Sec.13

EGM 3520 Mechanics of Materials (MoM)

Beer et al. 2012, Mechanics of Materials, McGraw-Hill.

P4.5, p.237

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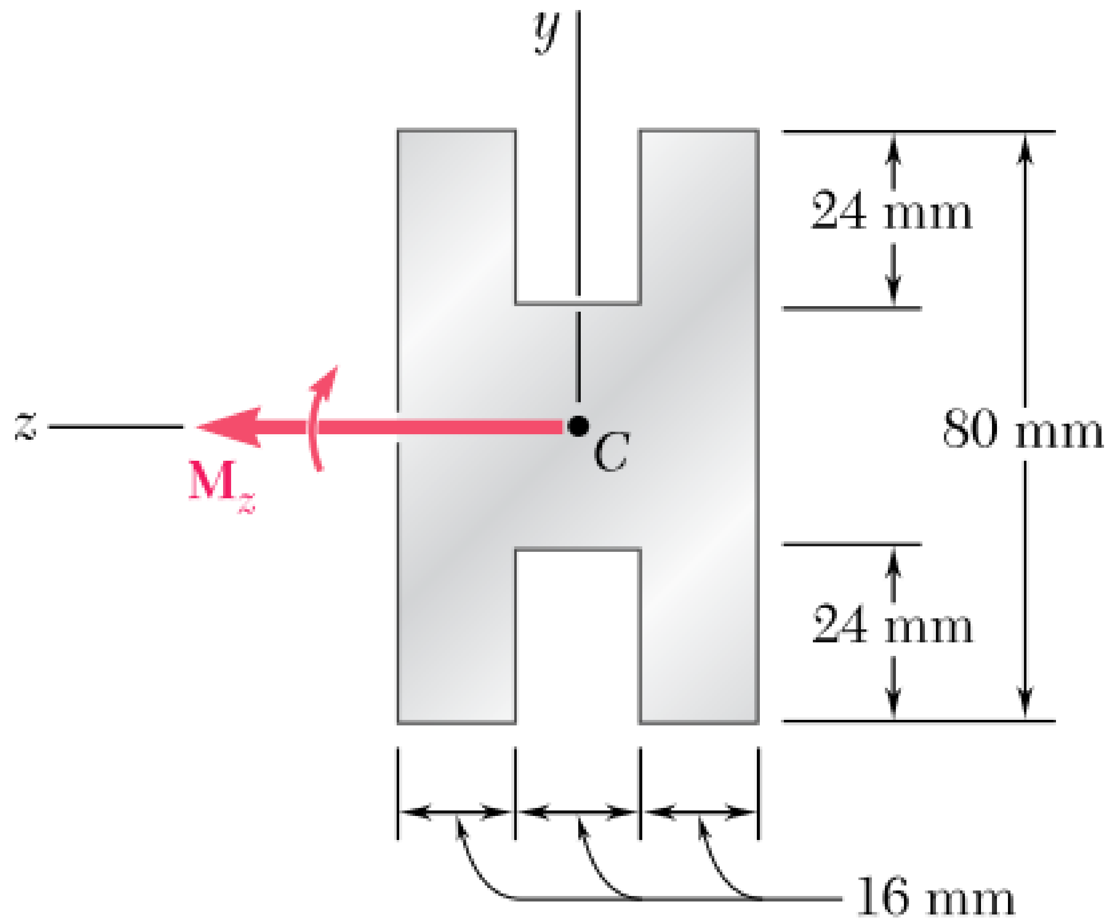


A beam of the cross section shown is extruded from an aluminum alloy for which $\sigma_Y = 250$ MPa and $\sigma_U = 450$ MPa. Using a factor of safety of 3.00, determine the largest couple that can be applied to the beam when it is bent about the z axis.

Method

$M_{z,\, max}$ maximum allowable bending moment (or couple, i.e., double arrow) along the z axis

M_{z, \, max}

Relation between normal stress and bending moment

$$\sigma_x = -\frac{M_z\, y}{I_z} \qquad (1)$$

\sigma_x = - \frac{M_z \, y}{I_z}

σ_x normal stress on a facet with normal in the positive x axis

M_z bending moment (double arrow) along z axis (neutral surface)

y vertical distance from z axis (neutral surface)

I_z 2nd area moment of inertia wrt z axis (neutral axis)

