DEPARTMENT OF CIVIL ENGINEERING

CE-221 SOLID MECHANICS

Quiz-2 25/10/17 PAPER CODE: A

Note: Write your name & roll no. on answerbook and on summary answer sheet provided on the reverse.
You must submit the question-paper-cum-summary-answer-sheet along with the answerbook.
Closed book, closed notes test. No formula sheet allowed. No mobile phones allowed in the exam hall.
Both questions carry equal marks. Assume suitable data if required and state the same clearly

Problem 1

A member constructed of an equal angle section (i.e, $AB = BD$) is subjected to a tensile load $P = \mathbf{15}$ N**.** The load *P* acts out of the plane of the paper and acts through the point where the midlines of the equal legs intersect (as shown in Fig. 1). Take $I_{zz} = I_{yy} = 7.67mm^4$, $I_{zy} = 4.38mm^4$, $A = 5.44mm^2$ where *A* is the area of the cross-section, $c = 1.27mm$ where *c* is the distance of the section centroid (*C*) from point *B* along *y* and *z* axes as shown in Fig. 1, and $t = 0.75mm$ where *t* is the uniform section thickness. Calculate the maximum tensile stress σ_t in the member. Relevant formulae are,

$$I_{y'z'} = \left(I_{zz} - I_{yy}\right)\frac{\sin 2\theta}{2} + I_{yz}\cos 2\theta \quad ; \quad I_{y'y'} = I_{yy}\cos^2\theta + I_{zz}\sin^2\theta + I_{yz}\sin 2\theta$$

Problem 2

For the singly-symmetric thin-walled cross-section having constant thickness (Fig. 2**),** calculate the distance *e* of the shear center measured from point O, and show its location on the summary answer sheet. All dimensions are given with respect to the midlines, as shown.

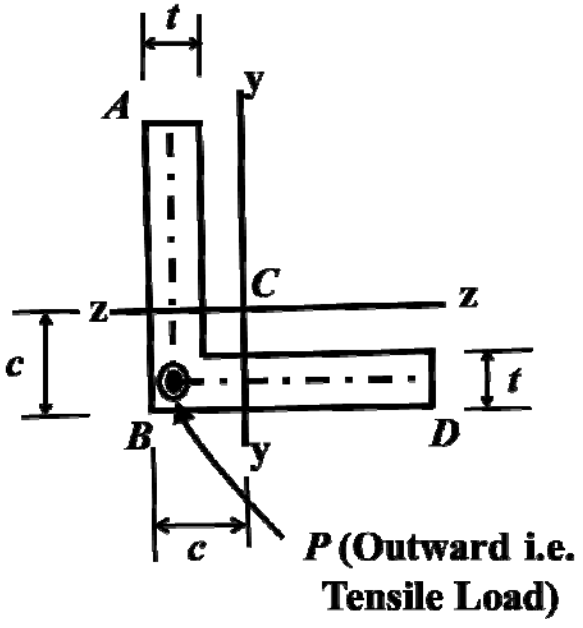


Fig. 1

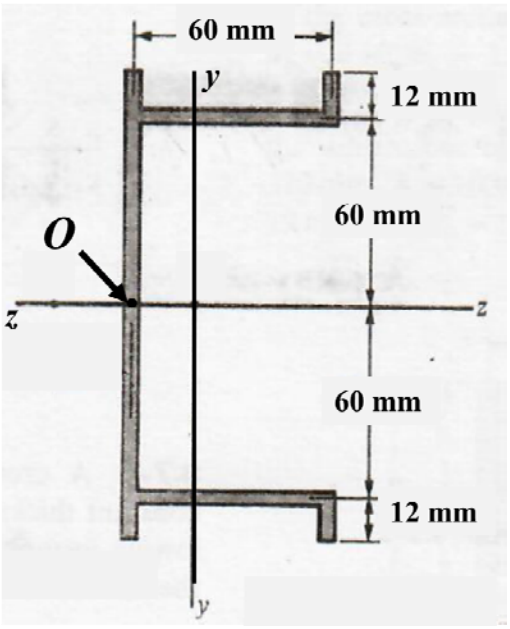


Fig. 2

SUMMARY ANSWER SHEET

PAPER CODE: A

Name:

