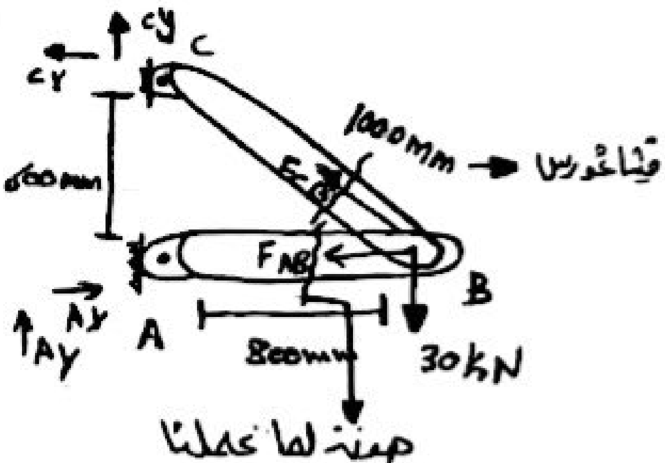
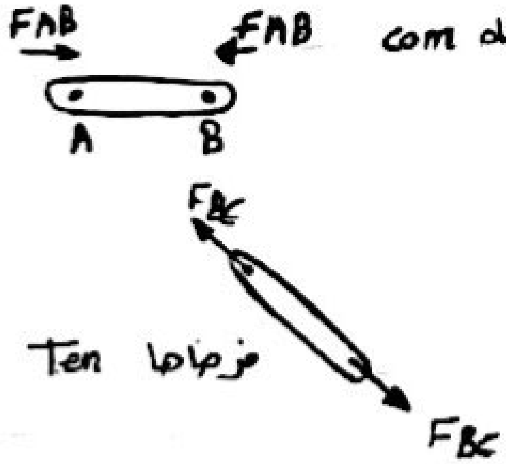
No

5/6

ch: 1 concept of stress
the main objechive of study of the machanics of matirials is to analyse and design agre structurs invohwing detrmination of stress and deformation...

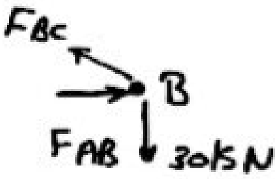
review examphless -





$F_{AB} \to$ Ay , Ax جهة

$F_{BC} \to$ cy , cx جهة



$\Sigma F_x = \; F_{AB} = F_{BC} \cos\theta$

$F_{AB} = F_{BC}\,(0.8)$

$\Sigma F_y = \; F_{BC} \sin\theta = 30 \times 10^3$

kN → N

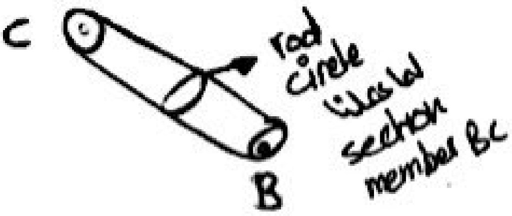
$F_{BC}\,(0.6) = 30 \times 10^3$

$F_{BC} = 50\ kN \to$ Tension

$F_{AB} = 40\ kN \to C$ الفرض صح

الفرضية

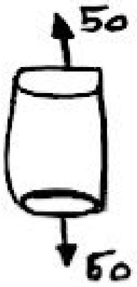
smile...

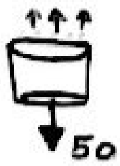


Diameter قطر

reduice بتخفض

* can the system with stand the load or will break down ?





normal stress

لما تكون القوة موازية لمحور الـ axis

المادة هي عبارة عن ذرات و لما اشدها بتكون قوة ترابط بين الذرات internal force

*القوة لما تكون عمودية على المقطع ← normal *stress : Intensity of the Internal Forces distributed over a given area

$$\sigma = \frac{P}{A} = \frac{N}{m^2} = Pa$$

stress ال normal

* لما تقل A تزيد ال stress
* Factors that depend to :-
  - material
  - Load
  - Area cross section

Analysis of design

Assume rod Bc is made of steel with maximam allowable stress $\sigma_{all} = 165 Pa$

$\sigma = \frac{P}{A}$

$A = \frac{\pi}{4} d^2$ diameter

$A = \pi R^2$ reduice

$\frac{50 * 10^3}{\frac{\pi}{4}(20 * 10^{-3})^2} = 159 pa$

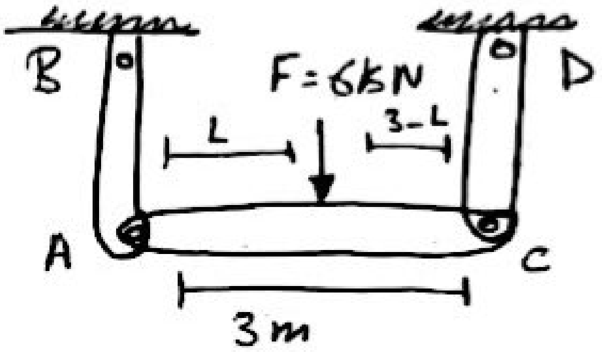
$159 pa < 160 pa$

* what will be the sutible diameter rod Bc if its rod alamunume with a $\sigma_{all} = 100 MPa$

$\sigma_{all} = \frac{P}{A}$ $\quad 100 * 10^6 = \frac{50 * 10^3}{\pi r^2}$

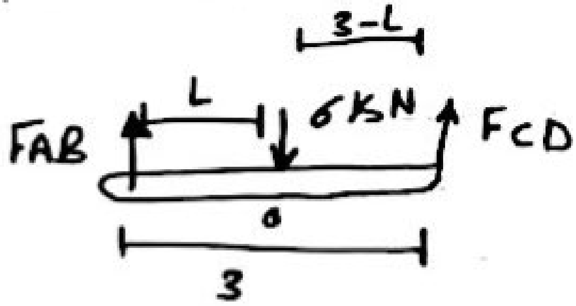
$r = 12.62$
$r \approx 13$
$d = 26$

Example



$A_{AB} = 12\,mm^2$
$A_{CD} = 8\,mm^2$

Find L so that the averge normal stress in each rod AB and CD is the same:-



$$\sigma_{AB} = \sigma_{CD}$$

$$\frac{P}{A} = \frac{P}{A}$$

$$\frac{F_{AB}}{12 \times 10^{-6}} = \frac{F_{CD}}{8 \times 10^{-6}}$$

$$\boxed{F_{AB} = 1.5 F_{DC}}$$

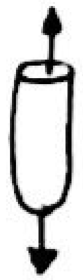
* $M_o =$

$$F_{CD}(3-L) - F_{AB}(L) = 0$$

$$F_{CD}(3-L) - 1.5(F_{CD})(L) = 0$$

$$F_{CD}(3 - L - 1.5L) = 0$$

$$L = 1.2\,m$$

* 

axial load
σ = normal stress

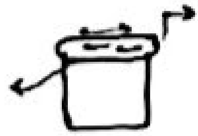
shear load ↓
ما زيو عالسطح كبس

shear load $\xrightarrow{\text{بتنتجه}}$ shear stress

* shearing stress (τ) :- transvearse Load is acting Parllel to cross section area

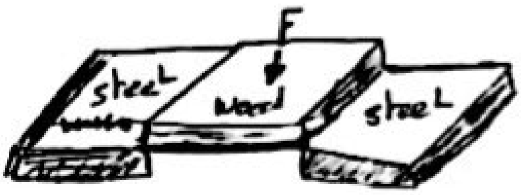
cross section → uniform

$$\tau_{avg} = \frac{V}{A_o} = \frac{N}{m^2} = Pa$$

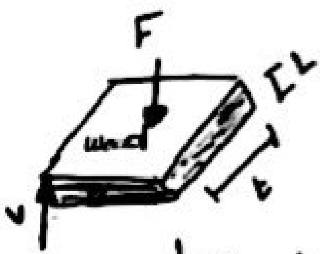


* Pin  → يتعرض لـ shear stress

*

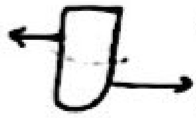


$$\tau_{avg} = \frac{V}{A} = \frac{F/2}{A}$$



$A = L * t$

→ مادتين
Double shear

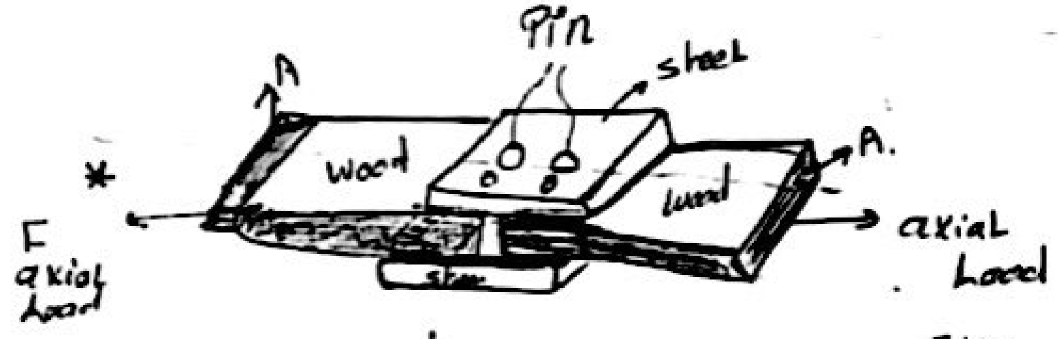


بيدو
single shear

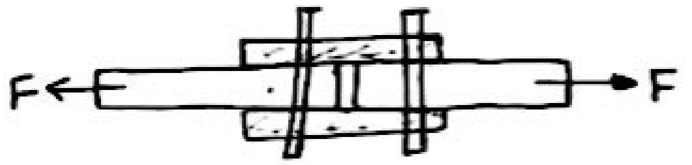
← Pin

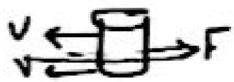
smile...

*



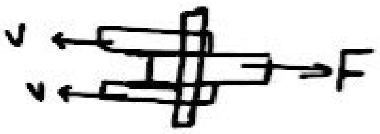
$$\tau = \frac{F/4}{A}$$





two pins $\tau = \frac{F/4}{A}$

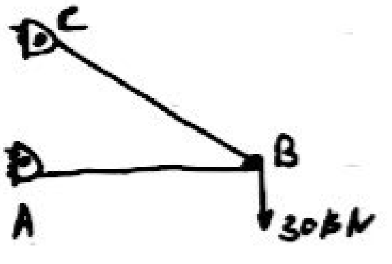
لو أخدنا Pin الأول لحاله



$\frac{F}{2} = V$

$\Sigma F_x = F = 2V$

*



$F_{AB} = 40kN\ (C)$

$F_{CB} = 50kN\ (T)$

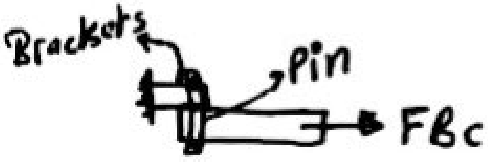
*ممكن الكسر يصير بال Pin

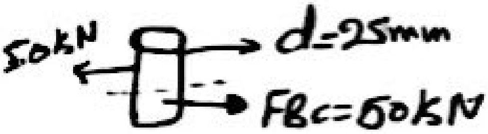
* اذا قيمة ال shear stress مقدار 6 عند اكبر من 60 ll بنكسر

$\tau < \tau_{all}$

smile

topview 8 - Pin (c)



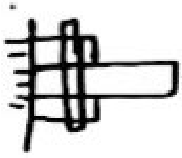


$$\tau = \frac{V}{A} = \frac{50 \times 10^3}{\frac{\pi}{4}(25 \times 10^{-3})^2} = 102\,MPa$$

$105\,M = \sigma_{shear}$ stress allowable لحتمل دنا ال

Failar مارح يصير $102\,MPa < 105\,MPa$

double shear $\leftarrow$ c Pin هسكا انو ال



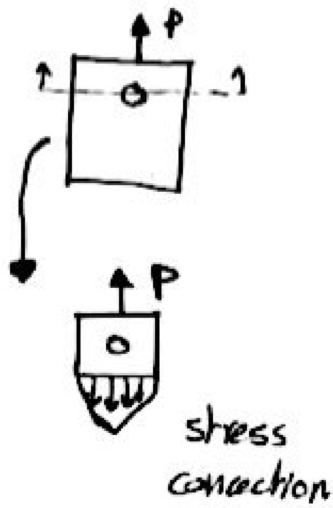
$$\frac{F/2}{A} = \text{double shear}$$

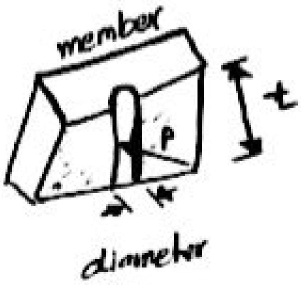
*

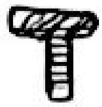
Bearing stress in connection

27/6
2-8
11/7

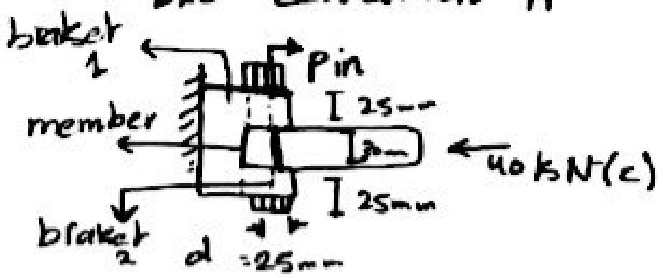
$$\sigma_b = \frac{P}{A}$$







Ex8 conection A



* شانشوف تأثير ال pin
ع ال link

braket 20 →

member ← 40

brak → 20

→ braket
كلهم بياخذ نص بس 20
كل braket = 20
أما ال member كامل
بياخذ كل ال Force عليه

In member AB Find the bearing stress?

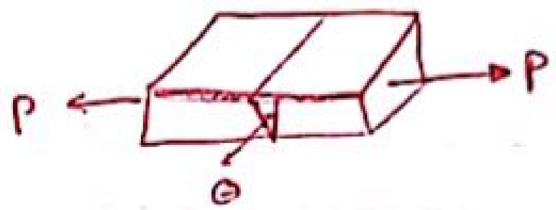
$$\sigma_b = \frac{40 * 10^3}{25 \times 30 \times 10^{-6}} = 53.3 \, Npa$$

In braket at A?

$$\sigma_b = \frac{20 \times 10^3}{25 \times 25 \times 10^{-6}} = 32 \, MPa$$

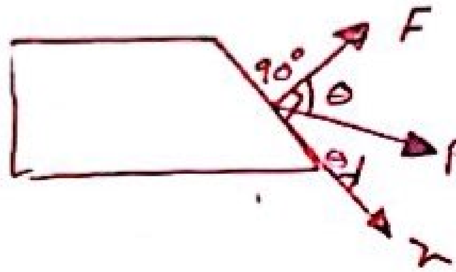
* stress on an oblique plane under axial loading...