Maximum stress for a given bending moment

$$\sigma_{x,\, max} = \frac{|M_z|\, |y|_{max}}{I_z} \qquad (2)$$

\sigma_{x, \, max} = \frac{| M_z | \, | y |_{max}}{I_z}

Bending moment in terms of maximum stress and its location

$$|M_z| = \frac{\sigma_{x,\,max}\, I_z}{|y|_{max}} \qquad (1)$$

| M_z | = \frac{\sigma_{x, \, max} \, I_z}{| y |_{max}}

Set maximum stress to ultimate stress to find the maximum bending moment, accounting for F.S. = 3:

$$|M_{z,\,max}| = \frac{(\sigma_{x,\,ult}/\text{F.S.})\, I_z}{|y|_{max}} \qquad (2)$$

| M_{z, \, max} | = \frac{(\sigma_{x, \, ult} / \text{F.S.})\, I_z}{| y |_{max}}

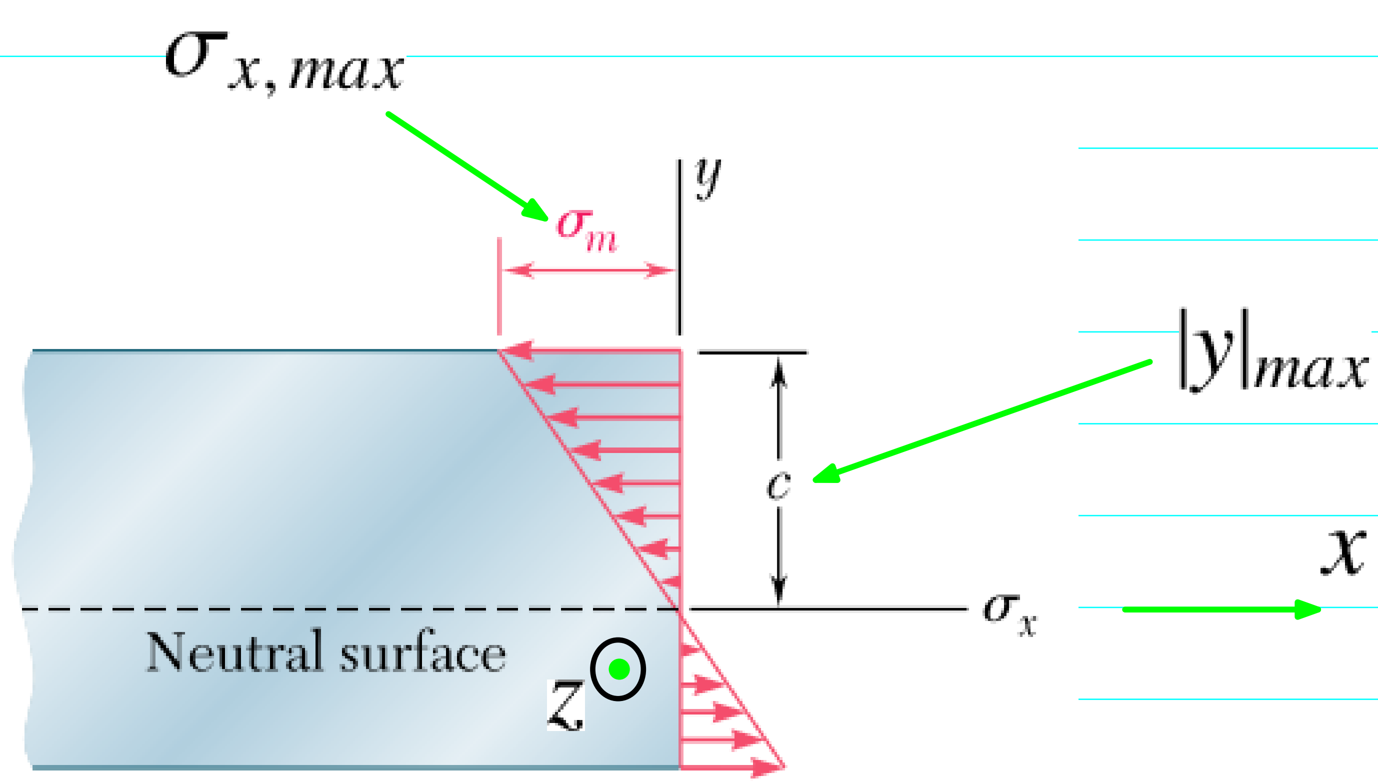


Fig. 4.11 Bending stresses.

Pause video NOW !

Work out the next step

→ on your own first

→ discuss with teammates

if you get stuck

then continue to watch the video

"Intelligence consists of this; that we recognize the similarity between different things, and the difference between similar things."

