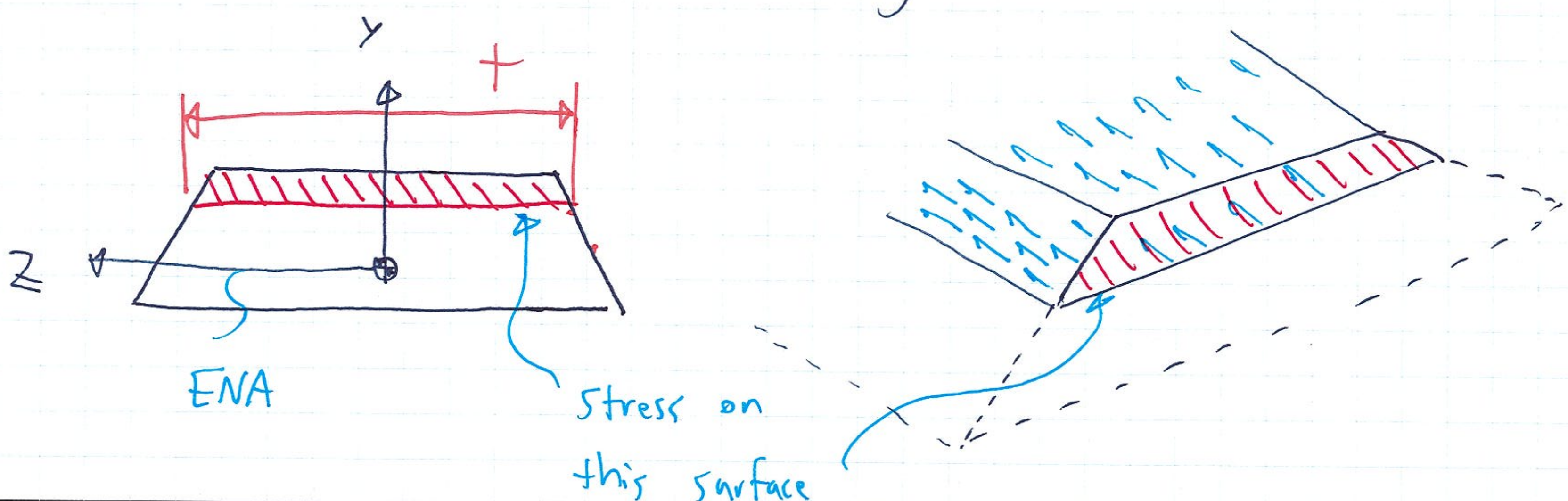

EQUIL:

