# ARCHITECTURAL STRUCTURES I: STATICS AND STRENGTH OF MATERIALS

ENDS 231

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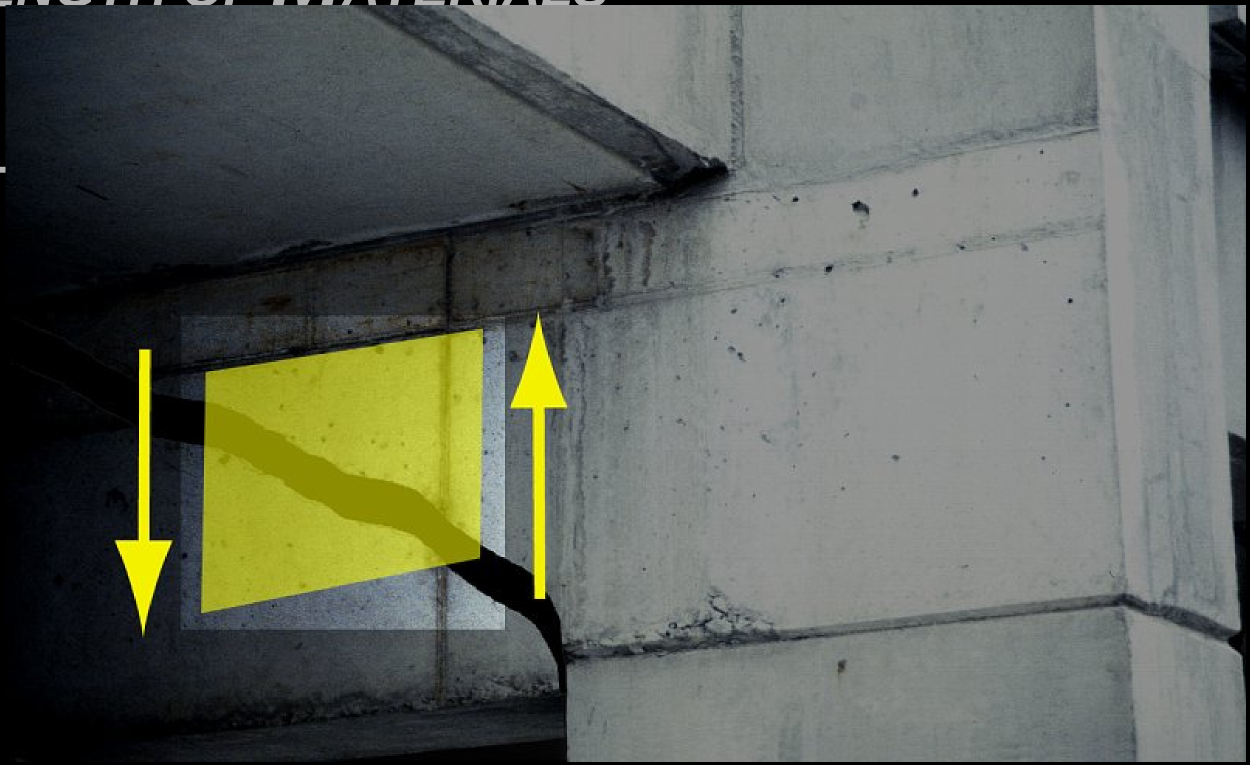
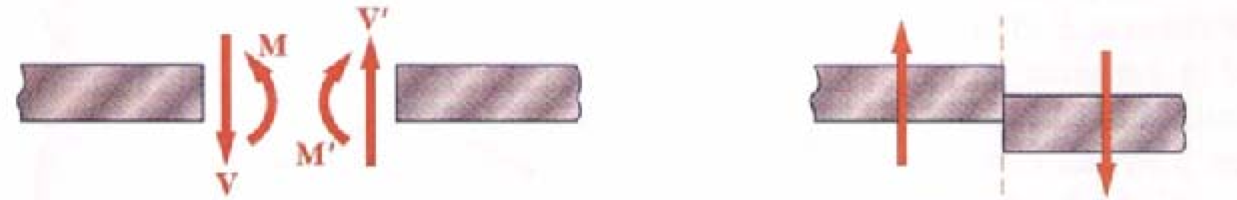
SPRING 2007