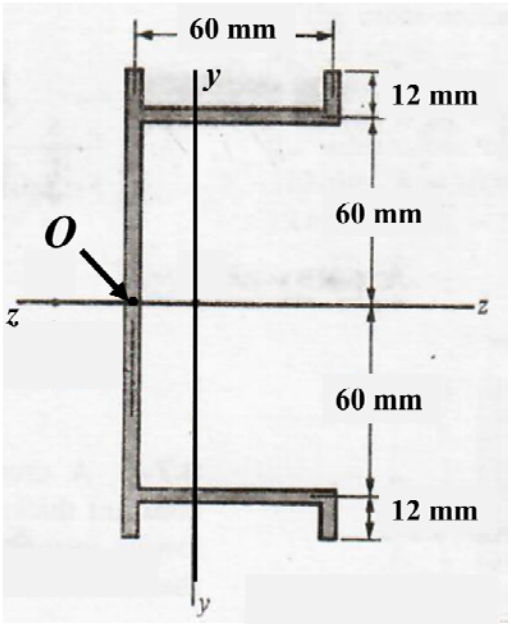
Roll no:

Problem 1

σ_t =

Problem 2

e =



DEPARTMENT OF CIVIL ENGINEERING

CE-221 SOLID MECHANICS

Quiz-2 25/10/17 PAPER CODE: B

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Problem 1

A member constructed of an equal angle section (i.e, $AB = BD$) is subjected to a tensile load $P = \mathbf{20}$ N**.** The load *P* acts out of the plane of the paper and acts through the point where the midlines of the equal legs intersect (as shown in Fig. 1). Take $I_{zz} = I_{yy} = 89mm^4$, $I_{zy} = 52.5mm^4$, $A = 15mm^2$ where *A* is the area of the cross-section, $c = 2.37mm$ where *c* is the distance of the section centroid (*C*) from point *B* along *y* and *z* axes as shown in Fig. 1, and $t = 1mm$ where *t* is the uniform section thickness. Calculate the maximum tensile stress σ_t in the member. Relevant formulae are,

$$I_{y'z'} = \left(I_{zz} - I_{yy}\right)\frac{\sin 2\theta}{2} + I_{yz}\cos 2\theta \quad ; \quad I_{y'y'} = I_{yy}\cos^2\theta + I_{zz}\sin^2\theta + I_{yz}\sin 2\theta$$

Problem 2

For the singly-symmetric thin-walled cross-section having constant thickness (Fig. 2**),** calculate the distance *e* of the shear center measured from point O, and show its location on the summary answer sheet. All dimensions are given with respect to the midlines, as shown.

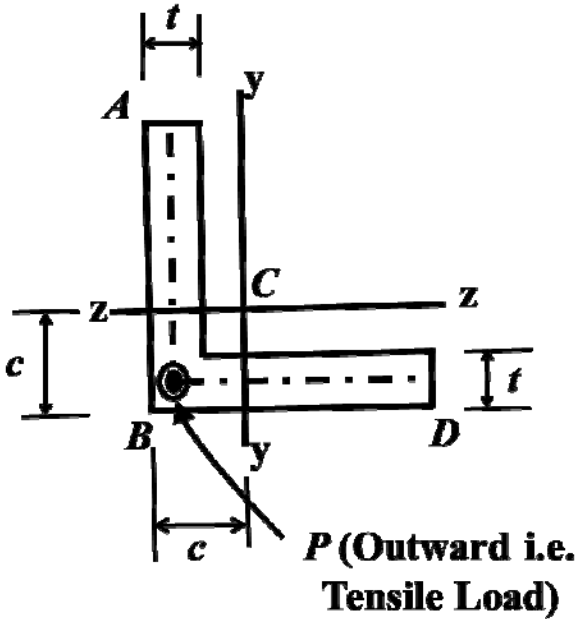


Fig. 1

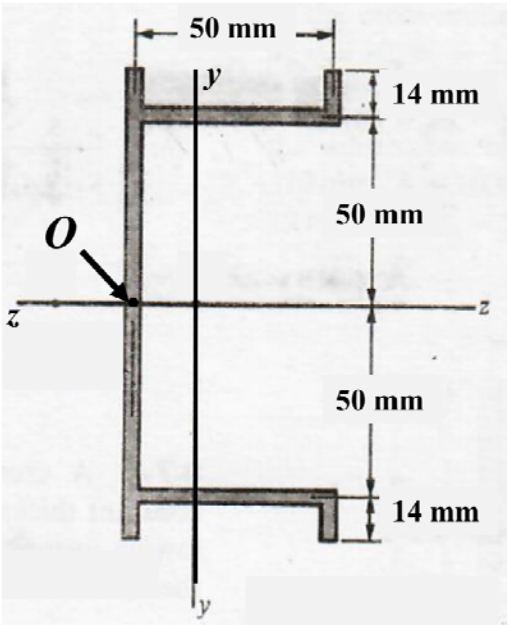


Fig. 2

SUMMARY ANSWER SHEET

PAPER CODE: B

Name:

