CE30 – Discussion 11

Shear Stress in Beams

Textbook: 13.1

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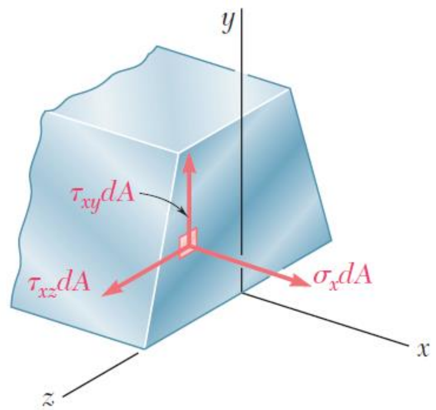
Announcements

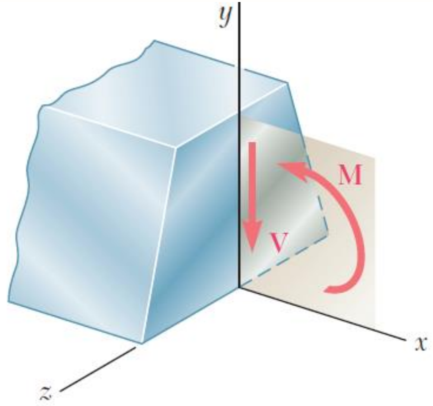
- HW11 Problems from the textbook:

  11.11, 12.45, 12.49, 12.88; 13.3, P13.9

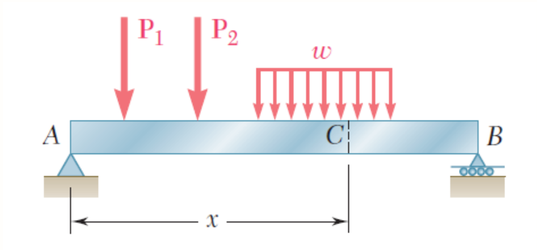
Beams Subjected to Shear and Moment

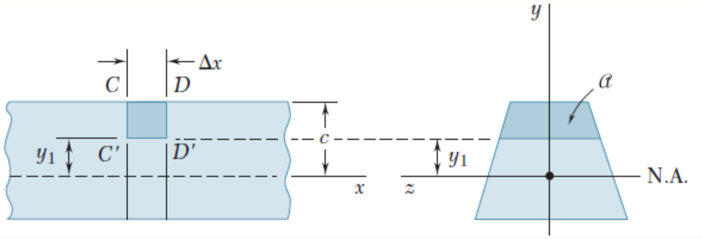
- In the case of pure bending, we ignored the shear stresses and deformations
- For a general loading case (V+M), we have shear stresses $\boldsymbol{\tau_{xy}}$ and $\boldsymbol{\tau_{xz}}$



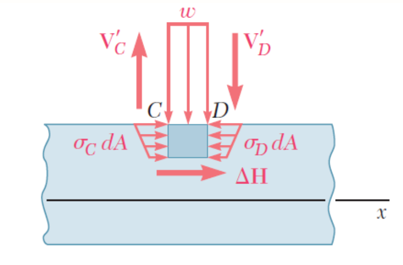


Shear Force on the Horizontal Face





Equilibrium of an area element



- From the equilibrium, we can get the horizontal shear force per length

$$q = \frac{\Delta H}{\Delta X} = \frac{\boldsymbol{VQ}}{\boldsymbol{I}}$$

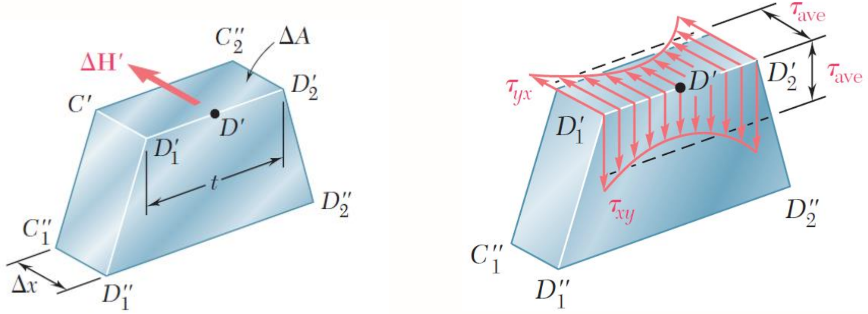
q : Shear flow (N/m)

V : Vertical shear force

$\boldsymbol{Q}$: First moment of the shaded area wrt n.a.

$\boldsymbol{I}$: Moment of inertia of the entire cross section wrt n.a.