lecture
twenty



# beams: shear stress

# Transverse Loading and Shear



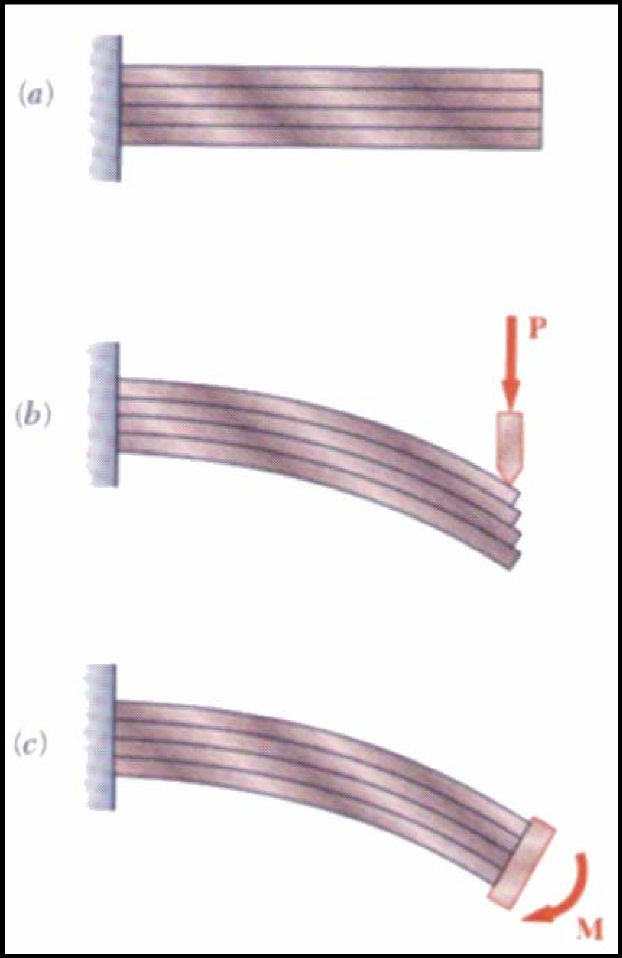
(a) Internal forces
(positive shear and positive bending moment)

(b) Effect of external forces
(positive shear)

