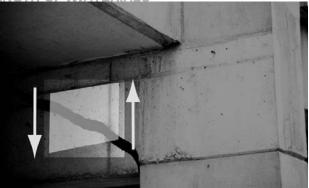
#### ARCHITECTURAL STRUCTURES I:

STATICS AND STRENGTH OF MATERIALS

**ENDS 231** DR. ANNE NICHOL **F**ALL 2007 lecture



beams: shear stress

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Transverse Loading and Shear

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

along with bending moment

perpendicular loading

internal shear

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(b) Effect of external forces

(positive shear)

## Bending vs. Shear in Design

 bending stresses dominate



 shear stresses exist horizontally with shear



 no shear stresses with pure bending

Lecture 20



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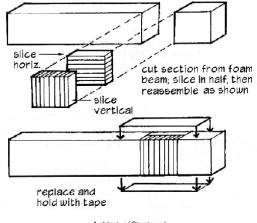
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### Shear Stresses

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Lecture 20

horizontal & vertical



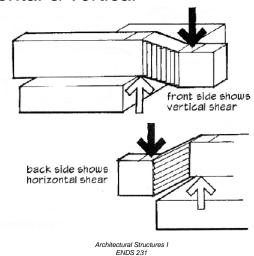
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#### Shear Stresses

horizontal & vertical

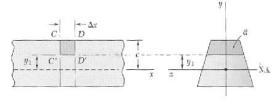


# Equilibrium

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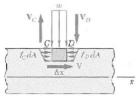
 horizontal force V needed



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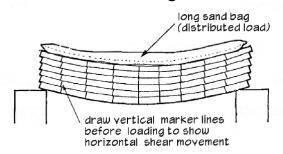
$$V_{longitudinal} = \frac{V_T Q}{I} \Delta x$$



Q is a moment area

#### Beam Stresses

horizontal with bending



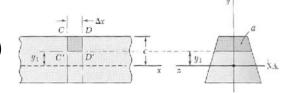
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### Moment of Area

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



• q is shear flow:

$$q = rac{V_{longitudinal}}{\Delta x} = rac{V_{T}Q}{I}$$

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## Shearing Stresses

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

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

$$f_{v_{n}} = \frac{VQ}{Ib}$$

$$f_{v_{n}} = \frac{VQ}{Ib}$$

$$f_{v_{n}} = \frac{VQ}{Ib}$$

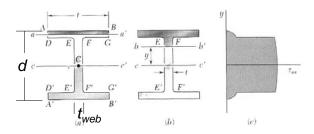
- $f_{v-a} = 0$  on the top/bottom
- b min may not be with Q max
- with  $h/4 \ge b$ ,  $f_{v-max} \le 1.008 f_{v-ave}$

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### Steel Beam Webs

- W and S sections
  - b varies

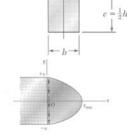


- stress in flange negligible
- presume constant stress in web

$$f_{v- ext{max}} = rac{3V}{2A} pprox rac{V}{A_{web}}$$

Rectangular Sections

$$I = \frac{bh^3}{12} \qquad Q = A\overline{y} = \frac{bh^2}{8}$$
$$f_v = \frac{VQ}{Ib} = \frac{3V}{2A}$$



•  $f_{v-max}$  occurs at n.a.

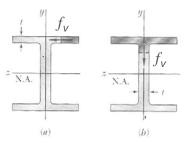
Beam Shear Stress 13

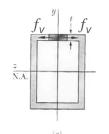
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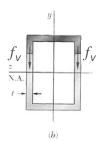
#### Shear Flow

- loads applied in plane of symmetry
- cut made perpendicular

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





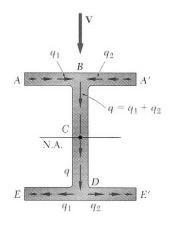


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### Shear Flow Quantity

sketch from Q

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



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### Vertical Connectors

isolate an area with vertical interfaces

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

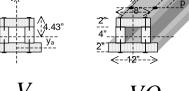
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### Connectors Resisting Shear

plates with

- nails
- rivets
- bolts
- splices



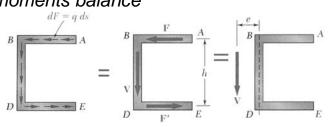
 $\frac{V_{longitudinal}}{p} = \frac{VQ}{I}$ 

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

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# Unsymmetrical Shear or Section

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



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