مائل



shear ← لما مثلاً ع شكل مائل عندي

normal



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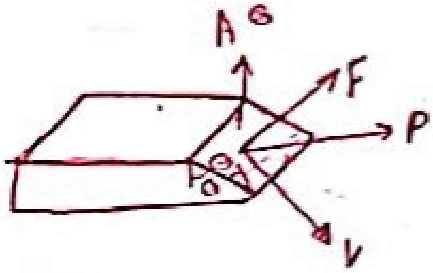


$A_o = A_\theta \cos\theta$

$F = P\cos\theta$

$V = P\sin\theta$

normal stress :-

$$\sigma = \frac{F}{A_\theta} = \frac{P\cos\theta}{\frac{A_o}{\cos\theta}} = \frac{P}{A_o}\cos^2\theta$$

shear stress :-

$$\tau = \frac{V}{A_o} = \frac{P\sin\theta}{\frac{A_o}{\cos\theta}} = \frac{P}{A_o}\sin\theta\cos\theta$$

$\theta = 45 =$

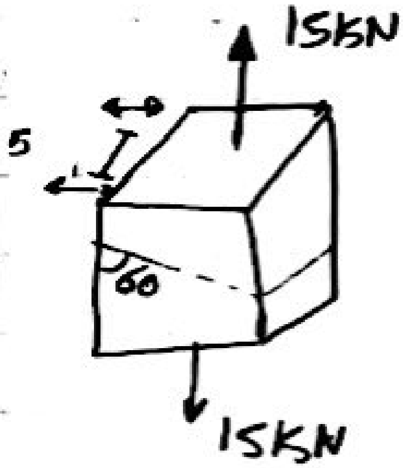
normal stress = shear stress

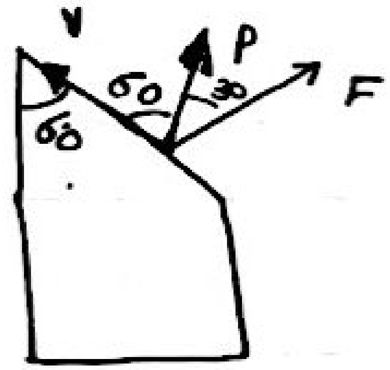
the 15 kN is acting on wooden member as shown, Find the normal, shearing stress in the obique plane

*لازم ال P متوسطة مال shear ال normal

* لما نرسم حدة تكملة عمودية ع الخط م لتابة معارضة لإيه

الكم تكون P وسط

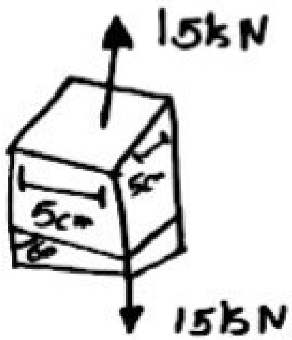


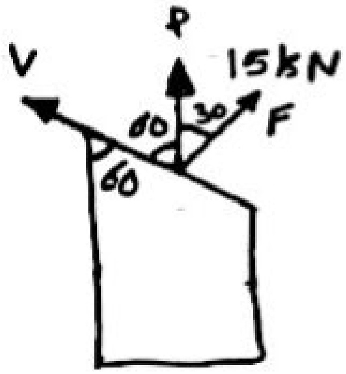


$$\sigma_b = \frac{15\times10^3 \cos^2(30)}{25\times10^{-4}} = 4.5\,\text{MPa}$$

$$\tau = \frac{15\times10^3 \sin 30^\circ \cos 30}{25\times10^{-4}} = 2.59\,\text{MPa}$$

* Example :- the 15kN Load is acting on wooden member as shown, Find the normal and shearing stress in the oblique plane





١) بنرسم المقطع حالة ونحدد الزاوية

٢) نحلل ال Force لقوة shear الموازية مع وقوة normal عمودية

٣) الزاوية اللي بدنا ياها لازم بين F P ← 30

٤) إيجاد قيم ال Force وتطبيقها على القوانين

$$\sigma = \frac{P}{A}\cos^2\theta \qquad = \frac{15 * 10^3}{25 * 10^{-4}} * \cos^2 30$$

$$T = \frac{P}{A}\sin\theta\cos\theta \qquad \frac{15\times10^3}{25\times10^{-4}} * \sin30\cos30$$

*

لهون اذا
طلب ال stress

* أما اذا بده بس sheer Force أو normal Force ← بحلل ال P ع الزاوية 60

* Factor of seafety (F.s)

$$F.s = \frac{\text{ultimal Load}}{\text{allowable Load}} = \frac{\text{ultimal stress}}{\text{allowable Load}} = \frac{\sigma_u}{\sigma_{all}} = \frac{\tau_u}{\tau_{all}}$$

* قيمة > ١

* لو عطينا على Area

رح طلعلنا stress بسيط

و stress تمام

* لازم نرجع لـ stress

يكون تقسيمه

$\frac{\sigma}{\sigma}$ $\frac{\tau}{\tau}$

$F.s > 1$

$F.s \neq 1$

* ultimate stress $(\sigma_u) = \frac{P_u}{A_o}$

* Example 8- IF the ultimal stress ($\sigma_u = 570$ MPa) Find the ~~dim~~ diameter of the rod unde axial Load $P = 400$ kN assum $Fs = 3.5$

* $Fs = \frac{\sigma_u}{\sigma_{all}} = 3.6 = \frac{570}{\sigma_{all}}$ $\sigma_{all} = 163$ MPa

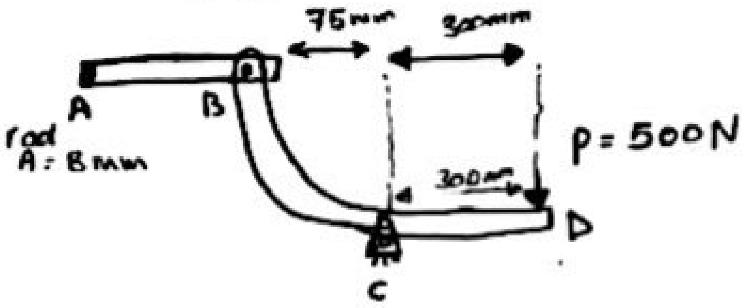
* $\sigma_{all} = \frac{P}{A} = 163 \times 10^6 \, Pa = \frac{400 \times 10^3}{d^2 \times \frac{\pi}{4}}$

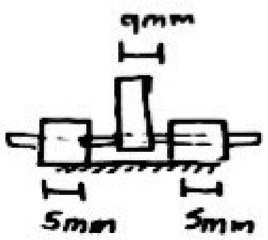
$d = 55.9$ mm

$d = 55.9 \times 10^{-3}$

Pin(B) - d = 4mm

*

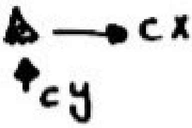




d = 6mm

Find:-

1. shear stress in the pin(c):-
2. Bearing stress in the member BCD at support c?
3. Bearing stress in each support bracket at (c)?
4. Normal stress in the rod AB?
5. shear stress at pin (B) with single shear?

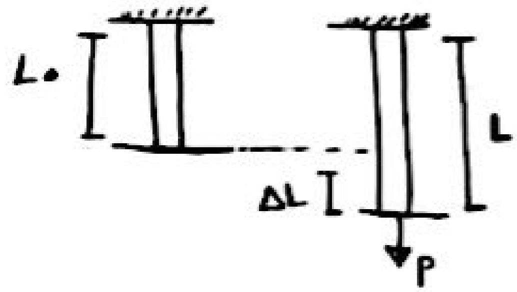


القوة التي تأثر على pinc هي

$$\sqrt{C_x^2 + C_y^2}$$

ch28- stress-strain under axial Loading

strain8 إستطالة

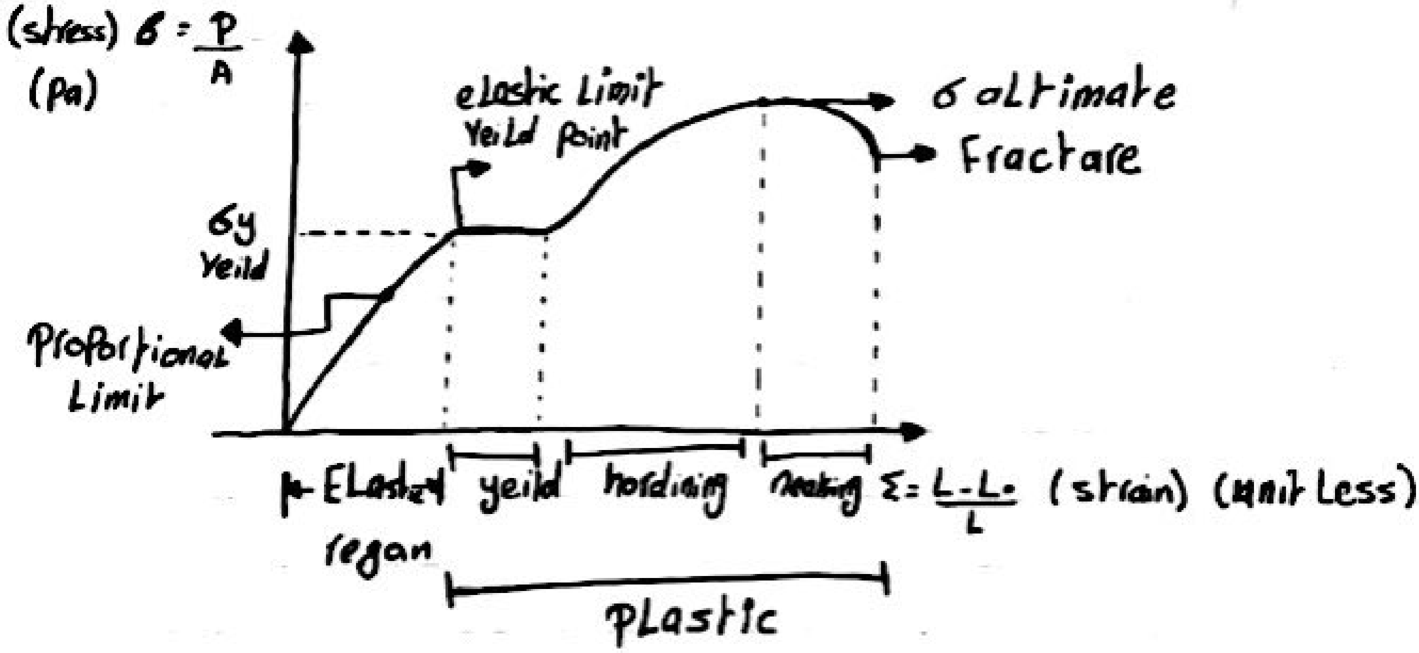


$\Delta L = L - L_0$

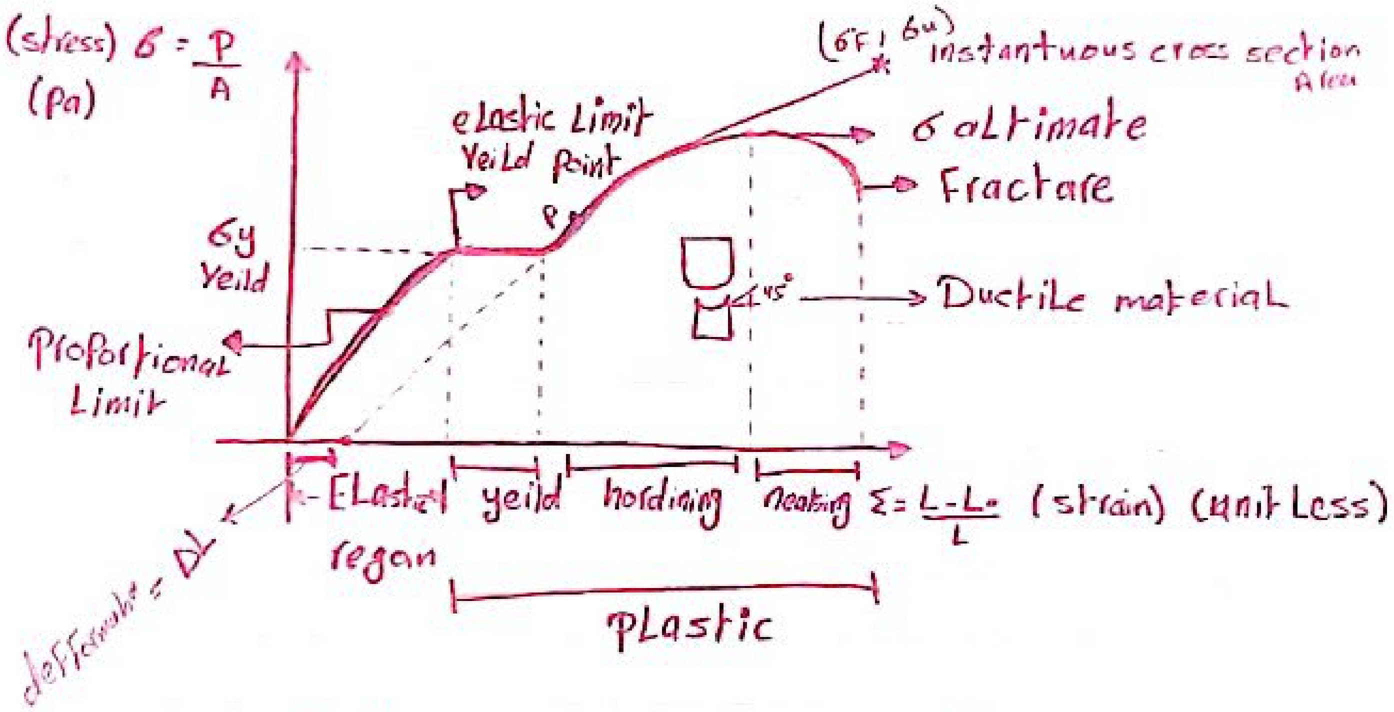
strain ↴

$$\varepsilon = \frac{\Delta L}{L_0} = \frac{\text{التغير بالطول}}{\text{الطول الأصلي}} = \frac{m}{m} = \text{unitless}$$

* stress strain diagram:-



* stress strain diagram:-



* Ductile material → 45° تتكسر زاوية

*العلاقة بين ال stress وال strain

$\sigma \propto \varepsilon$ (In elastic region)

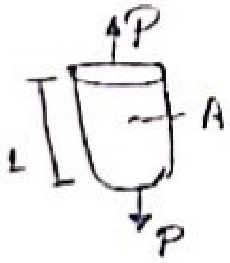
$\sigma = E\varepsilon$ E :- modulus of elasticity (pa)

Hook's Law

* Deformation in elastic region under axial Loading :-

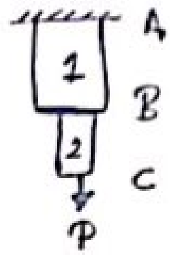
$$\sigma = \varepsilon E$$

internal داخلية $\leftarrow \frac{P}{A} = \frac{E\,\Delta L}{L}$ $\rightarrow$ $\underset{\text{deformation}}{\Delta L} = \frac{PL}{AE}$

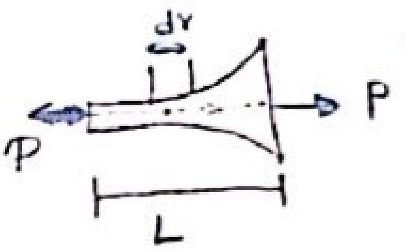


* For multi section

$$\delta_{total} = \sum_{i=1}^{n} \frac{P_i L_i}{A_i E_i}$$



لما ال cross section C←B←A uniform



* اذا كان nonuniform section :-

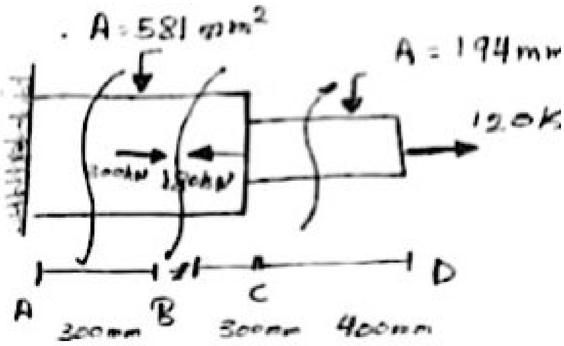
$$d\varepsilon = \frac{d\delta}{dx}$$

$$\int_0^L d\delta = \int_0^L \frac{P(x)\,dx}{A(x)\,E} = \int$$

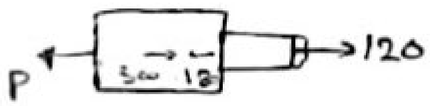
smile..

Examples:

Determine the deformation of the steel load rod under the axial loading if $E = 200\,GPa$?