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

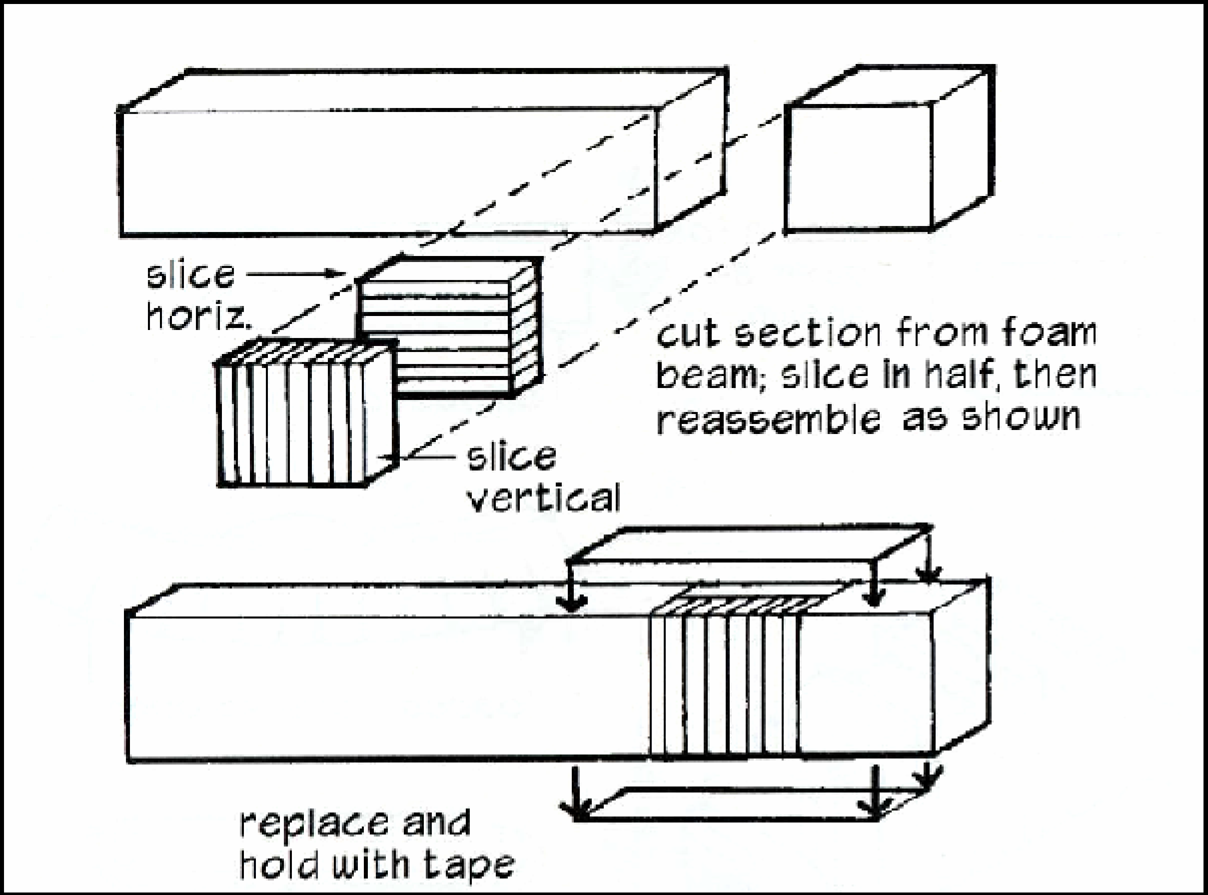
# *Bending vs. Shear in Design*

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



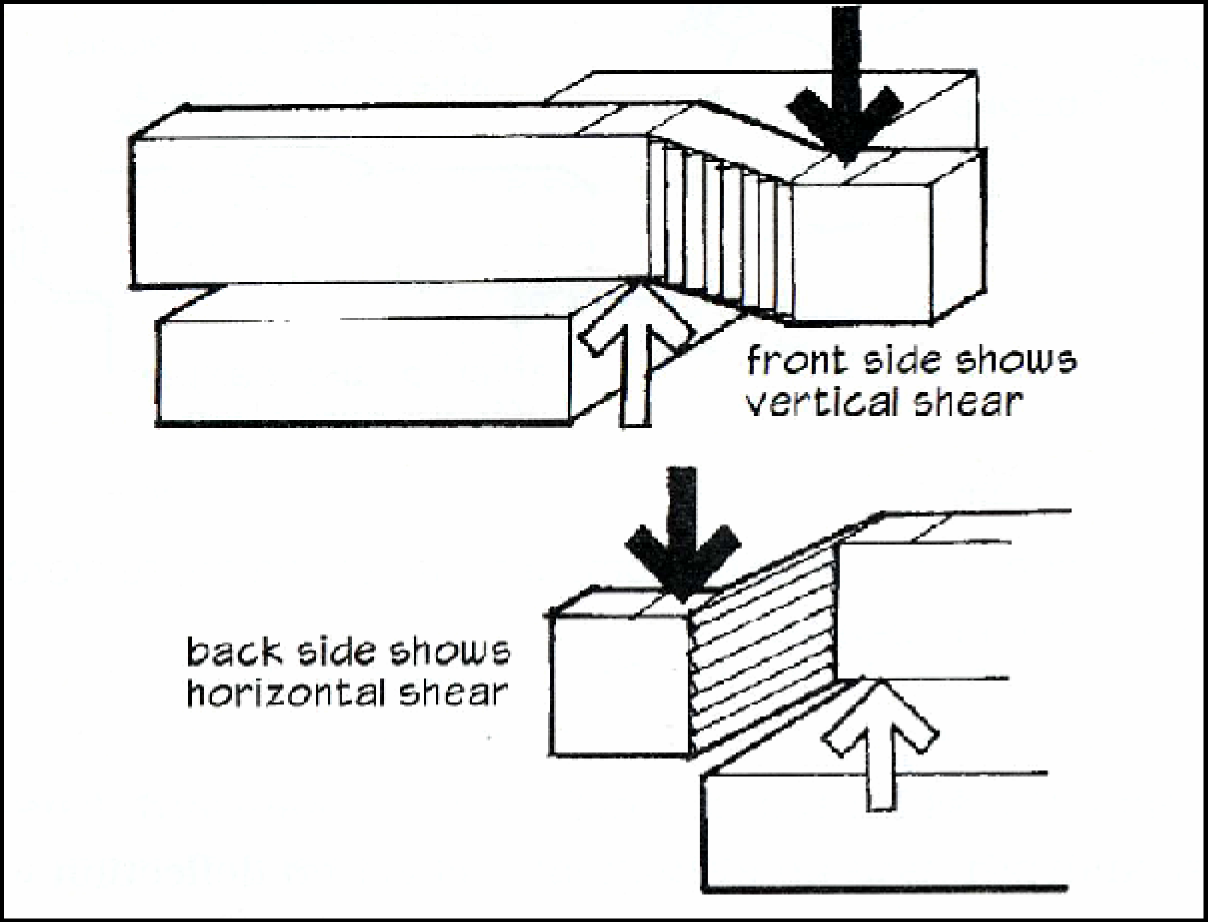
