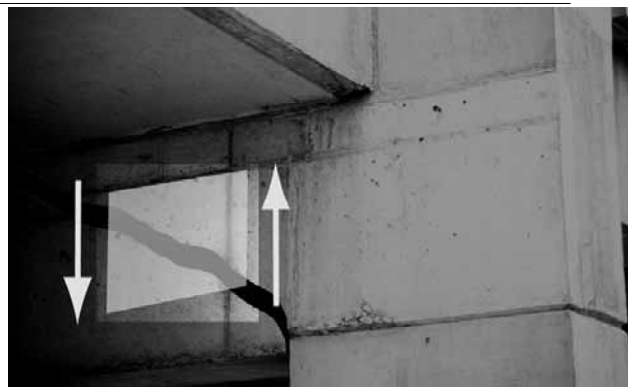
ARCHITECTURAL STRUCTURES I:
STATICS AND STRENGTH OF MATERIALS
ENDS 231
DR. ANNE NICHOLS
SPRING 2008

lecture
twenty



beams:
shear stress

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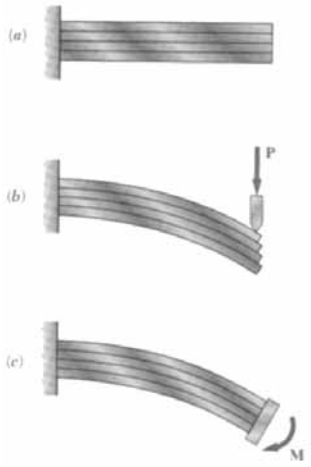
Transverse Loading and Shear

- *perpendicular loading*
- *internal shear*
- *along with bending moment*

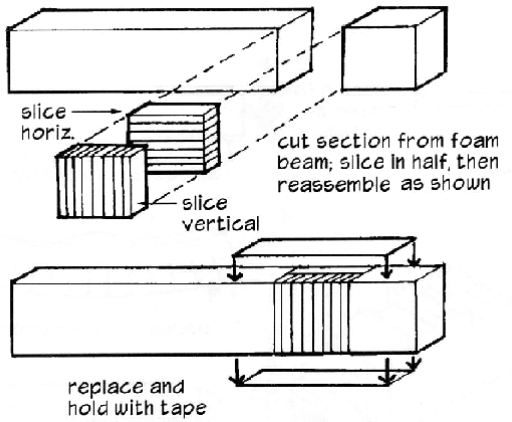
Bending vs. Shear in Design

- *bending stresses dominate*
- *shear stresses exist horizontally with shear*
- *<u>no shear stresses</u> with pure bending*



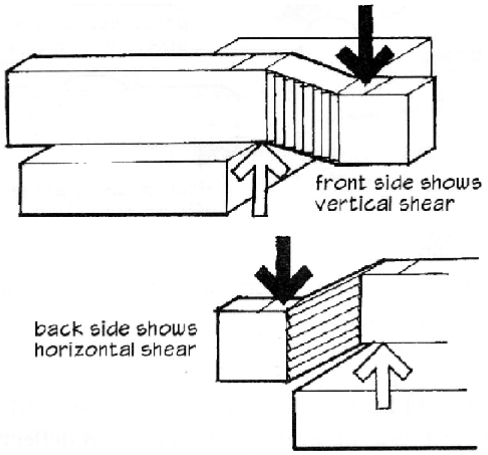
Shear Stresses

- *horizontal & vertical*



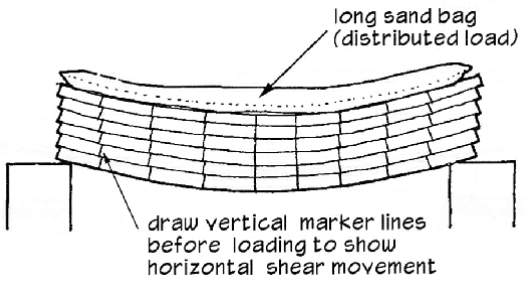
Shear Stresses

- *horizontal & vertical*



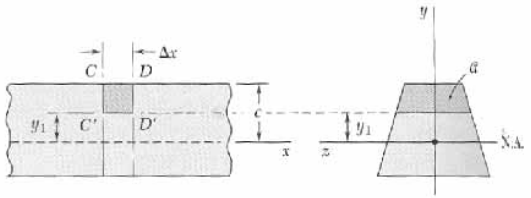
Beam Stresses

- *horizontal with bending*

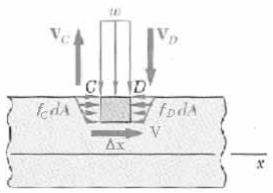


Equilibrium

- *horizontal force V needed*



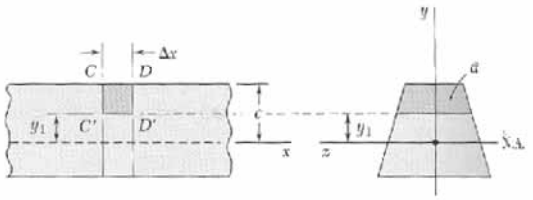
$$V_{longitudinal} = \frac{V_T Q}{I} \Delta x$$



- *Q is a moment area*

Moment of Area

- *Q is a moment area with respect to the n.a. of area <u>above or below</u> the horizontal*
- *Q_{max} at y=0 (neutral axis)*