١) صعوبة الشكل multi
٢) بشوف كم تغير عشان الـ Load
عشان أدخل section وأطلع الـ internal Load
٣) رسم F.B.D
٤) بطلع الـ reaction

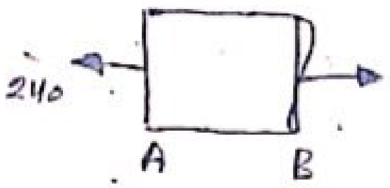


$\overset{+}{\rightarrow} \Sigma F_x = 0 \qquad -P + 300 - 180 + 120 = 0 \qquad P = 240\,kN$

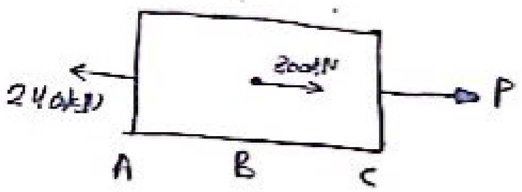
$$\delta_{A \to D} = \delta_{AB} + \delta_{B \to C} + \delta_{C \to D}$$

في الـ DeFFormation :
إذا كان T + ولو C -

* positive (tension Load) increasing Length
* negative (compression Load) decresing Length



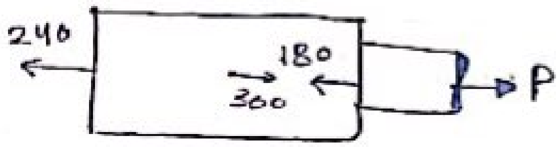
$$\delta_{A/B} = \frac{240 \times 10^{3} \times 300 \times 10^{-3}}{581 \times 10^{-6} \times 200 \times 10^{9}}$$



$$\Sigma F_x = -240 + 300 + P = 0$$

$$P = -60 \text{ kN}$$

$$\delta = \frac{-60 \times 10^{3} \times 300 \times 10^{-3}}{581 \times 10^{-6} \times 200 \times 10^{9}}$$



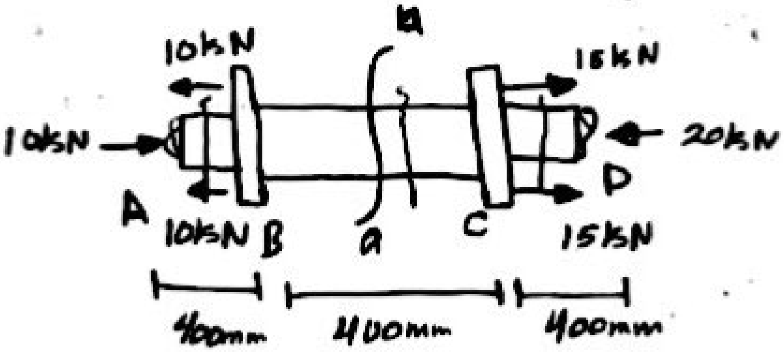
$$P - 180 + 300 - 240 = 0$$

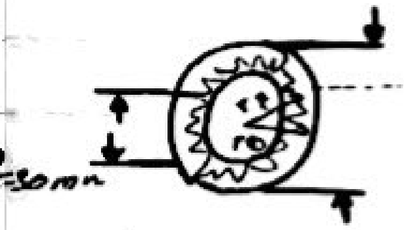
$$P = 120$$

$$\delta_{CD} = \frac{120 \times 10^{3} \times 400 \times 10^{-3}}{194 \times 10^{-6} \times 200 \times 10^{9}}$$

* آخر شي بنجمع لكل ال δ الي طلعناهم
*

* example :-





$t = r_o - r_i = 20 - 15 = 5mm$

$t = \frac{d_o}{2} - \frac{d_i}{2} =$

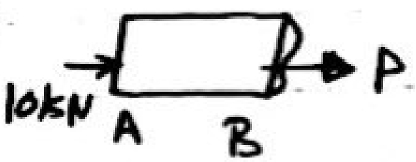
$d_o = 40mm$

sectionab :-

* segment AB & CD of the assembly are solid circule rod segment BC IF the assembly is made of steel with $E = 200$ Gpa determine the displacment of end D with respect end A?! $\delta D/A = ?!$

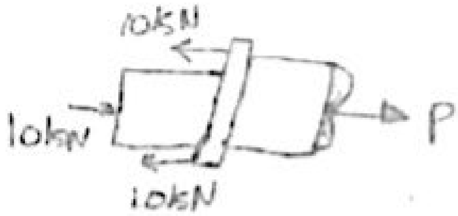
* $\delta_{D/A} = \delta_{A/B} + \delta_{B/C} + \delta_{C/D}$

*



$\Sigma Fx = P = -10$ $\boxed{C}$

$$\frac{10 \times 10^3 \times 400 \times 10^{-3}}{\frac{\pi}{4}(20 \times 10^{-3})^2 \times 200 \times 10^9}$$

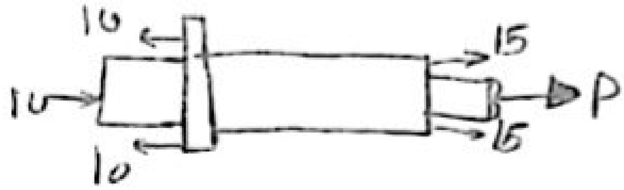


$\Sigma F_y = 0$

$10 - 20 + P = 0$

$\boxed{P = 10\,kN}$

$$\delta = \frac{10\times10^{3} \times 400\times10^{-3}}{\frac{\pi}{4}(40^2 - 30^2)\times10^{-6} \times 200\times10^{9}}$$



$\Sigma F_y = 0$

$10 - 20 + 30 + P = 0$

$P = -20\,kN$

$$\delta = \frac{-20\times10^{3} \times 400\times10^{-3}}{\frac{\pi}{4}(20\times10^{-3})^2 \times 200\times10^{9}}$$

$\Sigma \delta = \delta_1 + \delta_2 + \delta_3$

$= -0.154\,mm$

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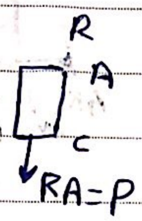
statically indetermine problem..♡

No.

Fixed support → P

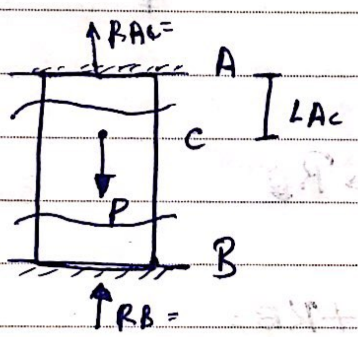
$\delta_{BC} = 0$

$\delta_{AC} \Rightarrow$



$$\delta_{A/B} = \delta_{A/C} + \delta_{C/B}$$

$$\frac{PL_{AC}}{AE} + 0 \quad \text{مافي Load}$$



$+\uparrow \Sigma F_y = 0 \qquad RA + Rb - P = 0$

عدد unknowns أكثر من عدد المعادلات

المحصلة = 0

$\Sigma\delta = 0 \quad {}_{cB}\delta = {}_{cA}\delta$ لأن

* Buckling → انقلام عكسي

بيصير

* We use the compatibility condition to solve the problem:-

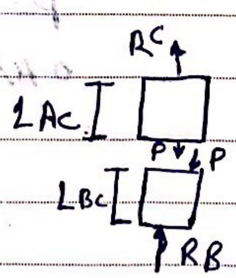
$\delta_{A/B} = 0$

statically indetermine problem

عدد المعادلات أقل من عدد المجاهيل

*

$$\delta_{A/B} = \frac{R_A L_{AC}}{AE} - \frac{R_C L_{BC}}{AE}$$



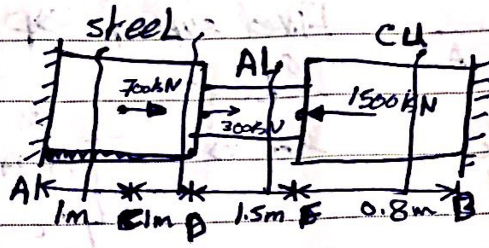
$R_A L_{AC} - R_B L_{BC} = 0 \rightarrow 1$

$R_A L_{AC} - (P - R_A) L_{BC} = 0$

$$R_A = \frac{P L_{BC}}{L} \qquad R_B = \frac{P L_{AC}}{L}$$

No. * Doha Alkhazhleh
CIVIL

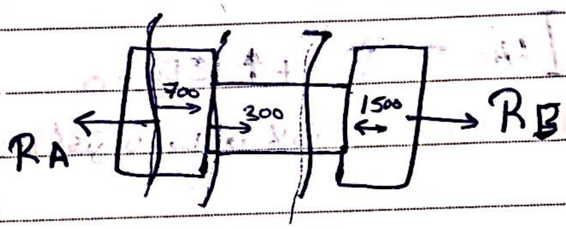
$\delta_{AE}=0$



$A_{steel} = 500 mm^2$
$A_{AL} = 300 mm^2$
$A_{cu} = 400 mm^2$
$E_{steel} = 200 GPa$
$E_{AL} = 70 GPa$
$E_{cu} = 110 GPa$

Find the reaction at A & B ?!

1) F.B.D → reaction

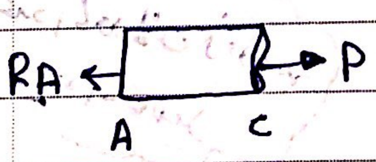


$\Sigma F_x = -RA + 700 + 300 - 1500 + RB =$

$RB - RA = 500 \rightarrow 1$

$\delta AB = 0 = \delta A/C + \delta C/D + \delta DE + \delta E/B$

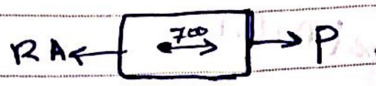
F.B.D



$P = RA$

$\delta A/C = \dfrac{RA * 10^3 * 1}{500 * 10^{-6} * 200 * 10^9}$

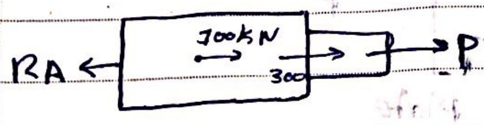
No.



$$\Sigma F_x = P + 700 - R_A = 0$$

$$P = R_A - 700$$

$$\delta_{CD} = \frac{(R_A - 700) \times 10^3 \times 1}{500 \times 10^{-6} \times 200 \times 10^9}$$

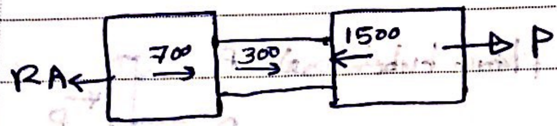


$$\Sigma F_y = 0$$

$$-R_A + 700 + 300 + P = 0$$

$$P = R_A - 1000$$

$$\delta_{DE} = \frac{(R_A - 1000) \times 10^3 \times 1}{70 \times 10^9 \times 300 \times 10^{-6}}$$



$$\Sigma F_y = 0$$

$$-R_A + 700 + 300 - 1500 + P = 0$$

$$P = R + 500$$

$$\delta_{EB} = \frac{0.8 \times 10^3 (R_A + 500)}{400 \times 10^{-6} \times 110 \times 10^9} =$$

نجمعهم كلهم ونساويهم بصفر

$$R_A = 632.58\ kN \rightarrow +$$

* اذا الاشارة سالب برجع للمعادلة الاصلية

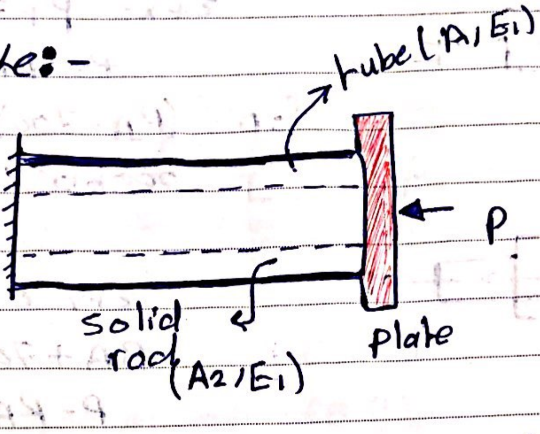
بعوضها سالب مثل ما هي

$$R_B = 1132.5$$

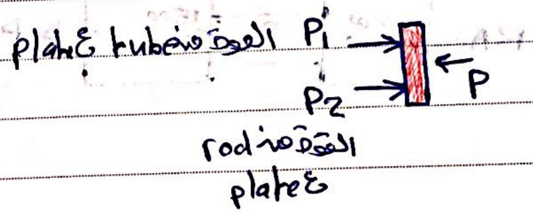
contraction → تقلص

No.

example:-

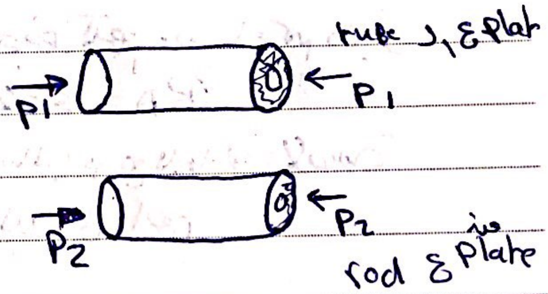


What is the deformation of the Rod and tube When the Force (P) is exerted on a rigid end plane??



$\Sigma F_x = 0$

$P_1 + P_2 - P = 0 \rightsquigarrow \underline{1}$



$\delta_1 = \delta_2$

$$\frac{P_1 L}{A_1 E_1} = \frac{P_2 L}{A_2 E_2} \rightsquigarrow \underline{2}$$

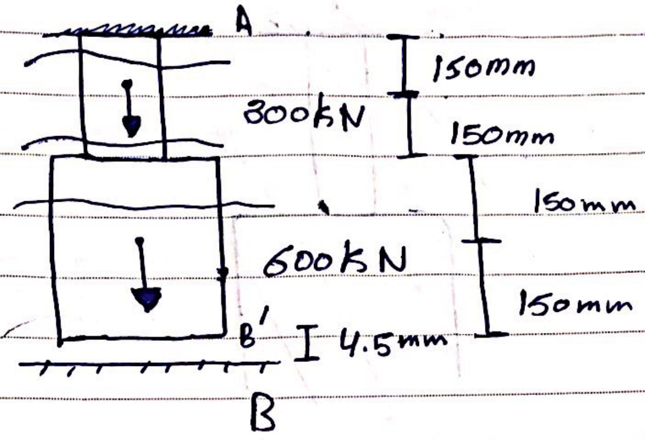
$$P_1 = P\left(\frac{A_1 E_1}{A_1 E_1 + A_2 E_2}\right)$$

$$P_2 = P\left(\frac{A_2 E_2}{A_1 E_1 + A_2 E_2}\right)$$

No.

بسبب دخول Load جديد

بسبب تغير cross section



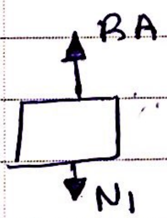
AB' < total Defformation

$\delta_{AB'}$

اذا الـ $\delta_{AB'}$ أقل من 4.5

يعني الرياكشن عند B = 0

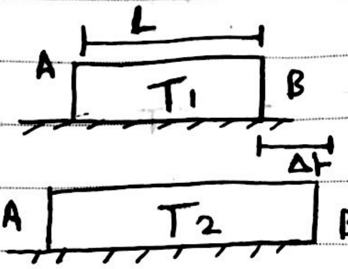
total الـ < AB' ← 4.5 = total Deformatio



$N_1 = R_A \quad \delta_1 = \underline{R_A * 150\times10^{-3}}$

* Problems involving temperature change :-

$T_2 > T_1$



على ماذا يعتمد؟
١) التغير بالحرارة
٢) التغير بالطول
٣) thermal

$\delta T = \alpha\ (\Delta T)\ L$

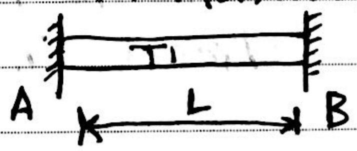
thermal
expansion $(1/C^\circ)$
coefficient

$m = \frac{1}{C^\circ} \cdot C^\circ * m$

"Thermal Forces"

at T_1 no reaction Force
at A and B at T_2

rod (α, A, E)



$T_2 > T_1$

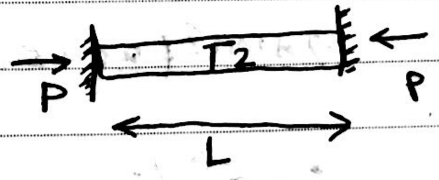
$\delta_{total} = 0$

$\delta T + \delta L = 0$

$(\alpha \Delta T * L) - \frac{PL}{AE} = 0$ Comp

$P = \alpha \Delta T . A . E$ total = 0

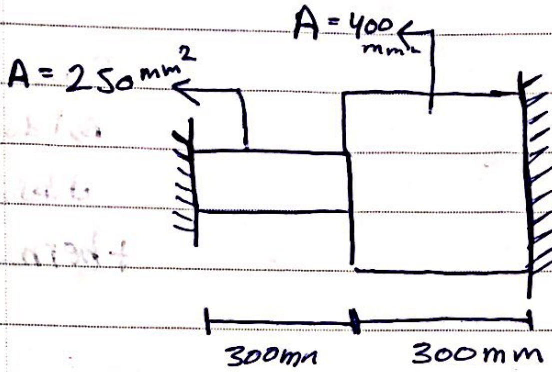
(بعدما تتعرض للحرارة رح يصير عنا رياكشن)



examples:-

thermal strain

$$\frac{\delta_T}{L} = \varepsilon_T$$



بسبب تغير بالحرارة
رح يكون عندي Thermal

examples:- $E_{AL} = 70\,GPa$

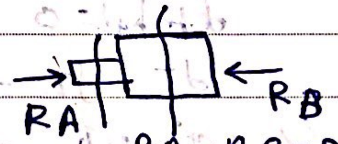
$T_1 = 20C^\circ$

$T_2 = 80C^\circ$

$\alpha = 21\times10^{-6}/C^\circ$

Find the reaction Forces at supports A and B stresses in section AC, BC

total $\delta = \delta_T + \delta_L$



$R_A = R_B = P$

ال δ_T ← ما بتعتمد على المتريال Area

~~2×10^-6 (80-20)~~

$21\times10^{-6}\,(80-20)C^\circ * 600\times10^{-3}$

No.

$$\delta_L = -\frac{P L_{AC}}{A_{AC} E} - \frac{P L_{CB}}{A_{CB} E}$$

$$-P\left(\frac{300\times10^{-3}}{70\times10^{9}\times250\times10^{-6}} + \frac{300\times10^{-3}}{70\times10^{9}\times400\times10^{-6}}\right)$$

$$\delta_L + \delta_T$$

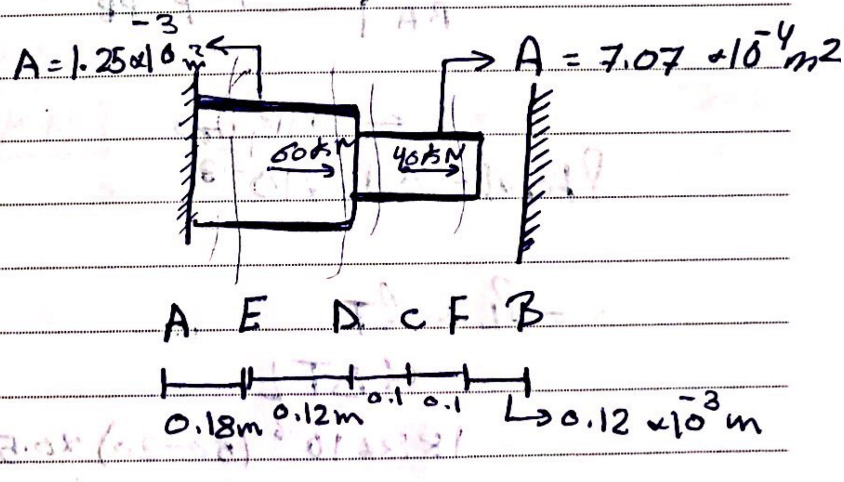
$$21\times10^{-6}\times60\cdot60\times10^{-3} + \#$$

$$P = 27.14\,kN$$

$$\sigma_{AC} = \frac{P_{AC}}{A_{AC}} = \frac{27.14\times10^{3}}{250\times10^{-6}} = 108.55\ MPa\ \text{(compresio)}$$

$$\sigma_{BC} = \frac{P_{BC}}{A_{BC}} = \frac{27.14\times10^{3}}{400\times10^{-6}} = 67.9\ MPa\ \text{(compres}$$

..... example :-



Find the reaction Forces A and B

IF $E = 105\,GPa$

$\alpha = 18.8\times10^{-6}/C^\circ$

$T_1 = 20C^\circ$ $T_2 = 50C^\circ$

No.