Shear Stress τ_{xy}



- We can get the average shear stress as

$$\boxed{\tau_{ave} = \frac{VQ}{It}}$$

t : Width of the beam at the cut

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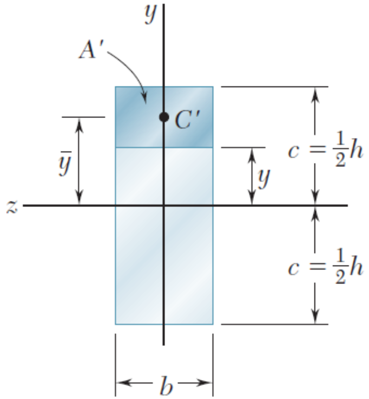
τ_{xy} in Rectangular Cross Sections



- For narrow, rectangular beams we can use $\tau_{xy} \approx \tau_{ave}$

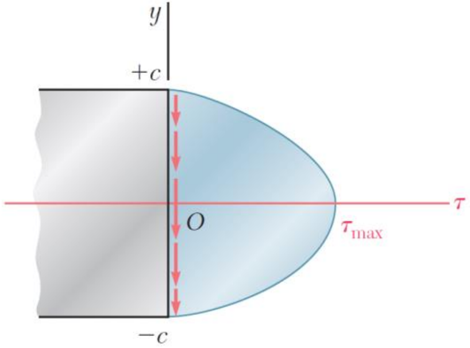
$$\tau_{xy} = \frac{VQ}{It}$$

$t = b$

Q of the shaded area A'

I of the entire section

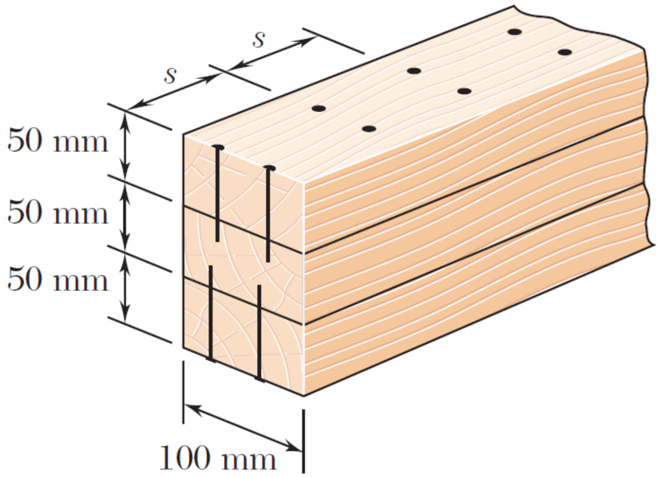
- Shear varies across the depth; we can find the max value as



$$\tau_{max} = \frac{3V}{2A}$$

Practice – Similar to HW P13.3

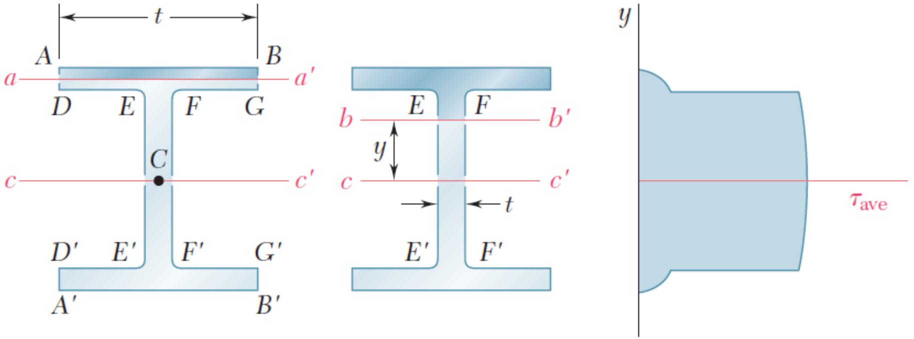
Three full-size 50 × 100-mm boards are nailed together to form a beam that is subjected to a vertical shear of 1500 N. Knowing that the allowable shearing force in each nail is 400 N, determine the largest longitudinal spacing s that can be used between each pair of nails.



τ_{xy} in W-Sections

- Average shear stress $\tau_{ave} = \dfrac{VQ}{It}$

- Shear is (almost) entirely carried by the web



> **Shear at $b - b'$ is much larger than $a - a'$**
>
> **Shear is mostly uniform along the web**

- Assuming all shear carried by the web, the max shear becomes $\tau_{max} = \dfrac{V}{A_{web}}$

Practice – Similar to HW P13.9

13.9 through 13.12 For the beam and loading shown, consider section *n-n* and determine (*a*) the largest shearing stress in that section, (*b*) the shearing stress at point *a*.