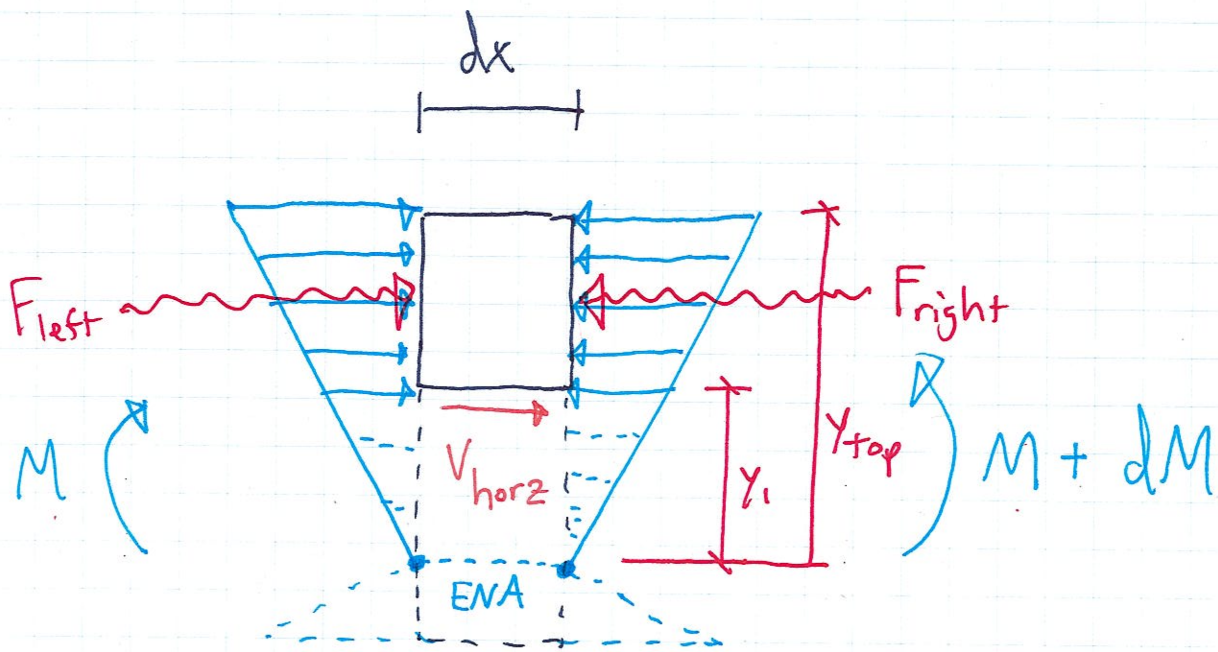
$$\Sigma F_x = 0$$

$$\Sigma F_y = 0$$

$$\Sigma M = 0 \Rightarrow \tau_{vert} = \tau_{Horz}$$

$\tau_{vert}$ IS NOT NECESSARILY $\tau_{AVG}$ EVERYWHERE IN THE CROSS-SECTION.






$$F_{left} = \int_{y_1}^{y_{top}} \sigma \, dA = \int_{y_1}^{y_{top}} \left| \frac{My}{I} \right| dA = \frac{M}{I}\left[\int_{y_1}^{y_{top}} y \, dA\right]$$

$$F_{right} = \int_{y_1}^{y_{top}} \frac{(M+dM)y}{I} \, dA = \frac{M+dM}{I}\left[\int_{y_1}^{y_{top}} y \, dA\right]$$

Q

Q IS THE FIRST MOMENT OF AREA ABOVE (OR BELOW) THE CUT

* $y_1$ is from the ENA to the cut

$F_{left} \neq F_{right}$ ∴ $\sum F_x \neq 0$, THUS A $V_{Horz}$ MUST OCCUR

$$V_{Horz} = \tau \, t \, dx$$

an area

$\sum F_x = 0;$

$$F_{left} + V_{horz} = F_{right}$$

$$\cancel{\frac{MQ}{I}} + \tau t\,dx = \frac{(\cancel{M} + dM)Q}{I} \Rightarrow \tau t\,dx = \frac{dM\,Q}{I}$$

$$\tau = \frac{\overbrace{dM}^{V}\,Q}{dx\,t\,I} = \frac{VQ}{It}$$

"shear flow"

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

Do not round intermediate calculations. Give your final answer(s) to three significant figures.

3-23-2020

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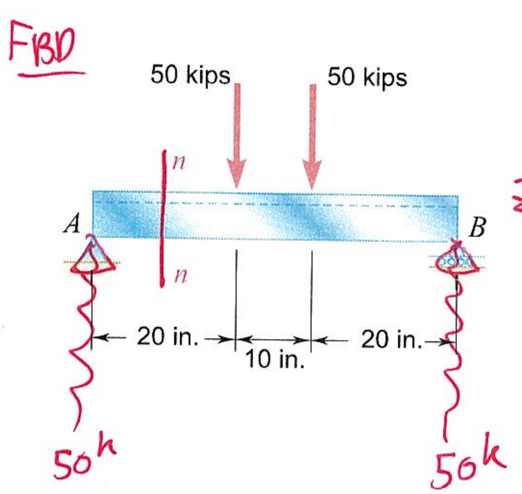
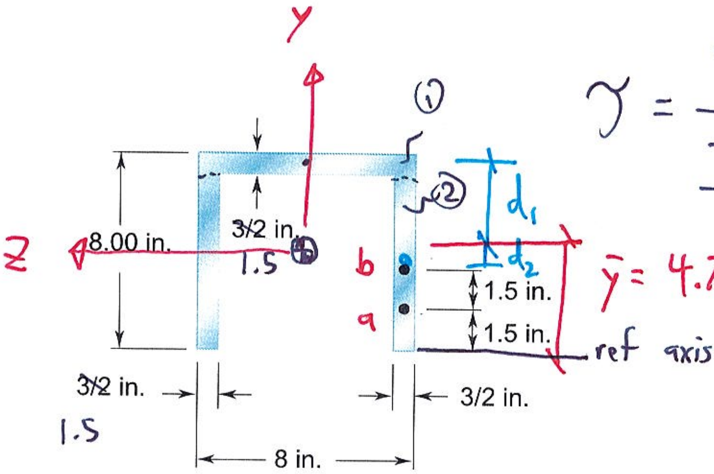
For the beam and loading shown, consider section $n-n$ and determine the shearing stress at ($a$) point $a$, ($b$) point $b$.