١) بدي اطلع $100 = R_A$

٢) $\delta_{total} >$ الفرق بين ٢ و الجسم

معناه ح يصطدم الجسم بالسبورت

ويعطي رياكشن عند B

معه RA

٣) $\delta_T = 0.12$

* solutions:-

$R_A = 100\,KN$

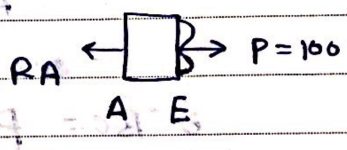
cheack

$$\delta_L = \delta_{AF} = \delta_{A/E} + \delta_{E/D} + \delta_{D/C} + \delta_{C/F}$$

$$* \frac{100\times10^3 \times 0.18}{1.25\times10^{-3} \times 105\times10^9} + \frac{40\times10^3 \times 0.12}{105\times10^9 \times 1.25\times10^{-3}} + \frac{40\times10^3 \times 0.1}{7.07\times10^{-4} \times 105\times10^9}$$

$$\delta = 0.2275\times10^{-3} > 0.12\times10^{-3}$$

لو هنشغل خطوات الحل



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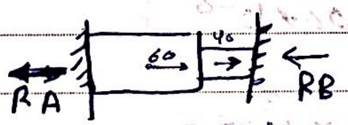
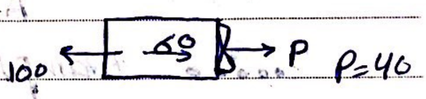
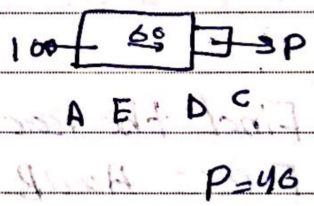






يعني بالك ←

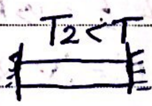
$\delta_{total} = 0.12\times10^{-3}$

$= \delta_L + \delta_T$

$\alpha \Delta T L$

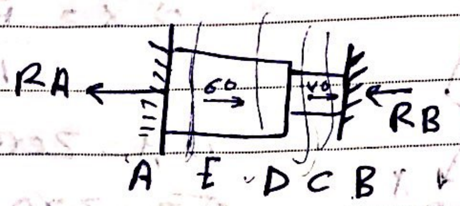
$18.8\times10^{-6}\,(50-20)\times0.5$

$= 2.82\times10^{-4}\,m$



(في رياكشن والمقة للعد T)

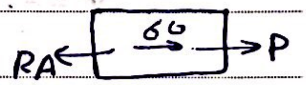
No.



$$\delta L = \frac{RA \times 10^{3} \times 0.18}{1.25 \times 10^{-3} \times 105 \times 10^{9}} + \frac{(RA-60) \times 10^{3} \times 0.12}{1.25 \times 10^{-3} \times 105 \times 10^{9}} + \frac{(RA-60) \times 10^{3} \times 0.1}{7.07 \times 10^{-4} \times 105 \times 9} + \frac{(RA-100) \times 10^{3} \times 0.1}{7.07 \times 10^{-4} \times 105 \times 10^{9}}$$

$RA = -32.48 \text{ kN}$

السالب عكس الفرض يعني

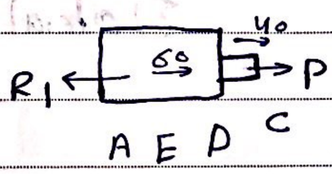


$P = (RA - 60)$

$\Sigma Fx = 0$

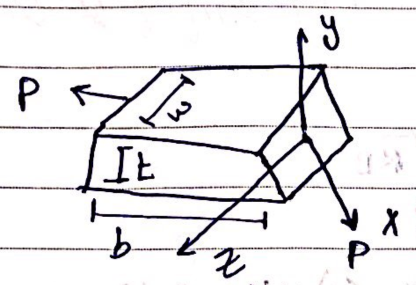
$-RA + 60 + 40 - RB = 0$

$\boxed{RB = 103.48 \text{ kN}}$



No.

Poissons ratio (ν)



axial stress

$$\sigma_x = \frac{P}{A} = \frac{P}{t\,w}$$

$\sigma_y = zero$

$\sigma_z = zero$

*Load $\longrightarrow$ شغال x:

Hook's Law:-

$\sigma_x = E\,\epsilon_x$ $\qquad \epsilon_x = \dfrac{\sigma_x}{E}$ axial loading

$$\nu = -\frac{\text{Lateral strain}}{\text{axial strain}} = \frac{-\epsilon_y}{\epsilon_x} = \frac{-\epsilon_z}{\epsilon_x}$$

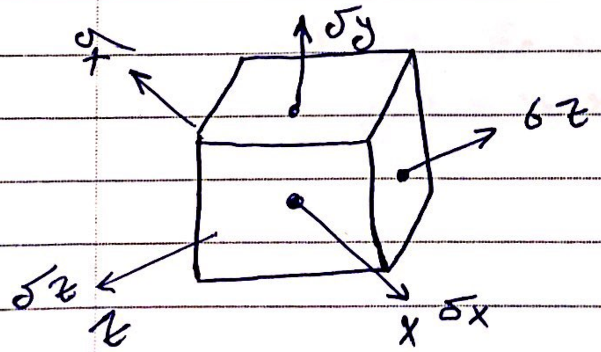
$$\epsilon_{Lateral} = \frac{-\nu\,\sigma_x}{E}$$

لما زاد ال lateral يقل ال axial

امتداد الطول للجسم ← axial

الاتجاه إلى مش axial ← lateral

* Multi axial loding (Generated and Hook's law):-



smile

No.

إذا لم يكن هناك قوة على x هذا يعني $\varepsilon_x = 0$

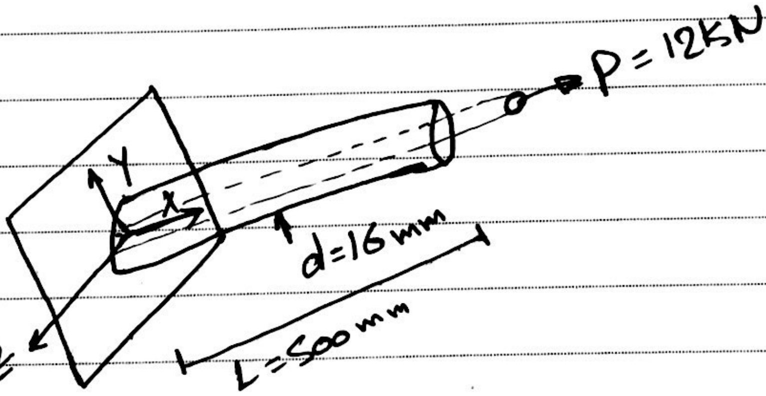
* ولا يعني انه في (y ولا $z = 0$)

$$\varepsilon_x = \frac{\sigma_x}{E} - \frac{\nu\sigma_y}{E} - \frac{\nu\sigma_z}{E}$$

Possions ratio < 1

$$\varepsilon_y = -\frac{\nu\sigma_x}{E} + \frac{\sigma_y}{E} - \frac{\nu\sigma_z}{E}$$

$$\varepsilon_z = -\frac{\nu\sigma_x}{E} - \frac{\nu\sigma_y}{E} + \frac{\sigma_z}{E}$$



$\delta_z = \delta_y = -2.4\,\mu m$

$\delta_x = 300\,\mu m$

$$* \ \nu = \frac{-\varepsilon_y}{\varepsilon_x}$$

$$\varepsilon_y = \frac{\delta_y}{d} = \frac{-2.4\times10^{-6}}{16\times10^{-3}} = 150\times10^{-6}$$

$$\varepsilon_x = \frac{\delta_x}{L_o} = \frac{300\times10^{-6}}{500\times10^{-3}} = 600\times10^{-6}$$

$$\nu = -\frac{-150\times10^{-6}}{600\times10^{-6}} = 0.25 < 1$$

No.

2)

$E = ??$

$\sigma_x = E \epsilon_x$

$\frac{P}{A} = E \, \varepsilon_x \rightarrow \frac{P}{A \varepsilon_x} = E$

$$\frac{12 \times 10^{3}}{\frac{\pi}{4}(16 \times 10^{-3})^{2} \times 600 \times 10^{-6}} = 99.5 \text{ Gpa}$$

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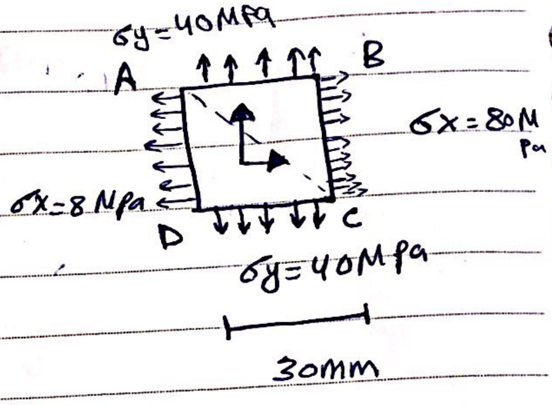
No.

*

example :- steel sequare $E_{steel} = 200\,GPa$
$\nu = 0.3$



Find the change in length
of 1) side AB
2) side Bc
3) Diagamal Ac

تغير

* $\varepsilon_x = \dfrac{\delta}{L_o}$ $\quad \varepsilon_x = \dfrac{\sigma_x}{E} - \nu\dfrac{\sigma_y}{E} - \nu\dfrac{\sigma_z}{E} \rightarrow$ zero

$\varepsilon_y = \dfrac{\delta}{L_o}$ $\quad \varepsilon_x$: side AB

$$\varepsilon_x = \frac{80\times10^6}{200\times10^9} - 0.3 * \frac{40*10^6}{200\times10^9} = 340\times10^{-6}$$

$$\delta_{A/B} = \varepsilon_x L_{AB} = \delta_{AB} = 340\times10^{-6} * 30*10^{-3}$$

$10.2*10^{-3}$ mm

~~$30*10^{-3} + 10.2*10^{-3} = 30$~~

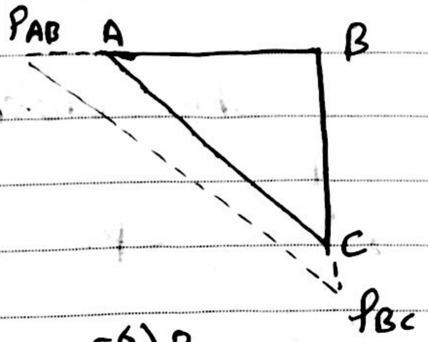
2) side Bc $\delta y \Rightarrow \dfrac{-\nu\sigma_x}{E} + \dfrac{\sigma_y}{E}$

$$\varepsilon_y = -0.3 * \frac{80*10^6}{200*10^9} + \frac{40\times10^6}{200\times10^9} = 80*10^{-6}$$

$\delta_{Bc} = \varepsilon_y * L_{Bc} \rightarrow 80*10^{-6} * 30\times10^{-3} = 2.4\times10^{-6}$

No.

3) Diagonal (AC)



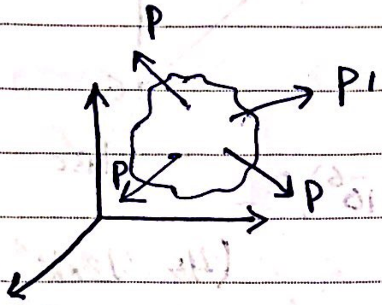
$$(L_{AB}+\delta_{AB})^2+(L_{BC}+\delta_{BC})^2$$
$$=(L_{AC}+\delta_{AC})^2$$

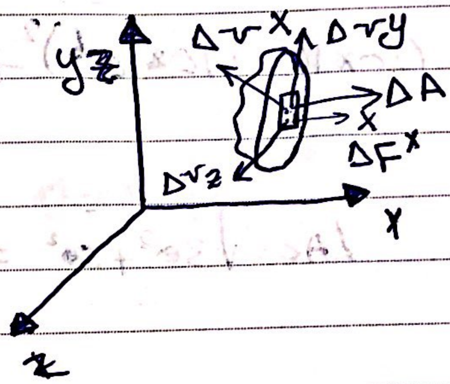
$$(30\times10^{-3}+10\times10^{-6})^2+(30\times10^{-3}+2.4\times10^{-6})^2=$$
$$(42.43\times10^{-3}+\delta_{AC})^2$$
$$\delta_{AC}=8.9\times10^{-3}\ mm$$

$$L_{AC}=\sqrt{30^2+30^2}=42.43\ mm$$

No.

stress under general loading conditions:
(components of stress)

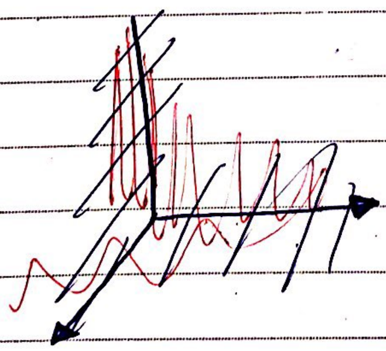




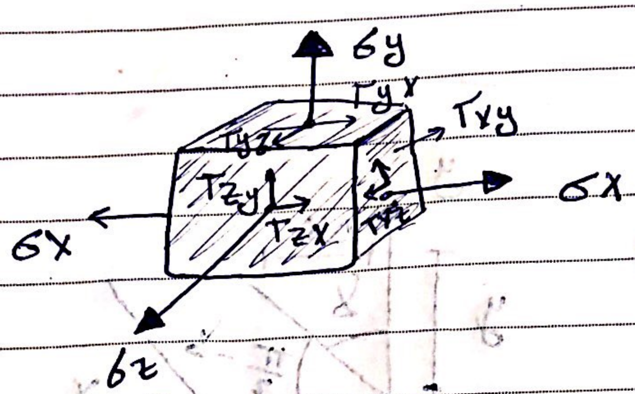
$$\sigma = \lim_{\Delta A \to 0} \frac{\Delta F^x}{\Delta A}$$

$$\tau_{xz} = \lim_{\Delta A \to 0} \frac{\Delta v_z^x}{\Delta A}$$

$$\tau_{xy} = \lim_{\Delta A \to 0} \frac{\Delta v_y^x}{\Delta A}$$



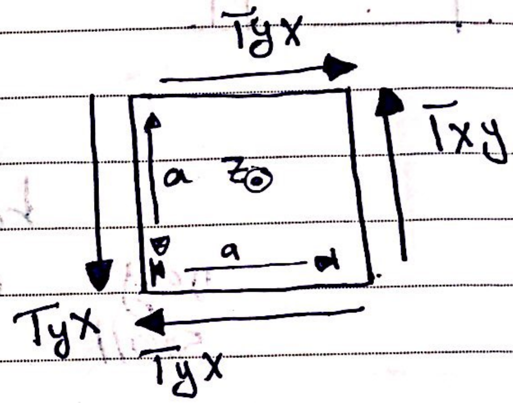
No.