# Shear Stresses

- *horizontal & vertical*



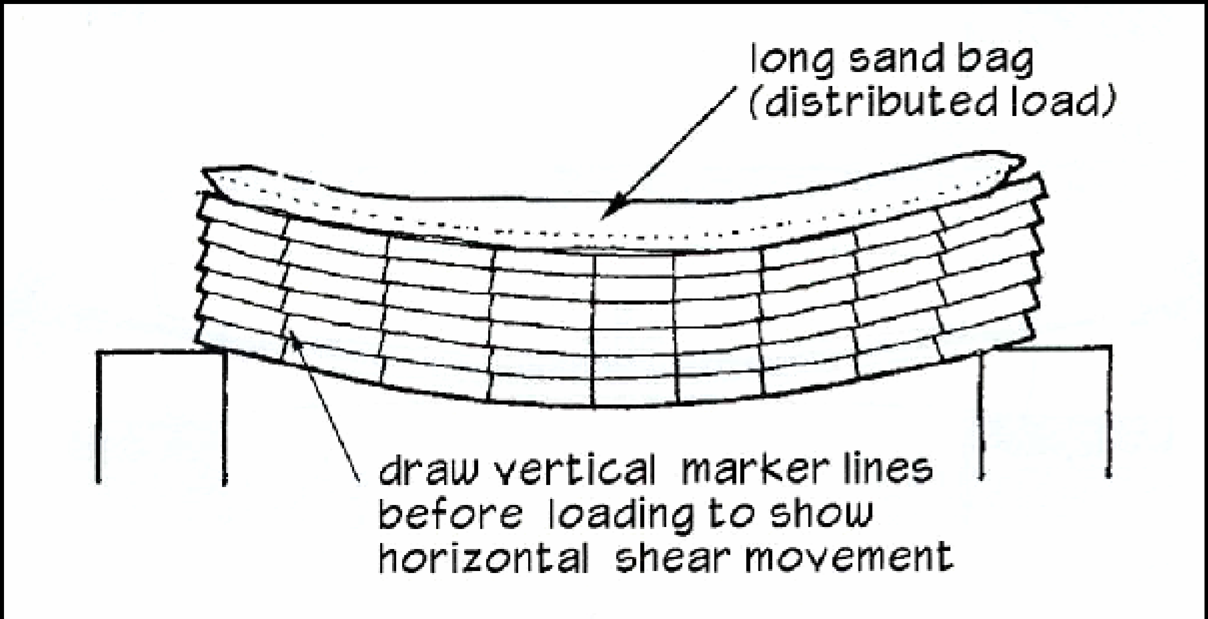
# Shear Stresses

- *horizontal & vertical*



# Beam Stresses

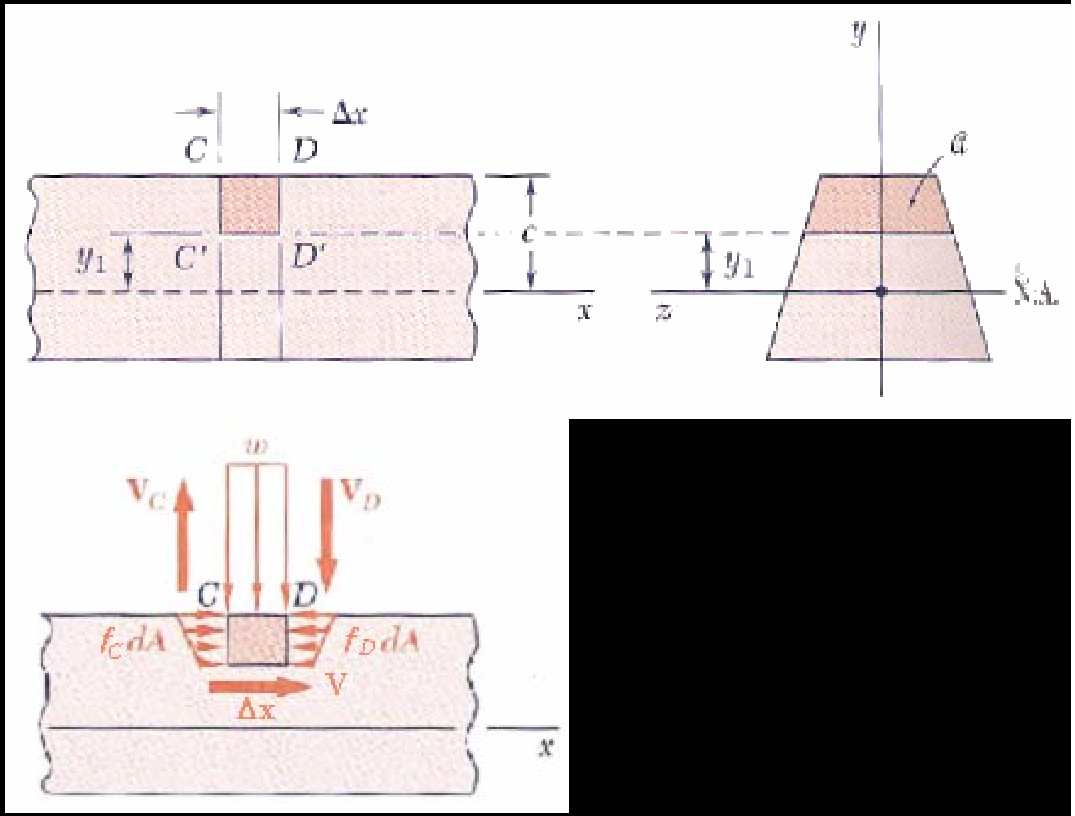
- *horizontal with bending*



# Equilibrium

- horizontal force V needed

