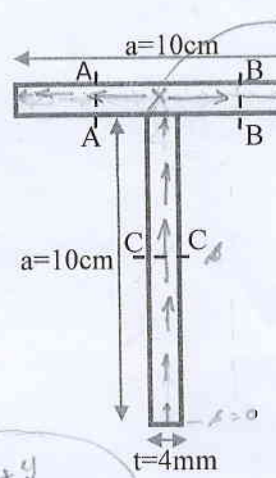
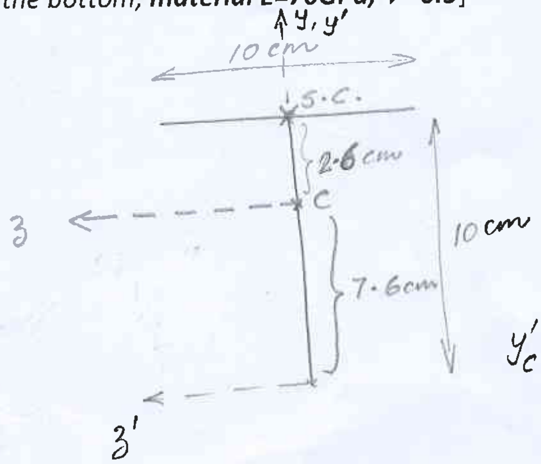
Common mistakes: Wrong centroid; Wrong I_{zz}; memory based mindless application of formulae

Quiz 2: Aerospace Structures

Name: Roll No.

Question: A cantilever beam of length *L=1m* is subjected to an end transverse shear force $V_y = 100kg$. The cross-section of the beam is symmetric, as shown in figure, with web and flange of size *a=10cm* each, and thickness *t=4mm*. At the locations marked *A-A, B-B, C-C* determine the following: (a) Shear Flow (b) Shear stress components σ_{xy}, σ_{xz}, (c) Assuming that the resultant shear force passes through the shear centre, mark location of shear centre on the figure. [*A-A is at 2cm from left end; B-B is at 2cm from right end; C-C is at 5cm from the bottom;* ***material E=70GPa, ν=0.3***]





$s = a + y$
$s = 0 \Rightarrow y = -7.6$
$\Rightarrow a = 7.6$

$$y'_c = \frac{10.2 \times 10 \times 0.4 + 5 \times 10 \times 0.4}{2 \times 10 \times 0.4} = 5.1 + 2.5 = \underline{7.6\,cm}$$

Since section is symmetric and V_y is only load, so we need

$$I_{zz} = \frac{1}{12} \times 10 \times 0.4^3 + 10 \times 0.4 \times (2.6)^2 + \frac{1}{12} \times 0.4 \times 10^3 + 10 \times 0.4 \times (-2.6)^2 = \underline{87.413\,cm^4}$$

$$\approx (27.04) \times 2 + 33.33$$

At AA: $$q_{xs}\big|_s = -\frac{V_y}{I_{zz}} \int_{s=0}^{s} t\,y\,ds = -\frac{V_y t}{I_{zz}} \times 2 \times 2.6 = \left(-\frac{5.2\,V_y t}{I_{zz}}\right)$$

$= 23.795\,N/cm$ negative

At BB: $q_{xs}\big|_s = q_{xs}\big|_{AA}$

At CC: $$q_{xs}\big|_s = -\frac{V_y}{I_{zz}} \int_{s=0}^{s} t\,y\,ds = -\frac{V_y}{I_{zz}} \int_{-7.6}^{-2.6} t\,y\,dy = -\frac{V_y t}{I_{zz}} \times \frac{y^2}{2}\Bigg|_{-7.6}^{-2.6}$$

$$= -\frac{V_y t}{I_{zz}} \left(\frac{1}{2}(-2.6)^2 - \frac{1}{2}(-7.6)^2\right) = +25.5\,\frac{V_y t}{I_{zz}} = 116.69\,N/cm$$ ← positive!