$\Sigma F_x = 0 \qquad \Sigma M_x = 0$

$\Sigma F_y = 0 \qquad \Sigma M_y = 0$

$\Sigma F_z = 0 \qquad \Sigma M_z = 0$



$$\circlearrowleft^{+} M_z = 0$$

$$(\tau_{xy}\,\Delta A)\frac{a}{2} - (\tau_{yx}\,\Delta A)\frac{a}{2}$$

$$+ (\tau_{xy}\,\Delta a)\frac{a}{2} - (\tau_{yx}\,\Delta A)\frac{a}{2} = 0$$

$$(\tau_{xy}\Delta A)a - (\tau_{yx}\Delta A)a = 0$$

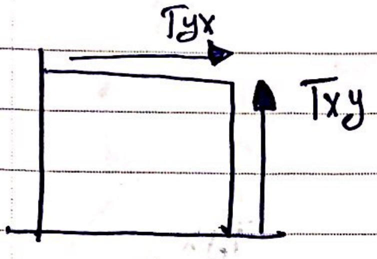
$$\tau_{xy} = \tau_{yx}$$

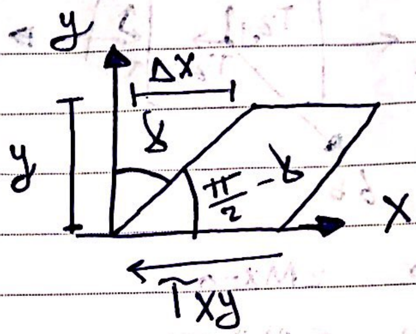
$$\tau_{xz} = \tau_{zx} \quad \#$$

$$\tau_{yz} = \tau_{zy}$$

No.

shear stress:-





$\tan \gamma = \frac{\Delta x}{\Delta y} = \gamma$

very small

$\tau_{xy} = G\, \gamma_{xy}$

↳ modulis of Rigidity (pa)

$\sigma \propto \varepsilon$

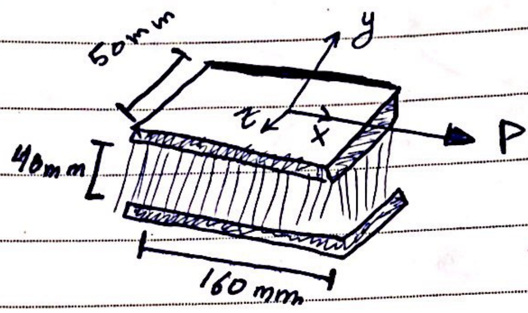
$\sigma = E\, \varepsilon$

* Relationship between G, E, γ

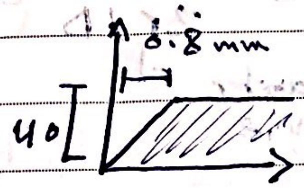
$$G = \frac{E}{2(1+\gamma)}$$

smile

examples:-



The upper plate is moved
0.8 mm $= \Delta X$
$G = 600\,MPa$
: Find the Force P??

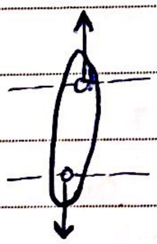


$$\gamma_{xy} = \frac{0.8 * 10^{-3}}{40 * 10^{-3}} = 0.02 \text{ unitless}$$

$$\tau_{xy} = G\,\gamma_{xy}$$

$$\frac{P}{A \rightarrow (160 \times 10^{-3} \times 50 \times 10^{-3})} = 600 * 10^{6} * 0.02 = 96\,kN$$

stress consentration ...:

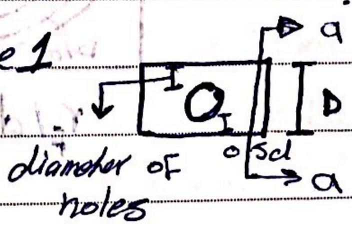


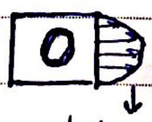
$$\sigma_{avg} = \frac{P}{A}$$

* تقل مساحة زدل stress
يعني عند الثقوب

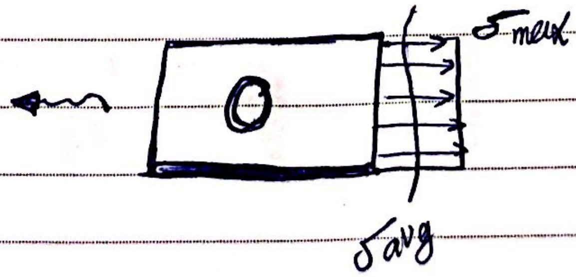
$$K = \frac{\sigma_{max}}{\sigma_{avg}}$$

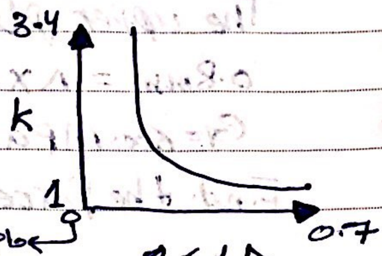
case 1





قوة الترابط
وقلت بين الجزيئات





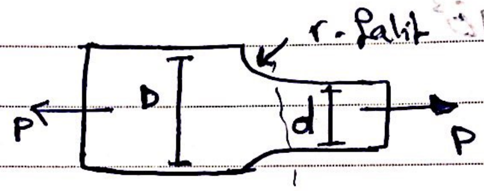
$\sigma_{avg} = \sigma_{max}$ بعيد عن hole معطي

$1 = K$

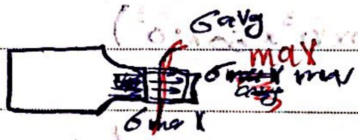
$2r/D$

diameter hole

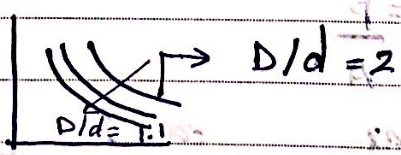
case II



r. f → عشان ما يكون في stress.concetration عالي

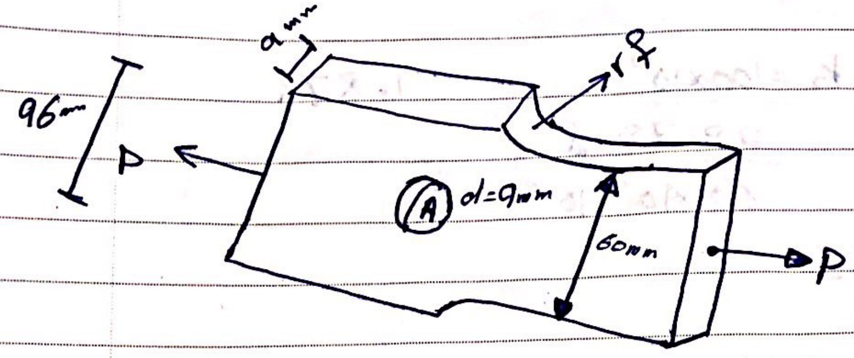


كل ما زاد ال curve بيقل ال stress



r_f/d small

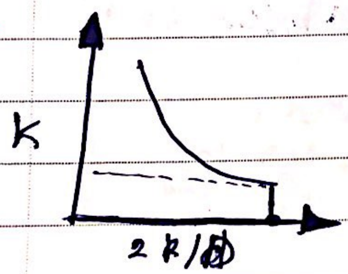
No.



1) the maximum allowable loade (P) if the allowable stress = 100 MPa (max)

2) the radius of Fillet (rf) For wich the same stress occurse at the hole

*



$$K = \frac{\sigma_{max}}{\sigma_{avg}}$$

hole

From Figure 2.6

١) أنا بجيب $\frac{2R}{D}$ وبرجع
ع الرسمة بجيب ال K
من خلال ....

(1)

$$\frac{2R}{D} = 9/96 = 0.09375 = 1$$

$$K = 2.7$$

$$2.7 = \frac{100 \times 10^6}{\sigma_{avg}} = 37.04\,\text{Mpa}$$

(2)

$$\sigma_{avg} = P/A$$

$$A_{net} = (96-9) \times 9 \times 10^{-6}$$

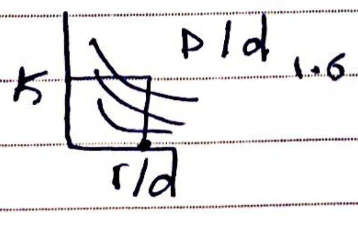
$$783 \times 10^{-6}\ m^2$$

$$P = 37.04 \times 10^6 \times 783 \times 10^{-6} = 28.78\,\text{KN}$$

* 2) $\sigma_{avg} = P/A$

$\sigma_{max} = 100 \times 10^6$

$K \rightarrow \frac{\sigma_{max}}{\sigma_{avg}}$



No.

$K = \frac{\sigma_{max}}{\sigma_{avg}} \Rightarrow K = \frac{100 \times 10^6}{\frac{28.78 \times 10^3}{60 \times 10^9 \times 10^{-6}}} = 1.876$

$\frac{D}{d} = \frac{96}{60} = 1.6$

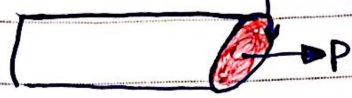
From Fig: $r_f / d = 0.19$

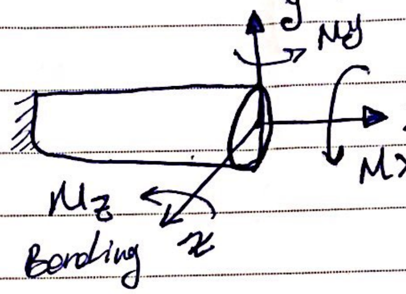
$0.19 \times 60 = r_f$

$r_f = 11.4$ mm

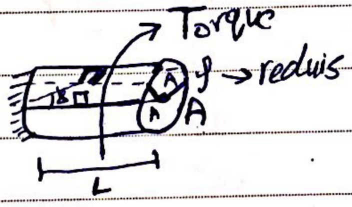
No.

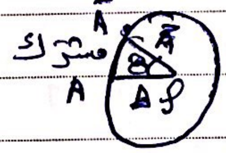
chapter (3) Torsion





Moment zy → Bending





ϕ = angle of twist (rad)

arc ← $AA' = \rho\phi$

$AA' = \gamma L$

$\rho\phi = \gamma L$

$$\boxed{\gamma = \frac{\rho\phi}{L}}$$

element → عنصر

defformation تشوه

γ = shear strain (unit less)

elastic * مادة [illegible] بترجع

موجود بحيث فيه shear strain

shear stress

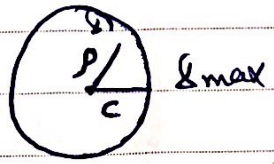
shear force

*

No.

shear strain γ avaries linearly wich distance from the axis of shaft :-

$$\frac{\gamma_{max}}{c} = \frac{\gamma}{\rho}$$



$$\frac{\rho \gamma_{max}}{c} = \gamma$$

* from Hocks law →

$$\tau = G \gamma$$ العلاقة خطية

max → عالسطح

zero → بالمركز

$$\tau = \tau_{max} \frac{\rho}{c}$$

$$T = \int \rho (\tau dA)$$

$\tau \to \frac{\rho}{c} \tau_{max}$

$$T = \frac{\tau_{max}}{c} \int \rho^2 dA$$ PoLar moment of Inertia

عزم القصور (مقاومة الجسم للحركة)

$$T = \frac{\tau_{max}}{c} J \rightsquigarrow \tau_{max} = \frac{Tc}{J}$$

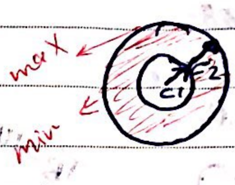
smile

No.

case 1 solid shaft

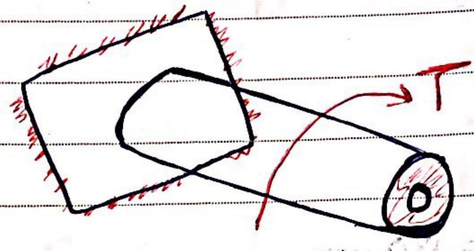
$J = \frac{\pi}{2} c^4$

case 2 Hollow shaft



$J = \frac{\pi}{2}(c_o^4 - c_1^4)$

example:-



$D_o = 60\,mm$

$D_i = 40\,mm$

$\tau_{max}(all) = 120\,MPa$

$\tau_{max} = \frac{T c_{out}}{J}$

$J = \frac{\pi}{2}(30^4 - 20^4)$ $\times 10^{-3}$ $\times 10^{-3}$

$120 \times 10^6 = \frac{T * 30 \times 10^{-3}}{\frac{\pi}{2}(30^4 - 20^4)}$

$T = 4.08 * 10^{-3}$

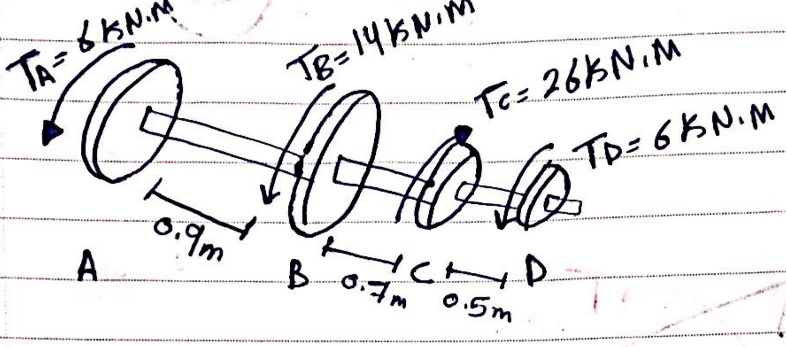
2) $\tau_{min} = \frac{T \rho \rightarrow c_i}{J}$

$\tau_{min} = \frac{4.08 \times 10^{-3} * 20 \times 10^{-3}}{1.02 \times 10^{-6}} = 80\,MPa$

$\tau_{min} = \frac{c_1}{c_o} \tau_{max}$

No.

* examples:



shaft Bc is hollow with $D_I = 90$ mm
$D_o = 120$ mm

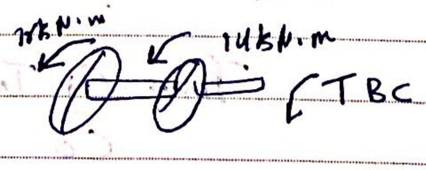
shaft AB & CD are solid with diamder (D)

① Find the maximum and minumem shearing stress is shaft Bc:-

② the requried diameter (D) of shaft AB & CD If allowble shearing stress is 65 MPa

solution :- center $\tau = 0$
$\tau = max$ ع E

$$\tau = \frac{T c}{J}$$



$$\tau max = \frac{20 \times 10^3 (c_{out})}{13.92 \times 10^{-6}}$$

$= 86.2$ MPa

$\Sigma M_x = 0$

$6 + 14 + T_{BC} = 0$

$T_{BC} = -20$

$c_{out} = 60 \times 10^{-3}$

$J = \frac{\pi}{2}(c_o^4 - c_i^4)$

$\frac{\pi}{2}(60^4 - 45^4) \times 10^{-12} = 13.96 . M^4 \times 10^{-6}$

No.

$\tau_{min} = \frac{c_i}{c_o} \tau_{max} = \frac{45}{60} * 86.2*10^6 = 64.7\ MPa$

$\tau_{min} = \frac{T_{BC} c_i}{J} \rightarrow 45\times10^{-3}$

* 2)

$\tau_{max} = \frac{T_{AB} c_o}{J}$

$65*10^6 = \frac{6\times10^3 * \cancel{c_o}}{\frac{\pi}{2}(c_o)^{\cancel{4}}} \rightarrow c_o^3$

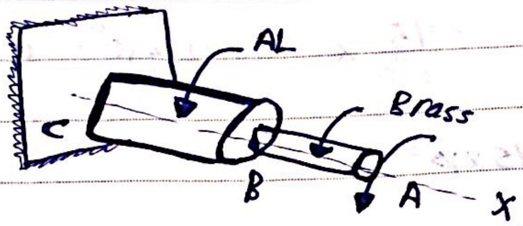
$c_o = 38.87\ mm$

reduis → diameter*

$c_o*2 = 2*38.87mm = 77.8\ mm$

*3) نفس القطر رح يطلع $= 77.8mm$

No.