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

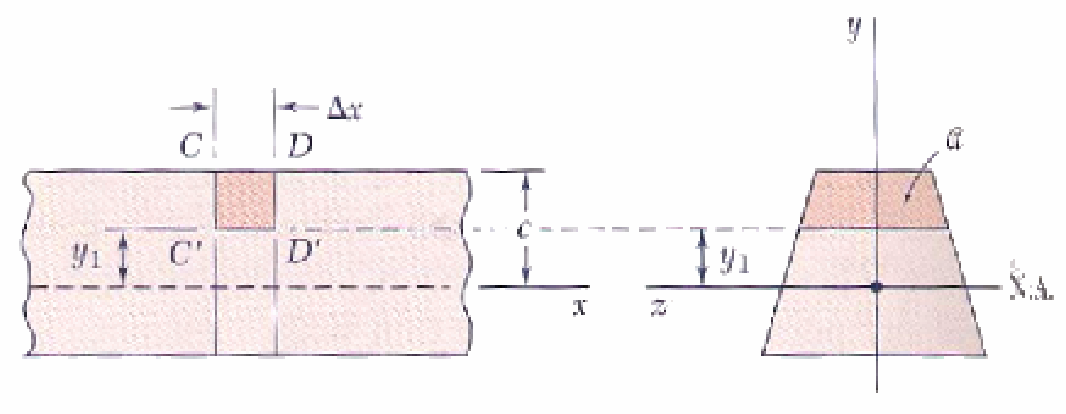



- Q is a moment area

# Moment of Area

- *Q is a moment area with respect to the n.a. of area above or below the horizontal*