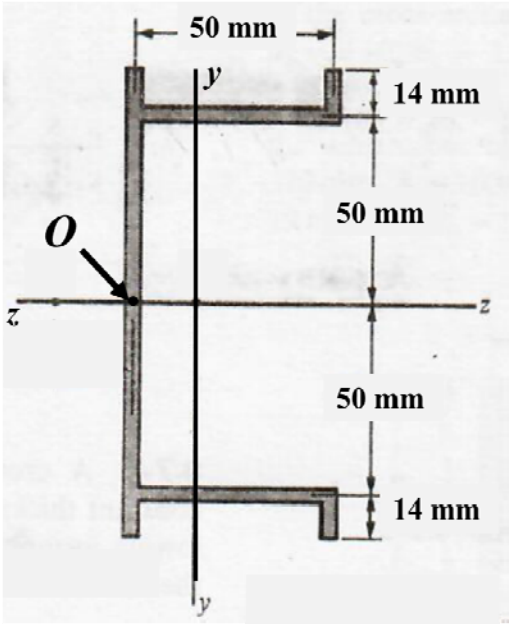
Roll no:

Problem 1

σ_t =

Problem 2

e =



DEPARTMENT OF CIVIL ENGINEERING

CE-221 SOLID MECHANICS

Quiz-2 25/10/17 PAPER CODE: C

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Problem 1

A member constructed of an equal angle section (i.e, $AB = BD$) is subjected to a tensile load $P = \mathbf{25}$ N**.** The load *P* acts out of the plane of the paper and acts through the point where the midlines of the equal legs intersect (as shown in Fig. 1). Take $I_{zz} = I_{yy} = 35.5mm^4$, $I_{zy} = 20.44mm^4$, $A = 11mm^2$ where *A* is the area of the cross-section, $c = 1.86mm$ where *c* is the distance of the section centroid (*C*) from point *B* along *y* and *z* axes as shown in Fig. 1, and $t = 1mm$ where *t* is the uniform section thickness. Calculate the maximum tensile stress σ_t in the member. Relevant formulae are,

$$I_{y'z'} = \left(I_{zz} - I_{yy}\right)\frac{\sin 2\theta}{2} + I_{yz}\cos 2\theta \quad ; \quad I_{y'y'} = I_{yy}\cos^2\theta + I_{zz}\sin^2\theta + I_{yz}\sin 2\theta$$

Problem 2

For the singly-symmetric thin-walled cross-section having constant thickness (Fig. 2**),** calculate the distance *e* of the shear center measured from point O, and show its location on the summary answer sheet. All dimensions are given with respect to the midlines, as shown.