$\tau_{all_{brass}} = 50 Mpa$

$\tau_{all_{AL}} = 25 Mpa$

$T = 1250 \, N.m$

Find the deameter 1) ~~rod~~ rod AB (solid)
2) rod BC

shaft AB :-

$$\tau_{Brass} = \frac{Tc}{J} = \frac{1250 * \cancel{C_o}}{J = \frac{\pi}{2} \cancel{C_o^4} \; C_3} = 50 \times 10^6 = C_o = 25.15 mm$$

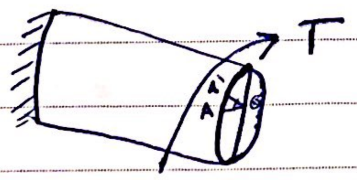
$D = 50.3 mm$

2) BC :- $\tau = \frac{Tc}{J} = \frac{1250 * \cancel{C_o}}{\frac{\pi}{2} \cancel{C_o^4} \; C_o^3} = 25 \times 10^6$

$C_o BC = 31.7 mm$

$D BC = 63.4 mm$

* Angle of twist inelastic regoin



$\tau = G \gamma$

$\gamma_{max} = \frac{C \phi}{L}$

$\gamma = \rho \phi$

$\delta = \frac{PL}{AE}$

$\tau_{max} = \frac{Tc}{J}$

smile

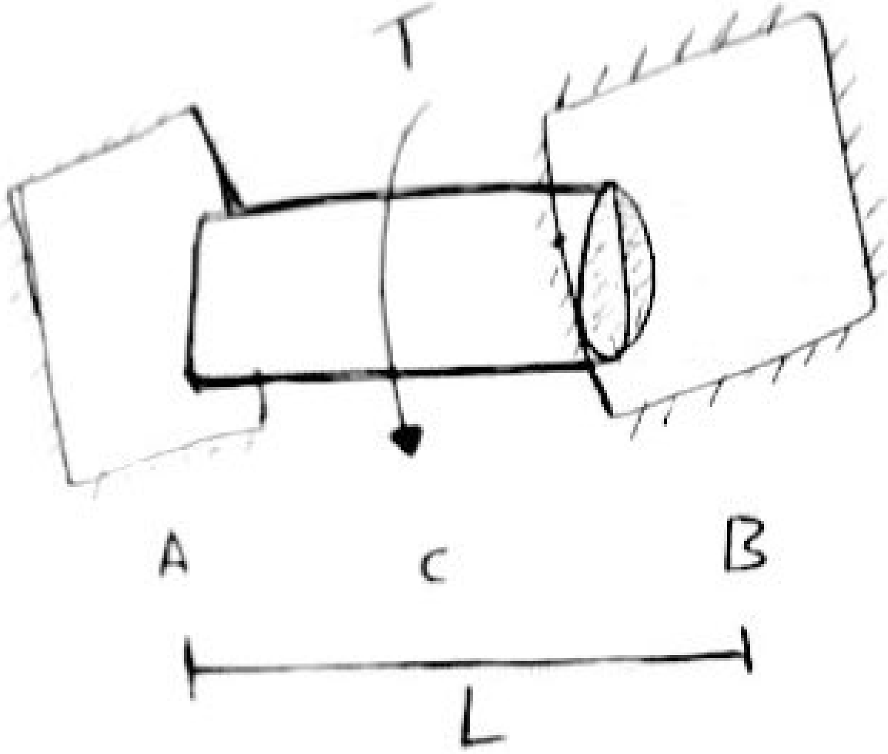
No.

$$\tau_{max} = G\gamma_{max}$$

$$\frac{T}{J} = \frac{G\phi}{L}$$

$$T = \frac{G\phi J}{L}$$

statically indeterminate shafts...



$\Sigma M_x = 0$

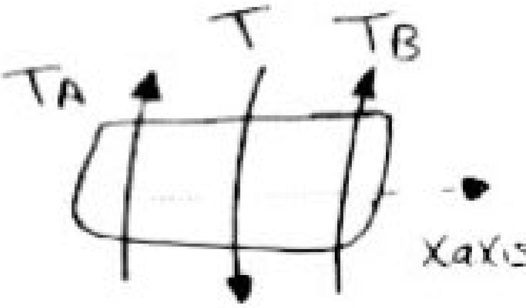
$T - T_A - T_B = 0$

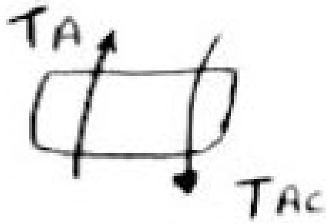
$\phi_{AB} = \phi_{AC} + \phi_{C/B}$

$= \dfrac{T_{AC} L_{AC}}{J G} - \dfrac{T_B L_{BC}}{J G}$

$T_A = \left(\dfrac{L_{BC}}{L}\right) T$

$T_B = \left(\dfrac{L_{AC}}{L}\right) T$



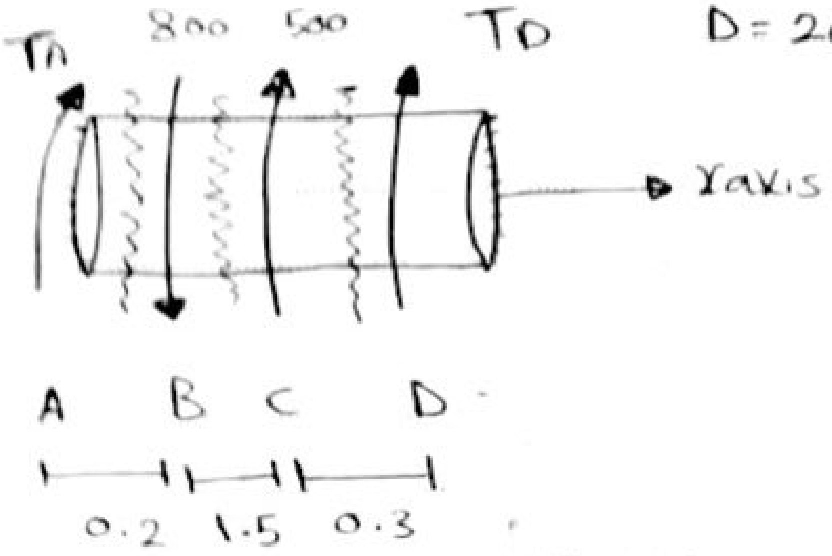


$T_A = T_{AC}$

$T_{BC} = T_B$

Find TA and TD ??

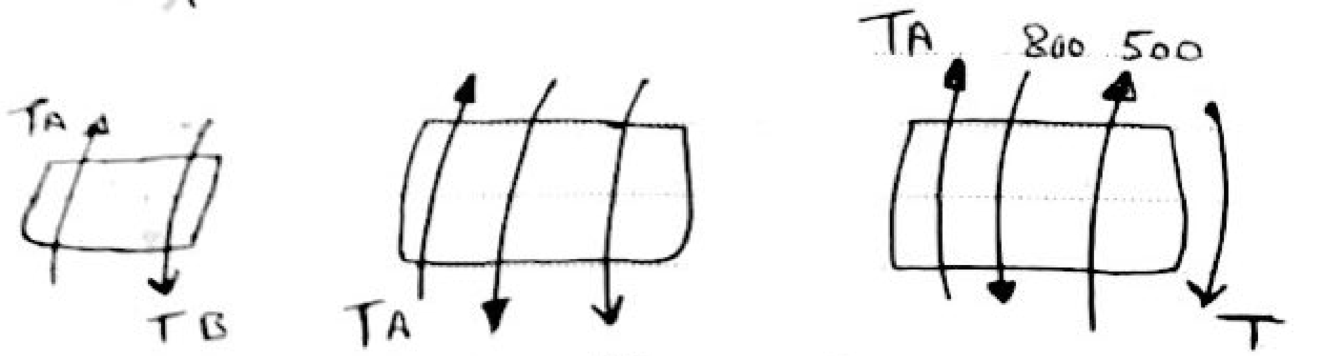
D = 20mm



$$\Sigma M_x = -T_A + 800 + 500 - T_D = 0$$

$$\phi_{A/D} = \phi_{AB} + \phi_{BC} + \phi_{CD}$$

$$0 = \frac{1}{JG}\left(T_A(0.2) + (T_A - 800)(1.5) + (T_A - 300)(0.3) \right)$$



800 T_{BC}

$-T_A + 800 - 500 + T_{CD}$

$T_A = T_B$

$0 = -T_A + 800 + T_{BC}$

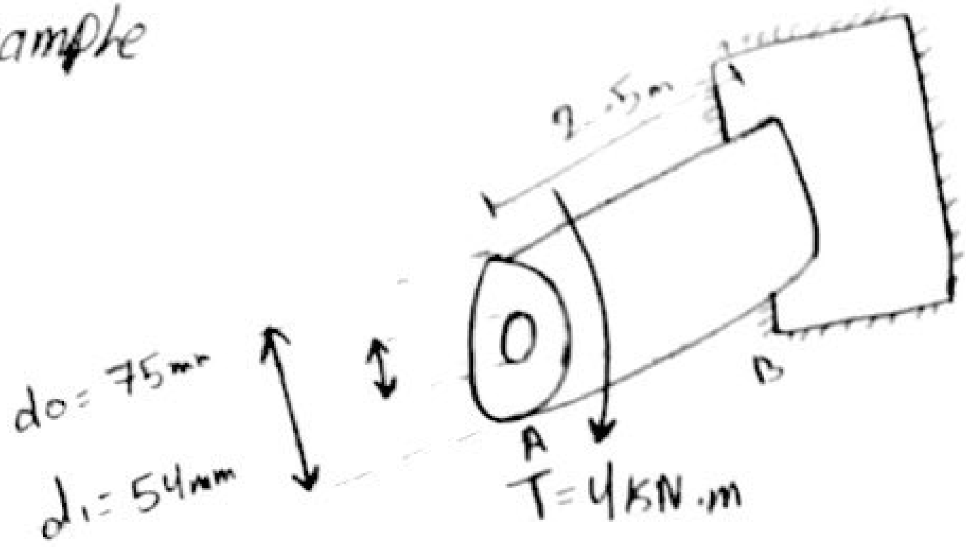
$T_{BC} = T_A - 800$

$T_{CD} = T_A - 800$

$T_A = 645$ N.m

$T_D = -345$ N.m

example



$G_{steel} = 77\ GPa$

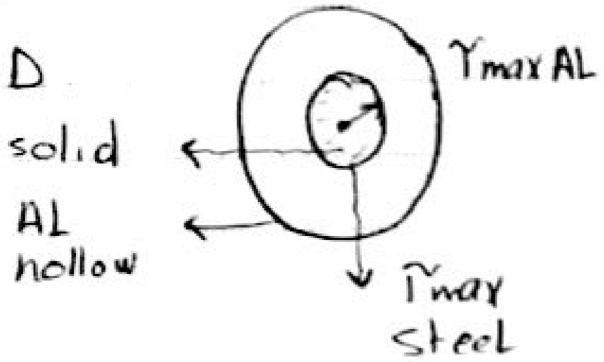
$G_{AL} = 27\ GPa$

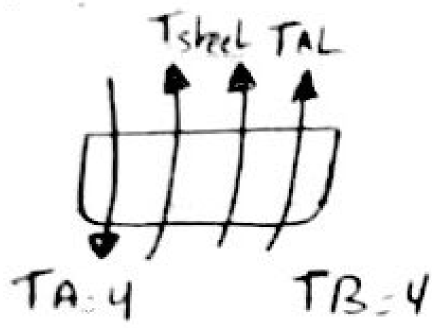
Determine 1) max shear stress in the steel core?

2) max shear stress in (A) Jacket

3) Angle of twist end A?

1- F.B.D





$\Sigma M = T_{steel} + T_{AL} = 4k$

compatibility condition:-

$$\phi_{steel} = \phi_{AL}$$

$$\frac{T_{st} * L}{J_{st} G_{st}} = \frac{T_{AL} L}{J_A G_A} = \frac{T_{steel}}{\frac{\pi}{2}(27\times10^{-3})^4 * 77\times10^9} = \frac{T_{ALL}}{27\times10^9 \times10^{-12} * \frac{\pi}{2}\left((37.5)^4-(27\ldots\right.}$$

$T_{steel} = 2275.86\ N.m$

$T_{AL} = 1724.14\ N.m$

$4 =$ [illegible]

$$\tau_{max\,steel} = \frac{2275.86 * 27 * 10^{-3}}{\frac{\pi}{2}(27)^4 * 10^{-12}}$$

$$= 73.6 \text{ MPa}$$

$$\tau_{max\,All} = \frac{1724.14 * 37.5 * 10^{-3}}{\frac{\pi}{2}(37.5^4 - 27^4) \times 10^{-12}}$$

$$= 34.4 \text{ MPa}$$

2) $\phi A = \phi AL = \phi\, steel = \dfrac{2275.86 * 2.5}{\frac{\pi}{2}(27)^4 \times 10^{-12}}$

$\phi A = 5.07$

$\tau_{min\,steel} = 0$

$$\tau_{min\,AL} = \frac{C_i}{C_o}\,\tau_{max\,AL}$$

$$\tau_{min} = \frac{T_{AL} * 27 \times 10^{-3}}{\frac{\pi}{2}(3754^4 - 27^4) \times 10^{-12}} = 24.47 \text{ Mpa}$$

$\tau_{min\,AL} \neq \tau_{max\,steel}$

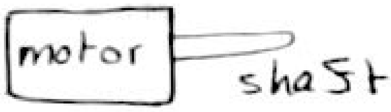
Design of transimission shaft

Power = T . w

(W) watt (N.m/s) ← Power

Torqu N.m ← T

↳ Angular velocity rad/s ← w



Power = T . 2πF

↳ Frequncy Hz s^{-1}

* asolid shaft is used to tranusimite 3750 W at Angular velocity 175 rPm → عدد اللفات بالدقيقة

IF the allowable shear stress 700 Mpa , Find the diameter of the shafts?

$P = T \cdot w$ ⇝ $175 * \frac{rev}{m} * \frac{2\pi}{rev(2\pi)} * \frac{60s}{1m \sim 60s}$

$3750 = T * 18.3$

$\frac{175 * 2\pi}{60} = 18.3 \frac{rad}{s}$

$T = 204.6 \, N.m$

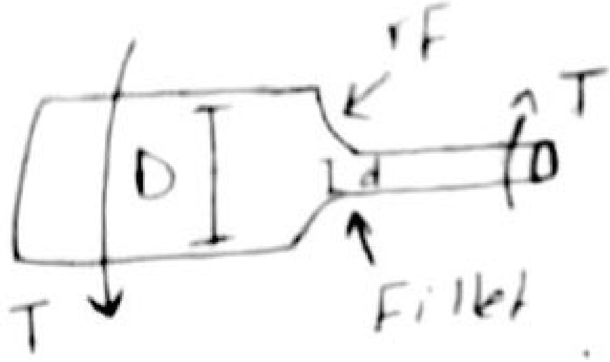
* $\tau_{max} = \frac{Tc}{J} = 700 \times 10^6 = \frac{204.6 * c}{\frac{\pi}{2} c^4}$