- $Q_{max}$ *at y=0 (n.a.)*



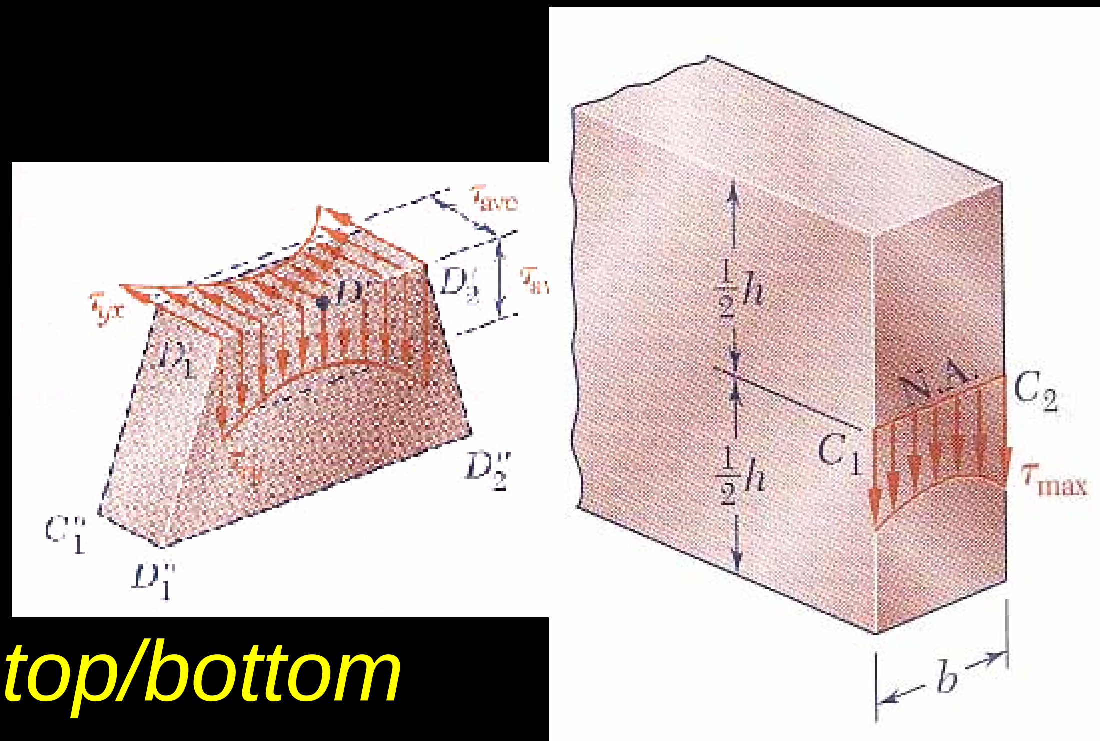

- *q is shear flow:*

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

# *Shearing Stresses*

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

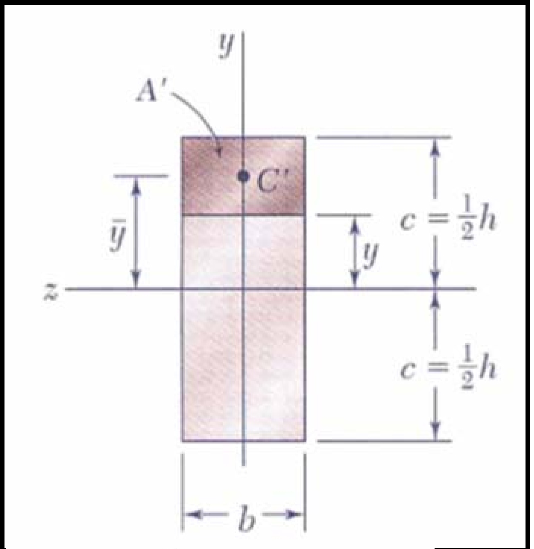
$$f_{v-ave} = \frac{VQ}{Ib}$$



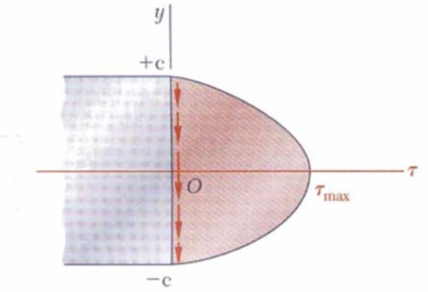

- *$f_{v-ave}$ = 0 on the top/bottom*
- *b min may not be with Q max*
- *with h/4 ≥ b, $f_{v\text{-}max} \leq 1.008\, f_{v\text{-}ave}$*

