Beam Bending

- Galileo
  - relationship between stress and depth^2
- can see
  - top squishing
  - bottom stretching

what are the stress across the section?

Pure Bending

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

Bending Moments

- sign convention:
- size of maximum internal moment will govern our design of the section
Normal Stresses

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

Neutral Axis

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

Derivation of Stress from Strain

- pure bending = arc shape

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

Derivation of Stress

- zero stress at n.a.

\[
f = E\varepsilon = \frac{Ey}{R} \\
f_{\text{max}} = \frac{Ec}{R} \\
f = \frac{y}{c} f_{\text{max}}
\]
**Bending Stress Relations**

\[
\frac{1}{R} = \frac{M}{EI} \quad f_b = \frac{My}{I} \quad S = \frac{l}{c}
\]

- curvature
- general bending stress
- section modulus

\[
f_b = \frac{M}{S} \quad S_{\text{required}} \geq \frac{M}{F_b}
\]

- maximum bending stress
- required section modulus for design

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**Bending Moment**

- resultant moment from stresses = bending moment!

\[
M = \Sigma f_y \Delta A
\]

\[
= \Sigma \frac{yf_{\text{max}}}{c} y \Delta A = \frac{f_{\text{max}}}{c} \Sigma y^2 \Delta A = \frac{f_{\text{max}}}{c} I = f_{\text{max}} S
\]

Figure 8.8 Bending stresses on section b-b.