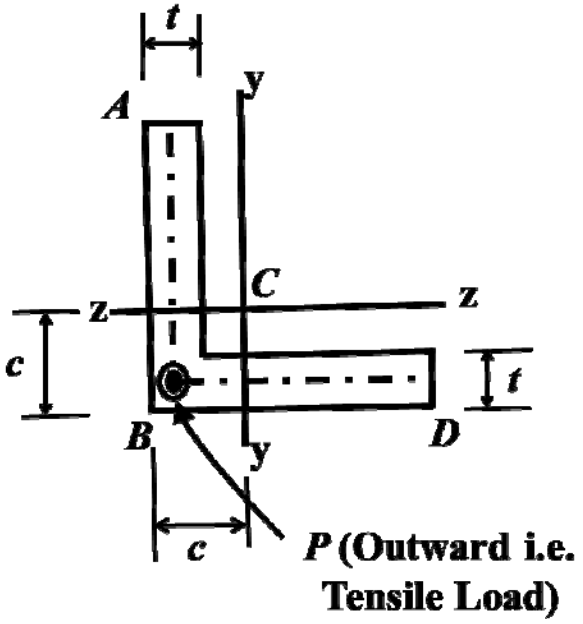


Fig. 1

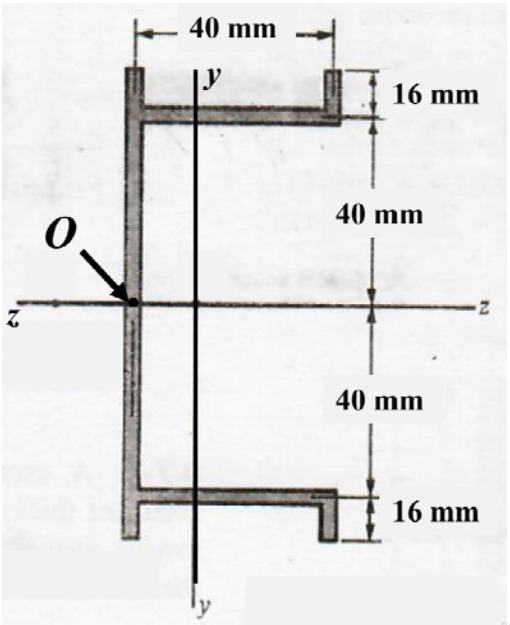


Fig. 2

SUMMARY ANSWER SHEET

PAPER CODE: C

Name:

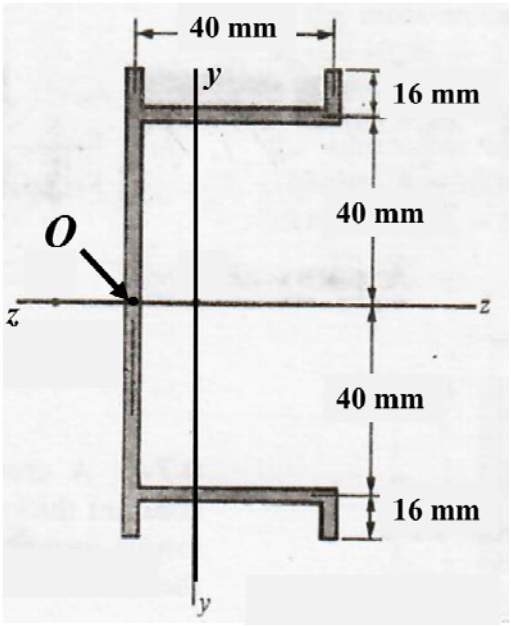
Roll no:

Problem 1

σ_t =

Problem 2

e =



DEPARTMENT OF CIVIL ENGINEERING

CE-221 SOLID MECHANICS

Quiz-2 25/10/17 PAPER CODE: D

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Closed book, closed notes test. No formula sheet allowed. No mobile phones allowed in the exam hall.
Both questions carry equal marks. Assume suitable data if required and state the same clearly

Problem 1

A member constructed of an equal angle section (i.e, $AB = BD$) is subjected to a tensile load $P = \mathbf{40}$ N**.** The load *P* acts out of the plane of the paper and acts through the point where the midlines of the equal legs intersect (as shown in Fig. 1). Take $I_{zz} = I_{yy} = 17.8mm^4$, $I_{zy} = 10.25mm^4$, $A = 7.98mm^2$ where *A* is the area of the cross-section, $c = 1.57mm$ where *c* is the distance of the section centroid (*C*) from point *B* along *y* and *z* axes as shown in Fig. 1, and $t = 0.875mm$ where *t* is the uniform section thickness. Calculate the maximum tensile stress σ_t in the member. Relevant formulae are,

$$I_{y'z'} = \left(I_{zz} - I_{yy}\right)\frac{\sin 2\theta}{2} + I_{yz}\cos 2\theta \quad ; \quad I_{y'y'} = I_{yy}\cos^2\theta + I_{zz}\sin^2\theta + I_{yz}\sin 2\theta$$

Problem 2

For the singly-symmetric thin-walled cross-section having constant thickness (Fig. 2**),** calculate the distance *e* of the shear center measured from point O, and show its location on the summary answer sheet. All dimensions are given with respect to the midlines, as shown.