Baron de la Brède et de Montesquieu (1689-1755)

quoted in [Quantum field theory, E. Zeidler, 2008, p.175]

Computation

Find 2nd area moment of inertia

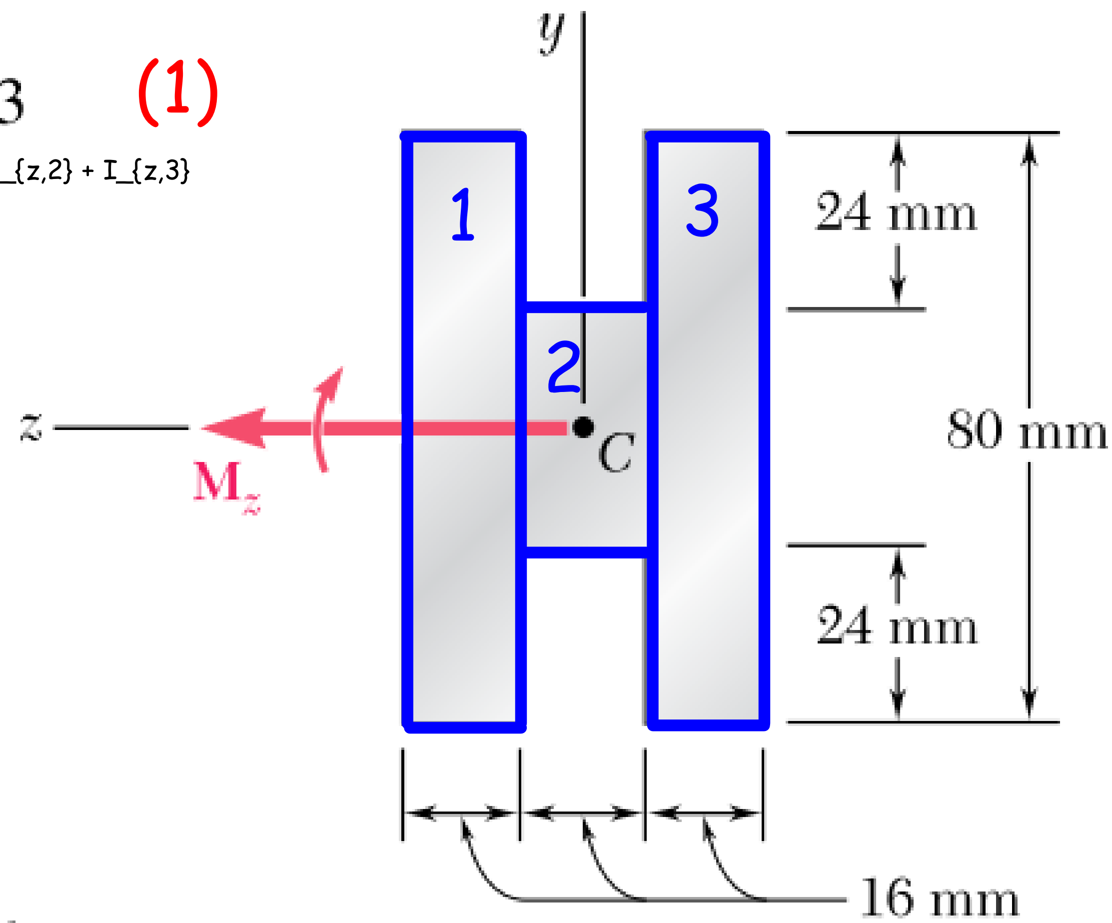
$$I_z = I_{z,1} + I_{z,2} + I_{z,3} \quad (1)$$

I_z = I_{z,1} + I_{z,2} + I_{z,3}

$$I_{z,i} = \frac{b_i \, (h_i)^3}{12} \quad (2)$$

I_{z,i} = \frac{b_i \, (h_i)^3}{12}

i = 1,2,3



Base:

$$b_1 = b_2 = b_3 = 16 \, mm \quad (3)$$

b_1 = b_2 = b_3 = 16 \, mm

Height: $$h_1 = h_3 = 80 \, mm \quad (4)$$

h_1 = h_3 = 80 \, mm

$$h_2 = (80 - 2 \times 24) \, mm \quad (5)$$

h_2 = (80 - 2 \times 24) \, mm

$$|y|_{max} = 80/2 \, mm \quad (6)$$

|y|_{max} = 80 / 2 \, mm

$$\sigma_{x, \, ult} = 460 \, MPa \quad (7)$$

\sigma_{x, \, ult} = 460 \, MPa