ARCHITECTURAL **S**TRUCTURES **I**:

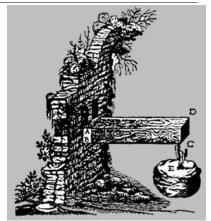
STATICS AND STRENGTH OF MATERIALS

ENDS 231

DR. ANNE NICHOLS

SPRING 2008

lecture Pighteen



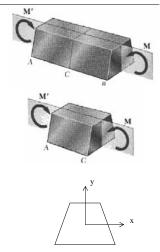
beams:

bending and shear

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Pure Bending

- bending only
- no shear
- axial normal stresses from bending can be found in
 - homogeneous materials
 - plane of symmetry
 - follow Hooke's law



Beam Bending

- Galileo
 - relationship between stress and depth²
- can see
 - top squishing
 - bottom stretching

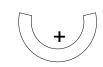


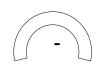
what are the stress across the section?

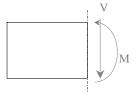
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Bending Moments

• sign convention:







 size of maximum internal moment will govern our design of the section

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Normal Stresses

- geometric fit
 - plane sections remain plane
 - stress varies linearly

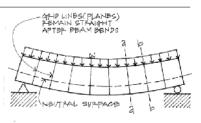


Figure 8.5(b) Beam bending under load.

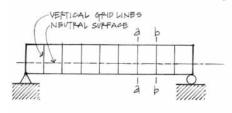


Figure 8.5(a) Beam elevation before loading.

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Beam cross section.

CENTROIDAL AXIS

ALSO CALLED THE NEUTRAL AXIS (N.A.)

Neutral Axis

- stresses vary linearly
- zero stress occurs at the centroid
- <u>neutral axis</u> is line of centroids (n.a.)

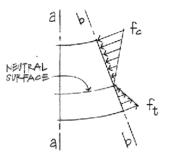


Figure 8.8 Bending stresses on section b-b.

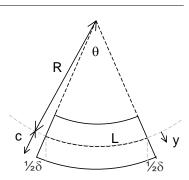
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Derivation of Stress from Strain

pure bending = arc shape

$$L = R\theta$$

$$L_{outside} = (R + y)\theta$$



$$\varepsilon = \frac{\delta}{L} = \frac{L_{outside} - L}{L} = \frac{(R + y)\theta - R\theta}{R\theta} = \frac{y}{R}$$

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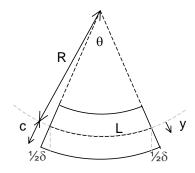
Derivation of Stress

• zero stress at n.a.

$$f = E\varepsilon = \frac{Ey}{R}$$

$$f_{\text{max}} = \frac{Ec}{R}$$

$$f = \frac{y}{c} f_{\text{max}}$$



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Bending Moment

resultant moment from stresses = bending moment!

 $M = \Sigma f y \Delta A$



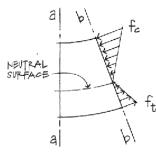


Figure 8.8 Bending stresses on section b-b.

$$= \Sigma \frac{y f_{max}}{c} y \Delta A = \frac{f_{max}}{c} \Sigma y^2 \Delta A = \frac{f_{max}}{c} I = f_{max} S$$

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Bending Stress Relations

$$\frac{1}{R} = \frac{M}{EI}$$

$$f_b = \frac{My}{I}$$

$$S = \frac{I}{c}$$

curvature

general bending stress se

section modulus

$$f_b = \frac{M}{S}$$

 $S_{required} \ge \frac{M}{F_b}$

maximum bending stress

required section modulus for design

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