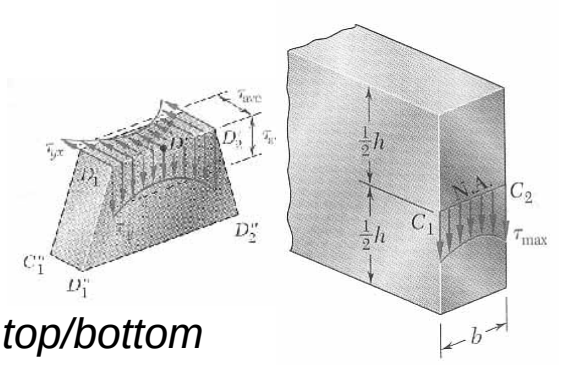
- *q is shear flow:*

$$q = \frac{V_{longitudinal}}{\Delta x} = \frac{V_T Q}{I}$$

Shearing Stresses

$$f_v = \frac{V}{\Delta A} = \frac{V}{b \cdot \Delta x}$$

$$f_{v-ave} = \frac{VQ}{Ib}$$

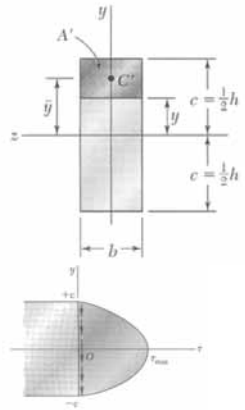


- $f_{v-ave} = 0$ on the top/bottom
- b min may not be with Q max
- with h/4 ≥b, $f_{v\text{-}max} \leq 1.008\, f_{v\text{-}ave}$

Rectangular Sections

$$I = \frac{bh^3}{12} \qquad Q = A\bar{y} = bh^2/8$$

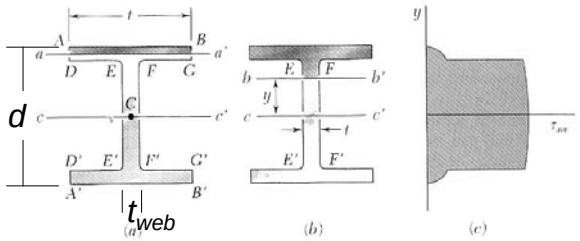
$$f_v = \frac{VQ}{Ib} = \frac{3V}{2A}$$



- $f_{v\text{-}max}$ occurs at n.a.

Steel Beam Webs

- W and S sections
  - b varies



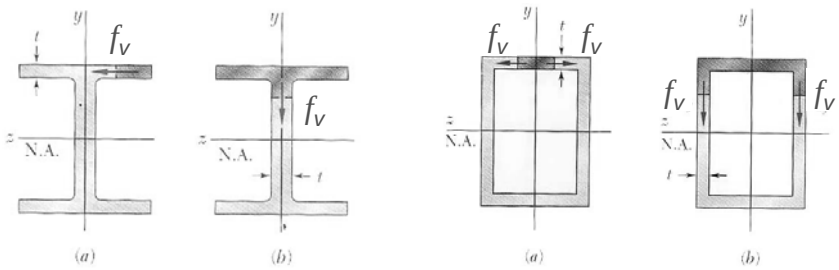
  - stress in flange negligible
  - presume constant stress in web

$$f_{v-\max} = \frac{3V}{2A} \approx \frac{V}{A_{web}}$$

Shear Flow

- loads applied in plane of symmetry
- cut made perpendicular

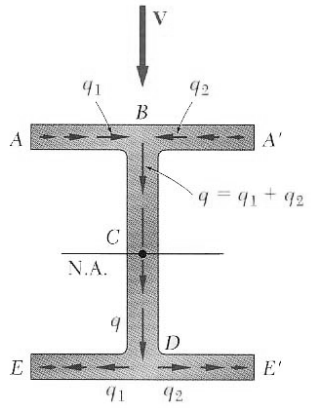
$$q = \frac{VQ}{I}$$



Shear Flow Quantity

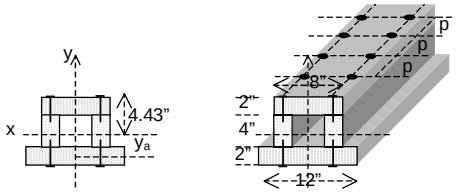
- *sketch from Q*

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



Connectors Resisting Shear

- *plates with*
  - *nails*
  - *rivets*
  - *bolts*
- *splices*



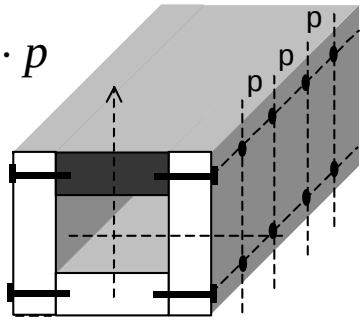
$$\frac{V_{longitudinal}}{p} = \frac{VQ}{I}$$

$$nF_{connector} \geq \frac{VQ_{connected\ area}}{I} \cdot p$$

Vertical Connectors

- *isolate an area with vertical interfaces*

$$nF_{connector} \geq \frac{VQ_{connected\ area}}{I} \cdot p$$



Unsymmetrical Shear or Section

- *member can bend and twist*
  - *not symmetric*
  - *shear not in that plane*
- *shear center*
  - *moments balance*