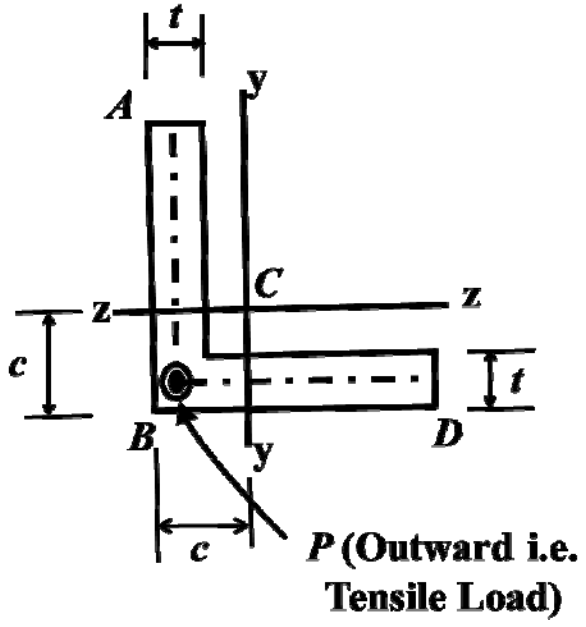


Fig. 1

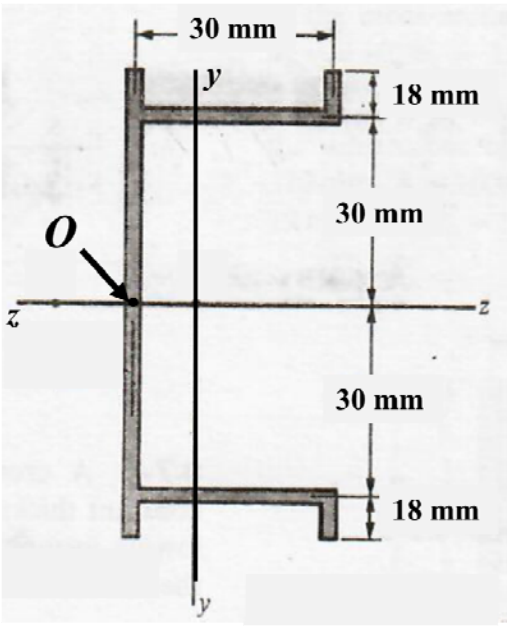


Fig. 2

SUMMARY ANSWER SHEET

PAPER CODE: D

Name:

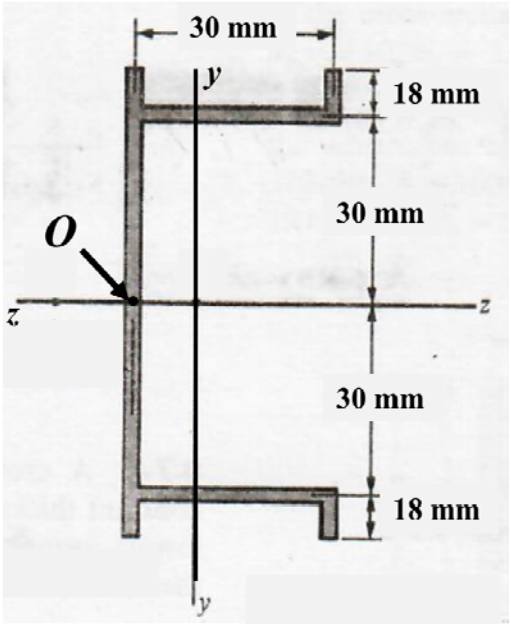
Roll no:

Problem 1

σ_t =

Problem 2

e =



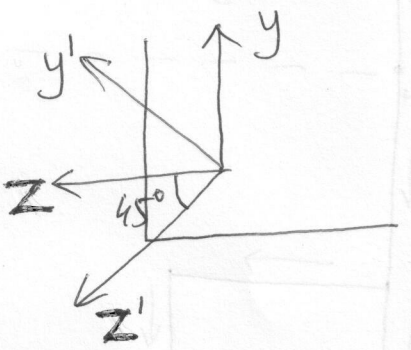
CE 201 SOLID MECH QUIZ-2 25/10/2017

P.1 $\because I_{yy} = I_{zz}$, $\tan 2\theta = \dfrac{2I_{yz}}{I_{yy} - I_{zz}} = \infty \Rightarrow \theta = \pm 45^\circ$

$I_{y'y'} = I_{yy} + I_{yz} \sin(-90)$

$I_{z'z'} = I_{yy} - I_{yz} \sin(-90)$

$M_z = P\left(c - \dfrac{t}{2}\right) = M_y$



$$\sigma_x = \frac{P}{A} - \frac{(M_z - M_y)\cos 45\, y'}{I_{z'z'}} + \frac{(M_z + M_y)\cos 45\, z'}{I_{y'y'}}$$

$$NA \Rightarrow \sigma_x = 0 \rightarrow z' = -\frac{P}{A}\frac{I_{y'y'}}{(M_z + M_y)\cos 45}$$

So max tensile stress at pt. B.

$$\sigma_x = \frac{P}{A} + \frac{M_z + M_y}{I_{y'y'}}\cos 45\,\underbrace{(c\cos 45 - [-c]\sin 45)}_{2c\cos 45}$$