$\sigma_{xs}\big|_{AA} = \sigma_{xz}\big|_{AA} = -5.2\,\frac{V_y}{I_{zz}}$; $\sigma_{xs}\big|_B = \sigma_{xz}\big|_{BB} = \sigma_{xz}\big|_{AA}$; $\sigma_{xs}\big|_C = \sigma_{xy}\big|_C = 25.5\,\frac{V_y}{I_{zz}}$

$\frac{V_y}{I_{zz}} \approx 11.44\,N/cm^4 \Rightarrow \sigma_{xz}\big|_A = -\sigma_{xz}\big|_B = -59.49\,N/cm^2$; $\sigma_{xz}\big|_C = 291.72\,N/cm^2$

$= \underline{-59.49 \times 10^4\,N/m^2}$ $\quad = \underline{291.72 \times 10^4\,N/m^2}$

$= -594900\,Pa$ $\quad 2917200\,Pa$

$\sigma_{xy}\big|_A \approx 0$

$\sigma_{xy}\big|_B \approx 0$

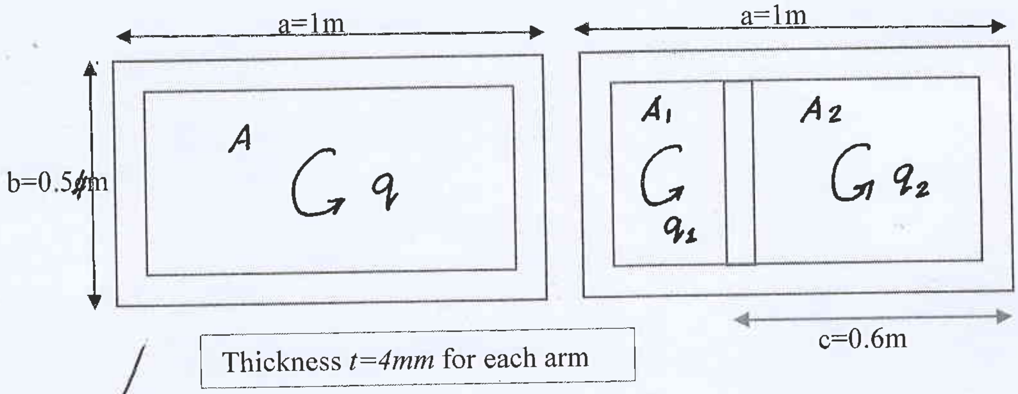
$\sigma_{xz}\big|_C \approx 0$

Common mistake: Wrong use of formula for α_1, α_2.

Quiz 3: Aerospace Structures

Name: Roll No.

Question: For the two cross-sections given, obtain the rate of twist. The sections are subjected to a torque of *T=100 N.m*. The section is made of Aluminum with ***E=70GPa, ν=0.3.***



$$T = 2Aq \Rightarrow q = T/2A$$

$$\alpha = \frac{1}{2A}\oint \frac{q\,ds}{Gt} = \frac{T}{4A^2Gt} \times 2 \times 1.5 = 3\,(T/Gt)$$

2-celled

$$T = 2A_1q_1 + 2A_2q_2 = 0.4q_1 + 0.6q_2$$

$$\alpha_1 = \frac{1}{2A_1Gt}\left(\oint_{C_1} q\,ds\right) = \alpha_2 = \frac{1}{2A_2Gt}\left(\oint_{C_2} q\,ds\right)$$

$$\Rightarrow \frac{1}{0.4}(1.8q_1 - 0.5q_2) = \frac{1}{0.6}(2.2q_2 - 0.5q_1) \Rightarrow q_2 = \frac{64}{59}q_1$$

$$\Rightarrow \boxed{q_1 = \frac{59}{62}T \; ; \; q_2 = \frac{64}{62}T}$$

$$\Rightarrow \alpha_1 = \alpha_2 = \alpha = \frac{371}{124}(T/Gt)$$

$$\alpha|_{S-C} = 2.786 \times 10^{-6} \text{ rad/m}$$ — (4)

$$\alpha|_{2-C} = 2.778 \times 10^{-6} \text{ rad/m}$$ — (6)