# *Rectangular Sections*

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



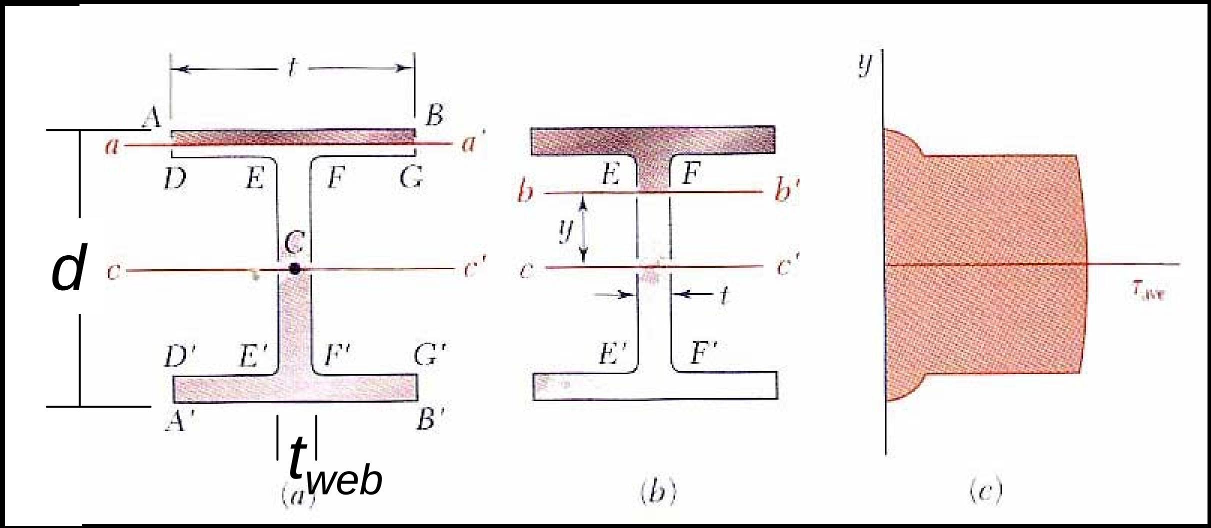

$$f_v = \frac{VQ}{Ib} = \frac{3V}{2A}$$




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

# Steel Beam Webs

- W and S sections
  - b varies



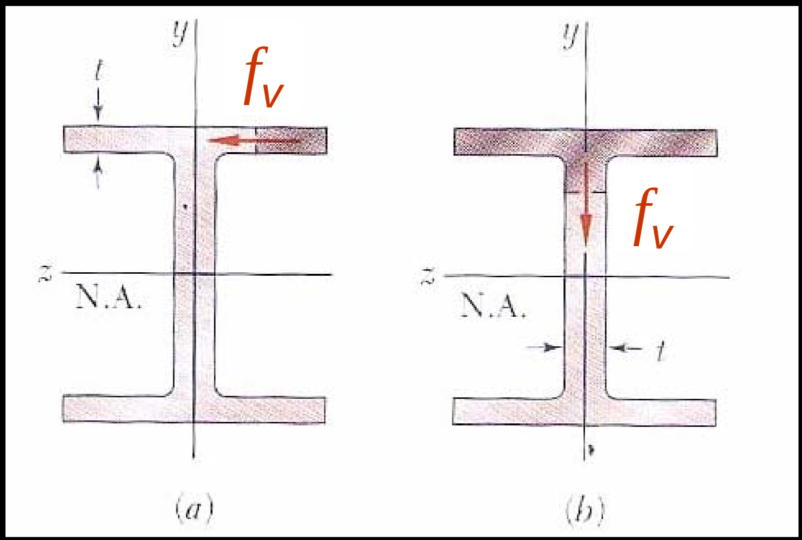

  - stress in flange negligible
  - presume constant stress in web

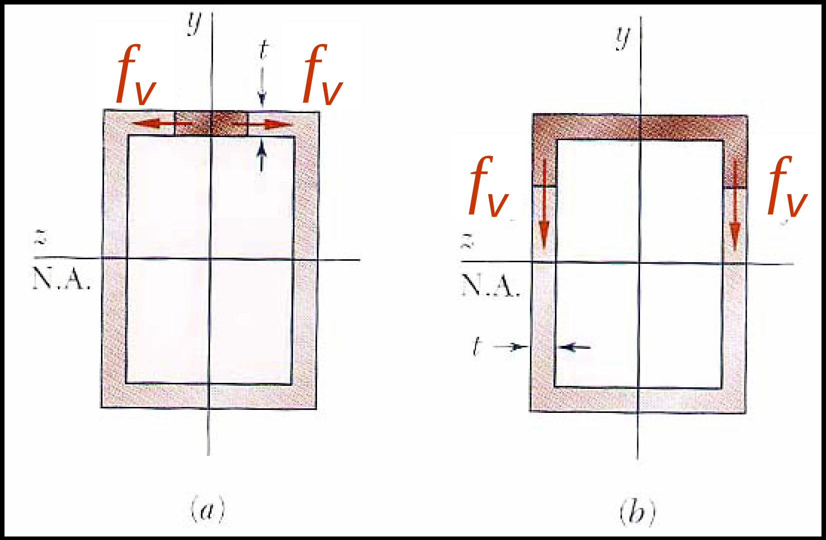
$$f_{v-\max} = \frac{3V}{2A} \approx \frac{V}{A_{web}}$$