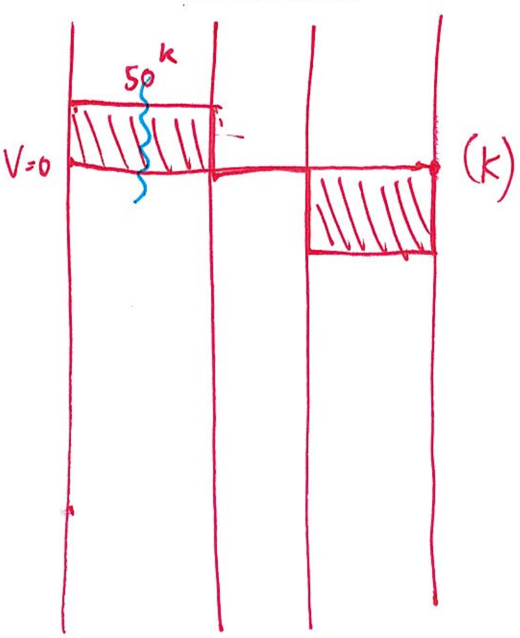




$$\tau = \frac{VQ}{It}$$

($a$) $\tau_a$ = ______ ksi

($b$) $\tau_b$ = ______ ksi

$$\bar{y} = \frac{8''(1.5'')(7.25'') + 2(6.5'')(1.5'')(3.25'')}{(8'')(1.5'') + 2(6.5'')(1.5'')} = 4.774''$$




$$V_{n-n} = 50^k$$

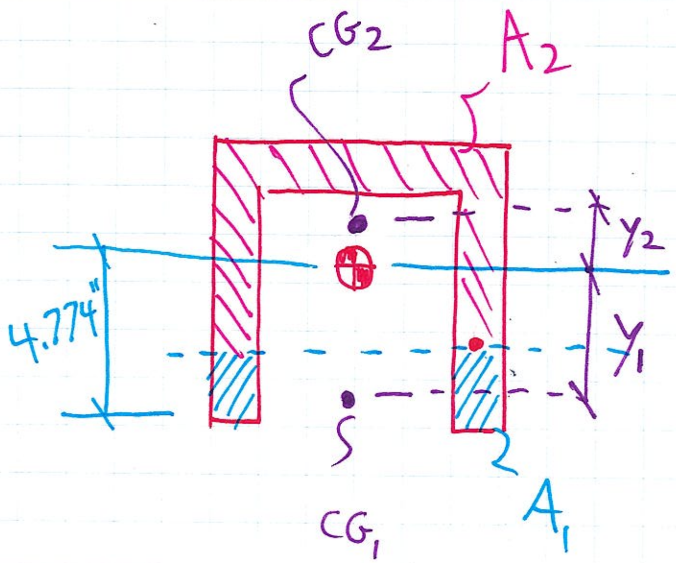
①

$$I = \Sigma(\bar{I} + Ad^2) = \left[\frac{1}{12}(8'')(1.5'')^3 + (8'')(1.5'')(4.774'' - 7.25)^2\right]$$

$$+ \left[2\left[\frac{1}{12}(1.5'')(6.5'')^3 + (1.5'')(6.5'')(4.774'' - 3.25'')\right.\right.$$

②

$$= 189.76 \text{ in}^4$$




$$Q = A_1 y_1 = A_2 y_2$$

$$Q_A = A_a y_a = (2\text{ legs})(1.5")(1.5")(4.774" - 0.75") = 18.108\ in^3$$

$$Q_B = A_B y_B = (2\text{ legs})(1.5")(3")(4.774" - 1.5") = 29.466\ in^3$$

(a) $$\tau_a = \frac{V Q_a}{I t} = \frac{50^k (18.108\ in^3)}{(189.76\ in^4)(2)(1.5")} = \underline{\underline{1.6\ ksi}}$$

(b) $$\tau_b = \frac{V Q_b}{I t} = \frac{(50)(29.466\ in^3)}{(189.76)(2)(1.5)} = \underline{\underline{2.6\ ksi}}$$