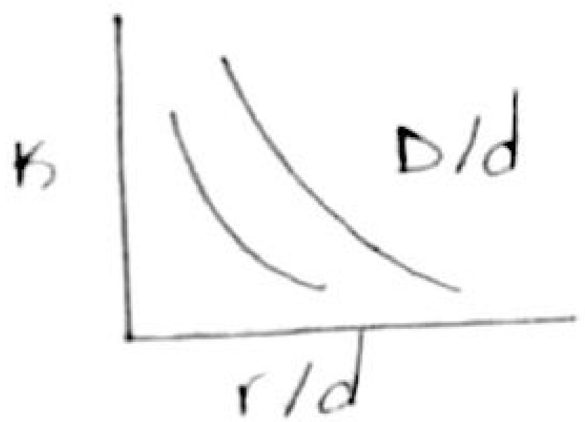
$c = 10.92 m$

$d = 22$

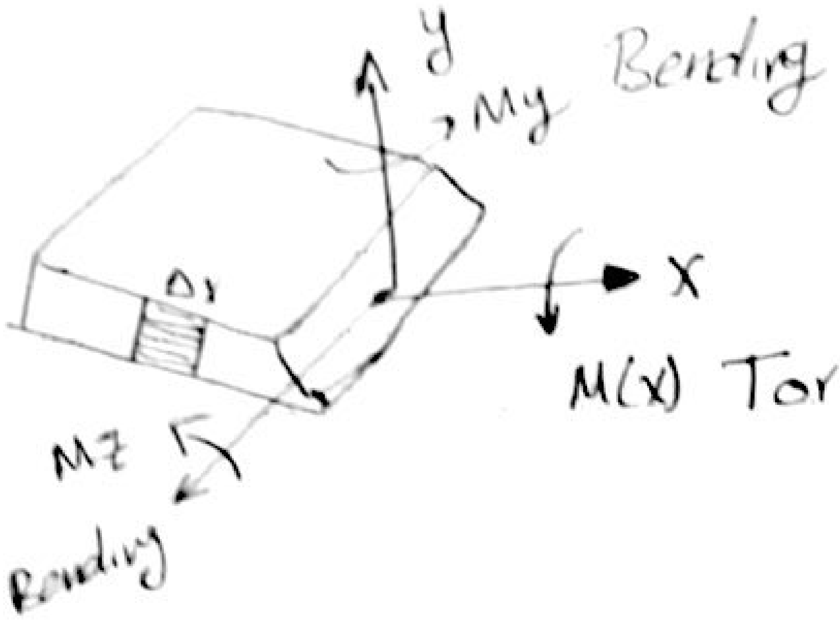
stress concentration in circular shaft

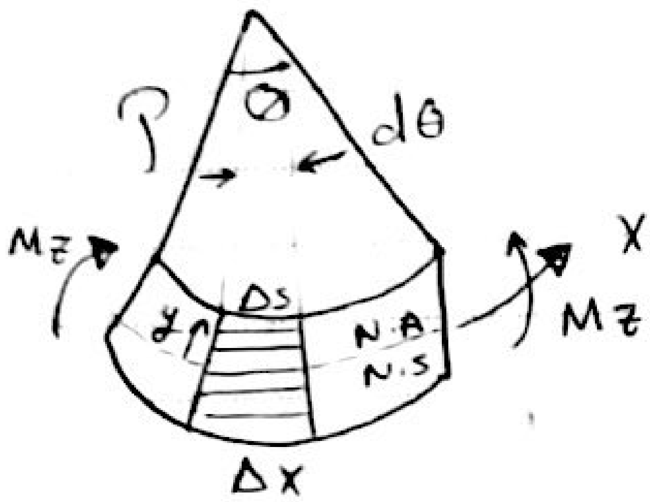
$$K_s = \frac{\tau_{max}}{\tau_{avg}}$$





chapter (4) Pure Bending





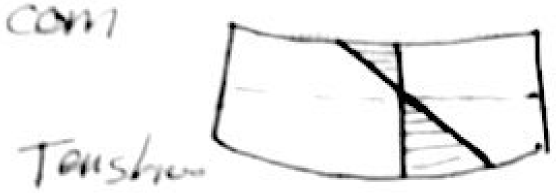
$$\varepsilon_A = \frac{\delta}{L} = \frac{\Delta s - \Delta x}{\Delta x}$$

$$(\rho - y)\,\Delta\theta = \Delta s$$

$$\rho\,\Delta\theta = \Delta x$$

$$\varepsilon_A = \frac{-y}{\rho}$$

N.A → ثابت طوله
nutral axis
ρ → ثابتة
Δx → الطول الأصلي



Linear (y, ε)

$$\varepsilon_x = -\frac{y}{c}\,\varepsilon_{max}$$

$$\sigma_x = -\frac{y}{c}\,\sigma_{max}$$

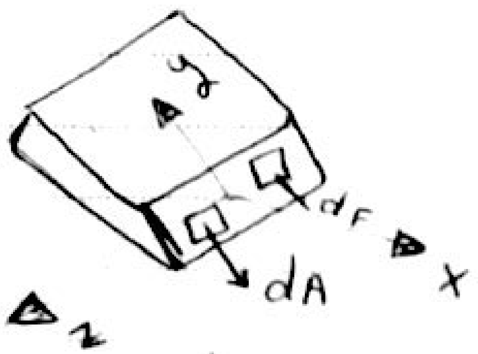
Inelastic regoin apply Hoocks is law:

Location of N.Axis

$\Sigma F_x = 0$ about center of axis

$$0 = \int_A dF = \int_A \sigma_x\, dA = \int_A -\frac{y}{c}\,\sigma_{max}\, dA$$

$$-\frac{\sigma_{max}}{c}\int_A y\, dA$$



First moment of inertia

(m^3)

the N.A pass throgh the centroid of area...

$$\sigma = \frac{dF}{dA}$$

$$M_z = \int_A dF\, y = \int_A y \times \sigma_x dA = \int_A y \times \frac{-y}{c} \sigma_{max}\, dA$$

$$-\frac{\sigma_{max}}{c} \int_A y^2\, dA$$ → second moment of inertia m^4

* $\sigma_{max} = \frac{-Mc}{I}$

* $\sigma_x = \frac{-My}{I}$ → ضغط

stress
compression

* $\sigma_{max} = -\frac{Mc}{I}$

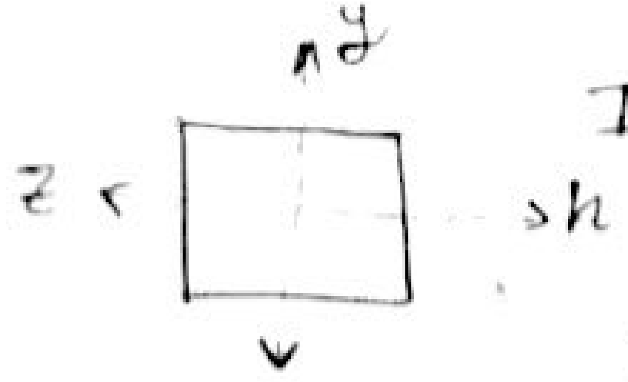
$\frac{I}{c} = S$ = elastic section modul

$\sigma_{max} = \frac{-M}{S}$

* $\left(\frac{1}{\rho} = \frac{\varepsilon_{max}}{c}\right) * E$

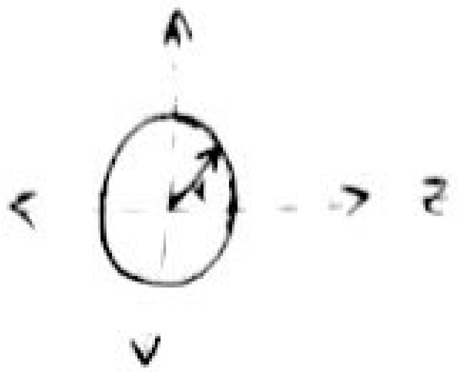
$$\frac{E}{\rho} = \frac{\sigma_{max} E}{c} =$$

$$\frac{E}{\rho} = \frac{\sigma_{max}}{c} = \frac{M\cancel{y}}{I\cancel{y}} \rightarrow \frac{1}{\rho} = \frac{M}{IE}$$

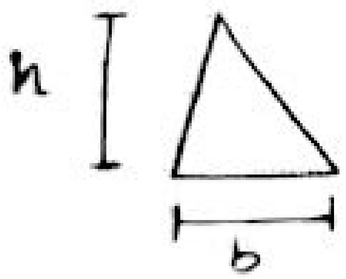


$$I_z = \frac{bh^3}{12}$$

$$I_y = \frac{hb^3}{12}$$



$$I_z = I_y = \frac{\pi}{4} r^4$$

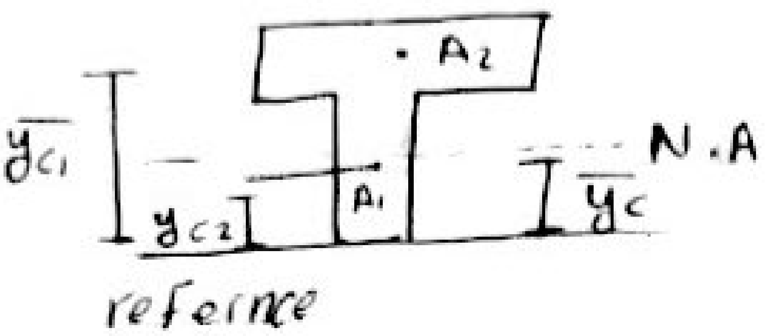


$$I_z = \frac{1}{36} bh^3$$

$$I_z = \frac{\pi}{8} r^4$$

centroid section :-

$$y_c = \frac{\sum_1^n A_i \bar{y}_{ci}}{\sum_1^n A_i} \qquad \bar{y}_c = \frac{A_1 \bar{y}_{c1} + A_2 \bar{y}_{c2}}{A + A_2}$$

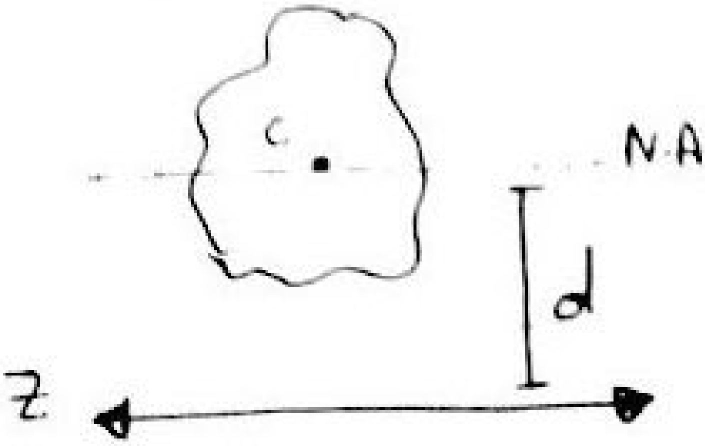


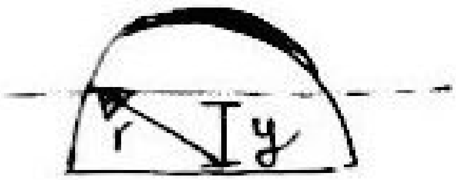
Parllel axis thermo

اذا N.A ما بمر بالC

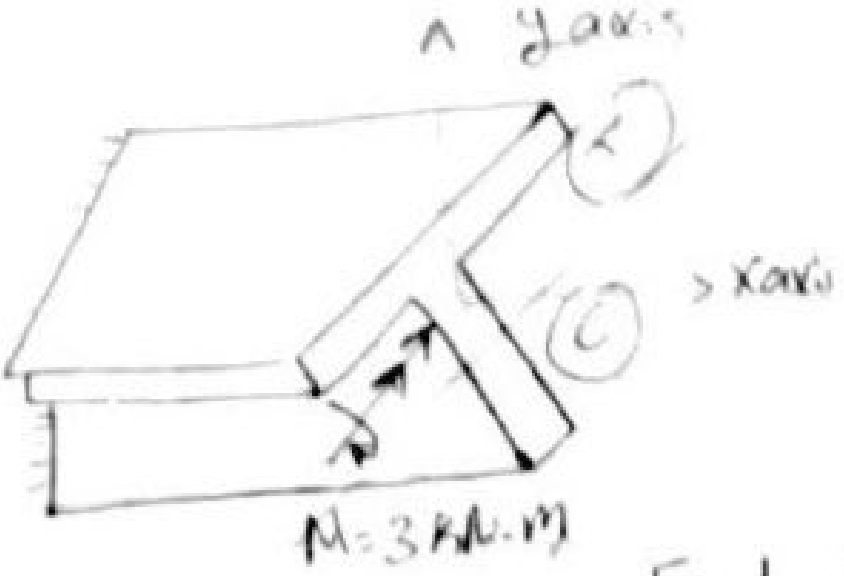
$$I_z = I_{N.A} + Ad^2$$

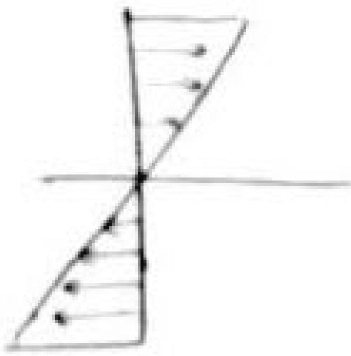
$$I_z = \frac{1}{12} bh^3 + (hb) d^2$$



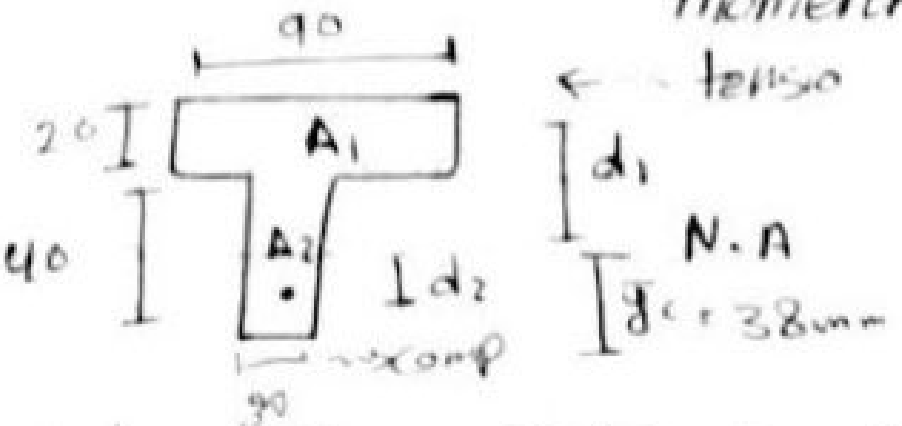


$$\bar{y}_c = \frac{4}{3} \quad \frac{\pi}{4}$$





Find the max tension stress due to bending moment??



1) centroid $\bar{y}_c = \dfrac{\sum A_i y_{ci}}{\sum A_i} = \dfrac{(20\times 90)50 + (30\times 40)\times 20}{(90\times 20) + (30\times 40)}$

$= 38$ mm

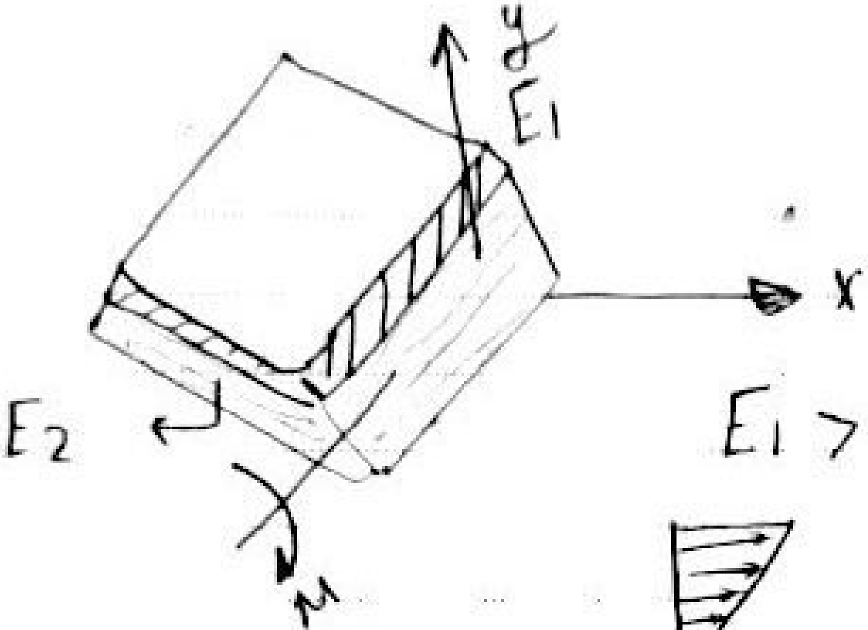
2) $I_{N.A} = \frac{1}{12}(90)(20)^3 + (90\times 20)(12)^2 + \frac{1}{12}(30)(40)^3 + 30\times 40 \times 18^2$

$= 868\times 10^{9}\ m^4$

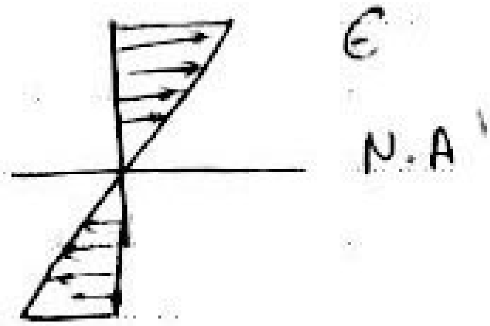
3) $\sigma_{max\ tension} = \dfrac{-Mc}{I} = \dfrac{-3\times 10^{2} \times 22\times 10^{-3}}{868\times 10^{-3}} = 76\,Mp$

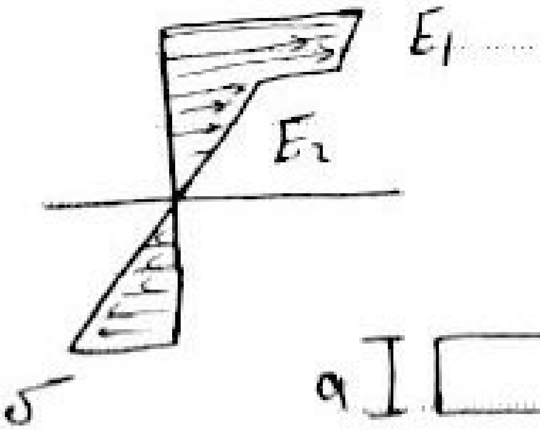
4) $\sigma_{max\ comp} = \left(\dfrac{30\times 10^{3} \times -38\times 10^{-3}}{868\times 10^{-3}}\right) = -131.3\,Mp$

Bending of members made of several matrials...