# Shear Flow

- loads applied in plane of symmetry
- cut made perpendicular

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

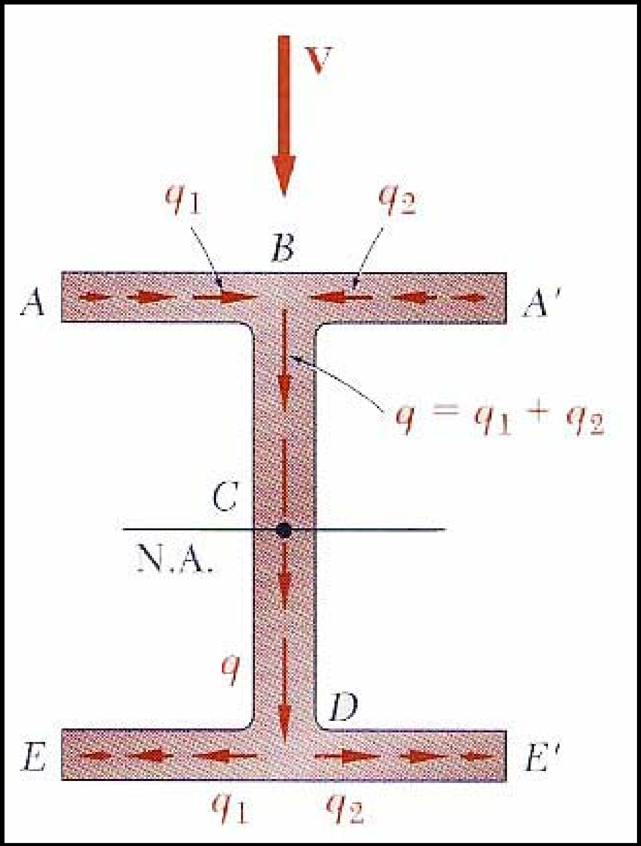


# Shear Flow Quantity

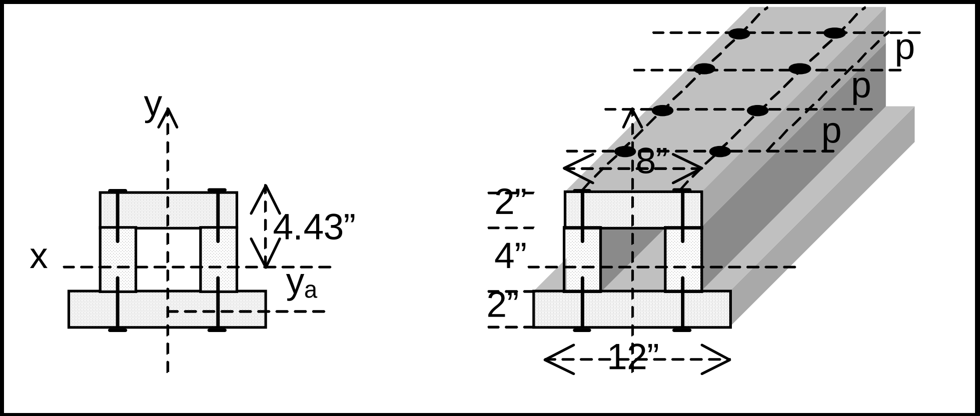
- sketch from Q

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



# Connectors Resisting Shear

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



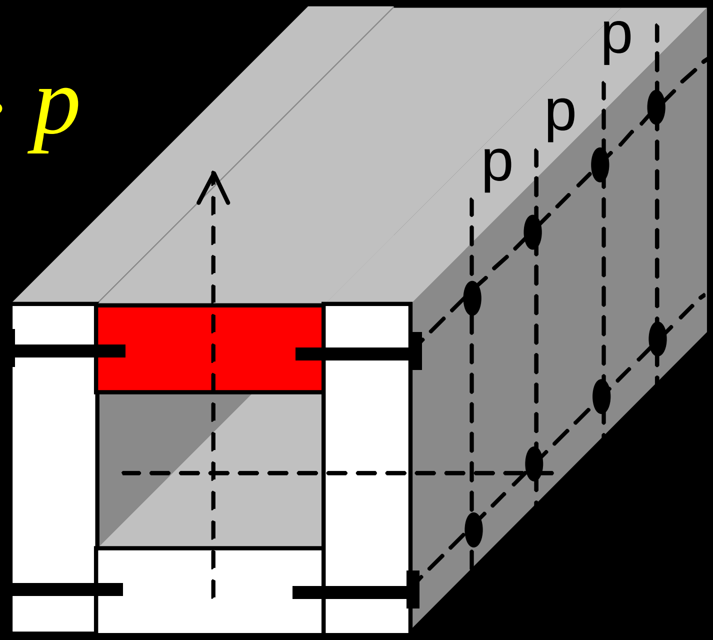

$$\frac{V_{longitudinal}}{p} = \frac{VQ}{I}$$

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

# *Vertical Connectors*

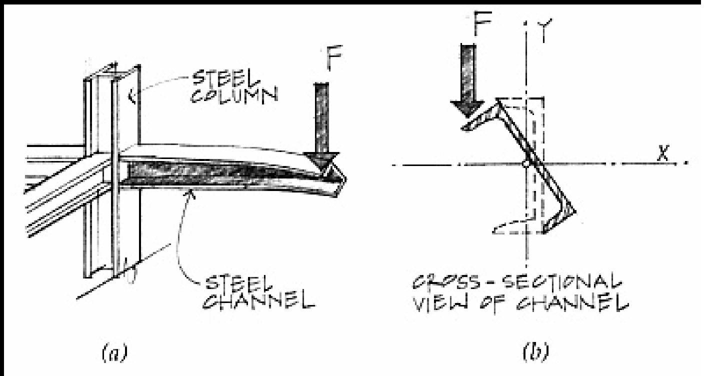
- *isolate an area with vertical interfaces*

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



# Unsymmetrical Shear or Section

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




- *shear center*
  - *moments balance*