Answers

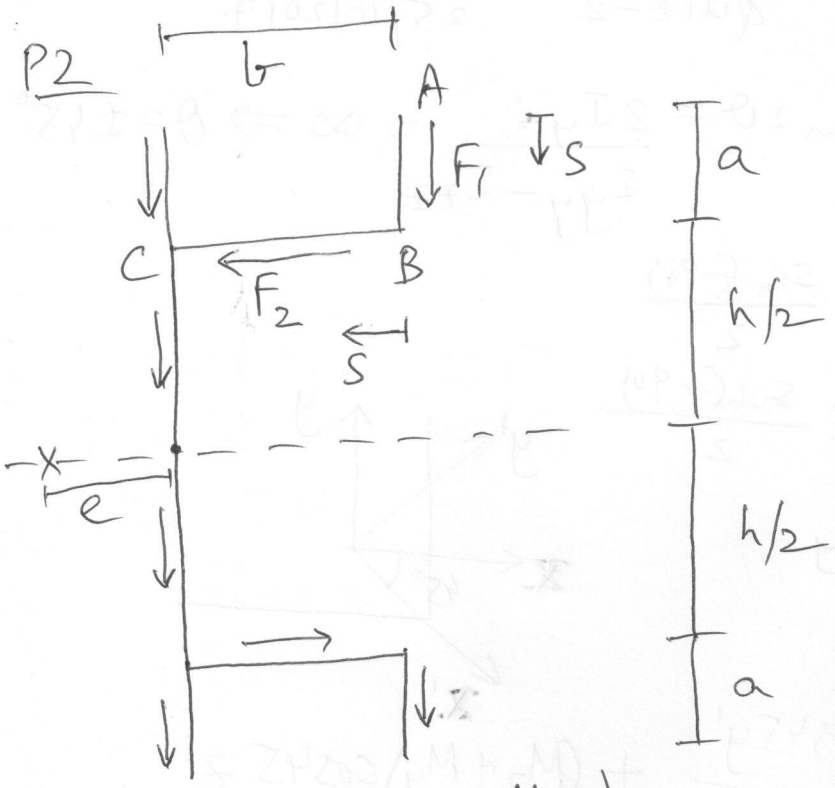
Code A: $(\sigma_t)_{max} = 13.11$ MPa

B 6.19

C 10.67

D 23.84

P2



ANSWERS.

Code A: e = 23mm

B → 18.71

C → 14.08

D → 9.08

(Direction of shear flow).

Vertical arm AB, (take V=1)

$$q = \frac{1}{I} ts\left(\frac{h}{2}+a-\frac{s}{2}\right) = \tau_{xy} t$$

$$F_1 = \int_0^a \tau_{xy} t\,ds = \frac{t}{I}\left[\left(\frac{h}{2}+a\right)\frac{a^2}{2} - \frac{a^3}{6}\right]$$

Horizontal arm BC,

$$q = q_B + \frac{1}{I} s t \frac{h}{2} = q\Big|_{\substack{\text{vertical}\\ \text{arm AB}\\ \text{at } s=a}} + \frac{1}{I} s t \frac{h}{2} = \frac{1}{I}\left[ta\left(\frac{h}{2}+\frac{a}{2}\right) + \frac{ths}{2}\right]$$

$$= \tau_{xz} t$$

$$F_2 = \int_0^b \tau_{xz} t\,ds = \frac{1}{I}\left[ta\left(\frac{h+a}{2}\right)b + th\frac{b^2}{4}\right]$$

$$I = \frac{2(h+2a)^3 t}{12} + 2bt\left(\frac{h}{2}\right)^2 - \frac{h^3 t}{12}$$

$$1.e = F_2 h - F_1 . 2b$$

$$e = \frac{\left(\frac{h+a}{2}\right)abh + \frac{h^2b^2}{4} - \left(\frac{h}{2}+a\right)\frac{a^2}{2}2b + \frac{a^3}{6}.2b}{\frac{(h+2a)^3}{6} + \frac{bh^2}{2} - \frac{h^3}{12}}$$

$$= \left(6abh^2 + \cancel{6a^2bh} + 3h^2b^2 - \cancel{6a^2hb} - 12a^3b + 4a^3b\right) \Big/ \left\{\begin{matrix} 2[h^3 + 3h^2.2a + \\ 3h.4a^2 + 8a^3] \\ +6bh^2 - h^3 \end{matrix}\right\}$$

Answer