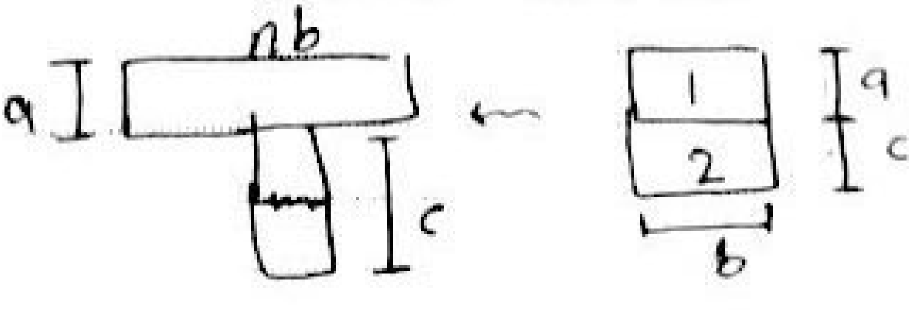
$E_1 > E_2$





use transformed section method

Assue $E_1 > E_2$



1) $n = \dfrac{E_1}{E_2}$

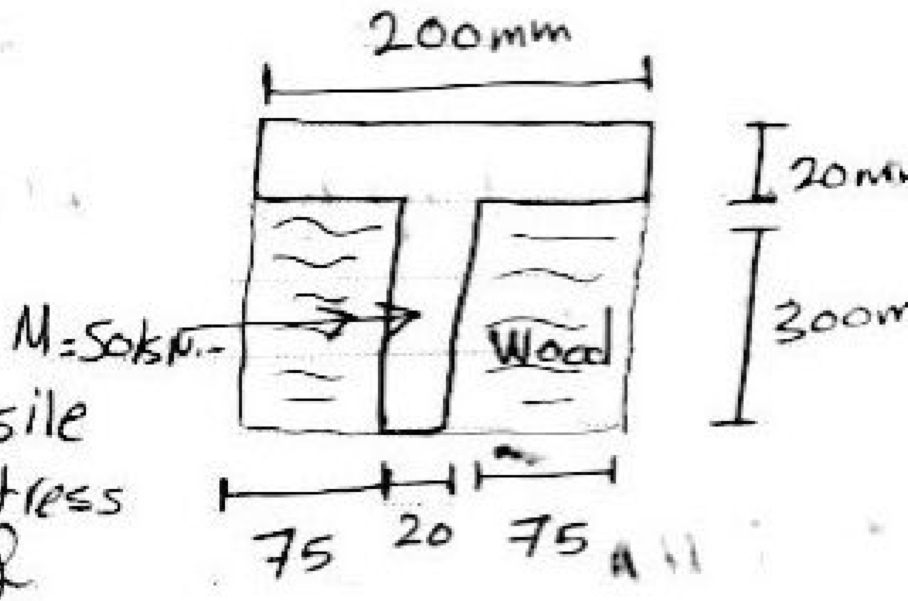
Subject

2) Multiply the width of matirial 1 by (b)
3) All section as made of matirial 2
4) Find the N.A & $I_{N.A}$
5) the stress at any point located on material 1

You should multibly by (b)

$$\sigma = n \cdot - \frac{My}{I}$$

example :-



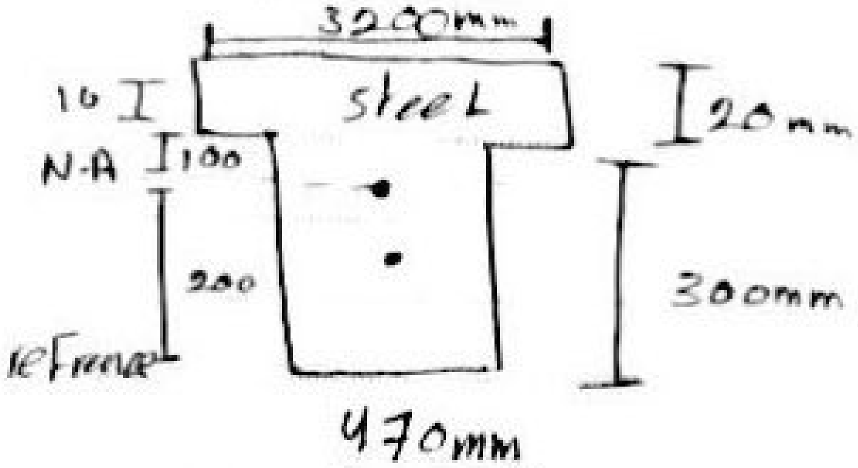
Find the max tensile & compressive stress in a both steel & wood ?

$E_{steel} = 200 GPa$
$E_{wood} = 12.5 GPa$

Scanned with CamScanner

* $n = \frac{E_{steel}}{E_{wood}} = \frac{200}{12.5} = 16$

* transformd one material



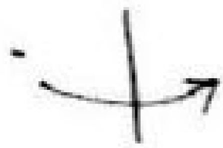
* centroid

1. $\bar{y}_c = \frac{(3200 * 20) * 310 + (470 * 300) * 150}{(3200 \times 20) + (470 \times 300)} = 200mm$

2. $I_{N.A} = I_{N.A_1} + A_1 d_1^2 + I_{NA_2} + A_2 d_2^2$

$\frac{1}{12} * (3200)(20)^3 + (3200 \times 20) \times 110^2 + \frac{1}{12}(300)^3 470 + 300 \times 470 \times 50^2$

$I_{N.A} = 2.19 \times 10^{-3} m^4$



wood → tension

$\sigma_{max} = \frac{(-50 \times 10^3) * 100 \times 10^{-3}}{2.19 \times 10^{-3}}$

$= 2.29$ Mpa

Radio → ...

σ_{max} compision $= \frac{-(-50 \times 10^3) * -200 \times 10^{-3}}{2.19 \times 10^{-3}} * 16 = -4.57$

steeL

steel

tension

$$\sigma_{max\ tension} = 16 * \frac{(-50 \times 10^{3}) * 120 \times 10^{-3}}{2.19 \times 10^{-3}} = 43.8\,MPa$$

ل هي اذا 16 هي n

مشان أخذ مع المادة comp

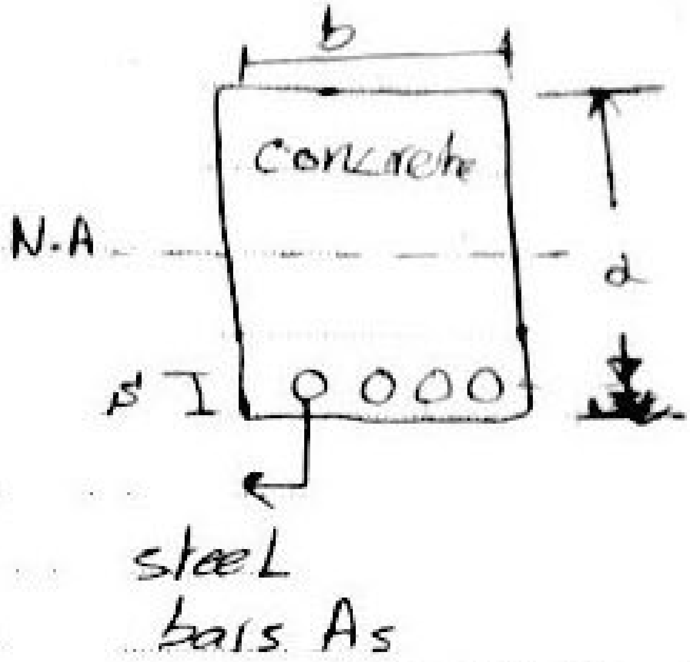
compression

$$\sigma_{max\ comp} = 16 * \frac{(-(-50 \times 10^{3}) * (200 \times 10^{-3}))}{2.19 \times 10^{-3}}$$

$$= -73.1\,MPa$$

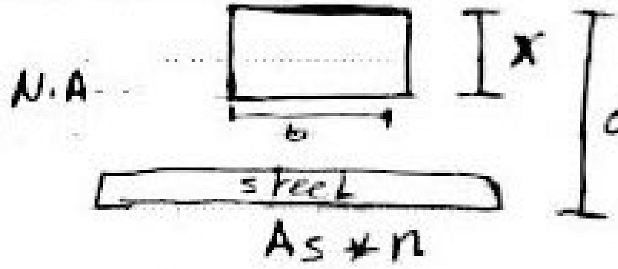
Reinforced concrete beams

Proceduers :-



1) $n = \dfrac{E_{steel}}{E_{concrete}}$

2) $0 = \int_A y \, dA$



ocation N.A

$(bx * x) - nA_s(d - x) = 0$

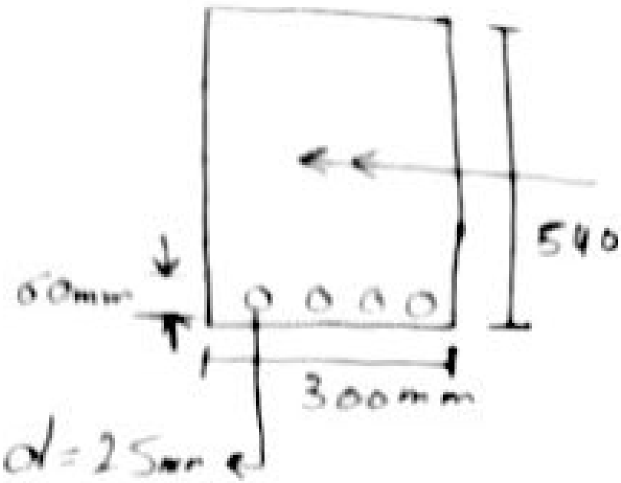
$\dfrac{bx^2}{2} + nA_s X - nA_s d = 0$

$0 < X < d$

3) $\sigma_{conc} = \dfrac{-Mc}{I}$

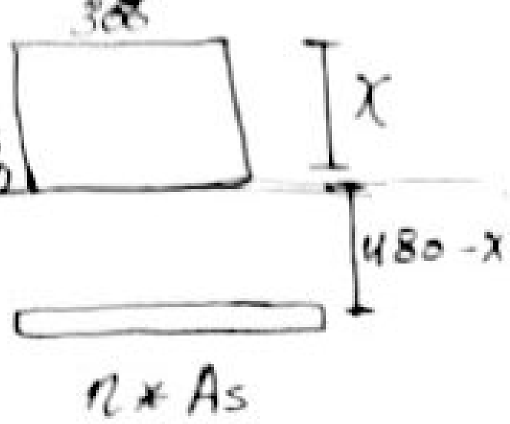
4) $\sigma_{steel} = n\left(\dfrac{-Mc}{I}\right)$

$E_{steel} = 200\,GPa$
$E_{conc} = 25\,GPa$
Find the max stress on steel & concrete??



$n = \frac{E_{steel}}{E_{con}} = \frac{200}{25} = 8$

$A_s = 4 \times \frac{\pi}{4} (25\times10^{-3})^2 = 1.9635 \times 10^{-3}\, m^2$



$\frac{300\times10^{-3}}{2} \times X^2 + 8\times1.96\times10^{-3}\, X$
$= 8\times1.9685\times10^{-3} \times 480\times10^{-3}$
$X = 178\, mm$
$X = 0.178$

$480 - 178 = 302$

$I_{N.A} = \frac{1}{12} \times 300 \times 178^3 + 300\times 178 \times (\frac{178}{2}\times10^{-3})^2$

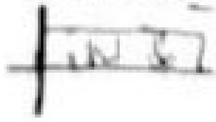
$I_{NA} = \frac{1}{12} \times \quad 8\times1.96\times10^{-3} \times (302\times10^{-3})^2$
$= 4.6 \times 10^{-3}\, m^4$

$I_{N.A} = \frac{1}{3} b X^3 + n A_s (d - x)^2$

$\sigma_{steel} = -8 \times \frac{175\times10^{-3} \times (302\times10^{-3})}{4.6\times10^{-3}} = 91.9\,MPa$

$$\sigma_{conc} = \frac{-175\times10^{-3} \propto 178\times10^{-3}}{4.6\times10^{-3}}$$

$\sigma_{conc} = 6.97\ MPa$



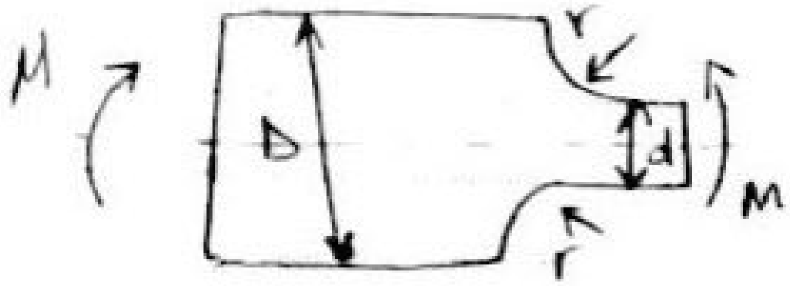
[illegible]

M Diag [illegible]

σ Max [illegible]

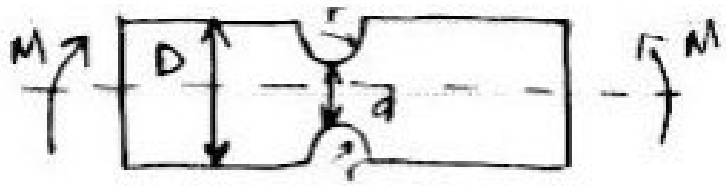
stress concentration due bending

case 1

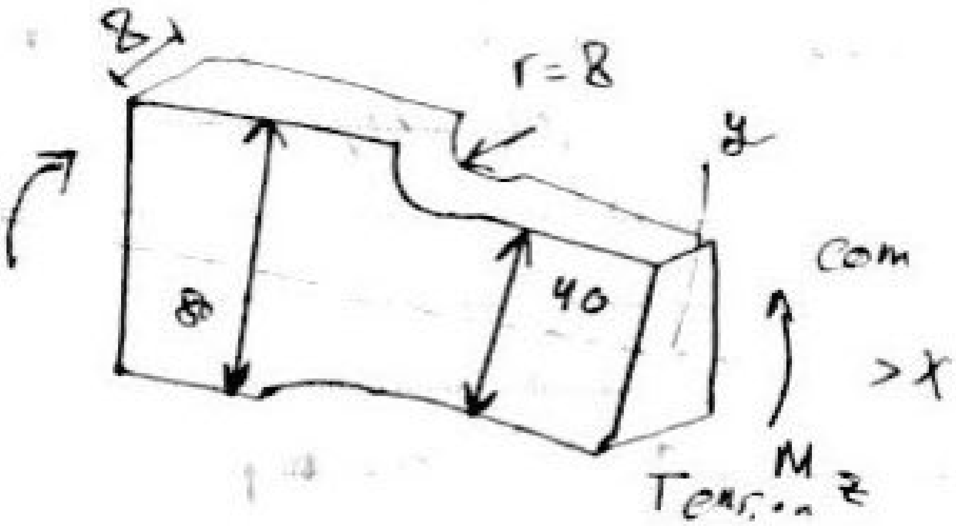


$$k = \frac{\sigma_{max}}{\sigma_{avg}} \qquad \sigma_{max} = k \frac{Mc}{I}$$

case 2



$$\sigma_{max} = \frac{kMc}{I}$$

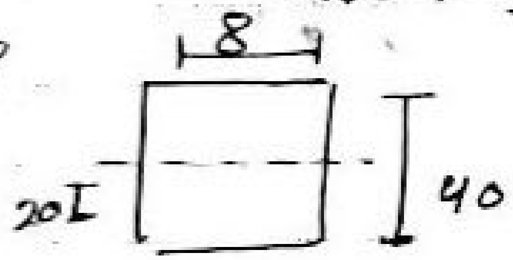


The allowable stress

$\sigma_{all} = 90\,MPa$

Find the moment max?

نوجد I ← نطها



$D/d = \frac{80}{40} = 2$

$r/d = \frac{8}{40} = 0.2$

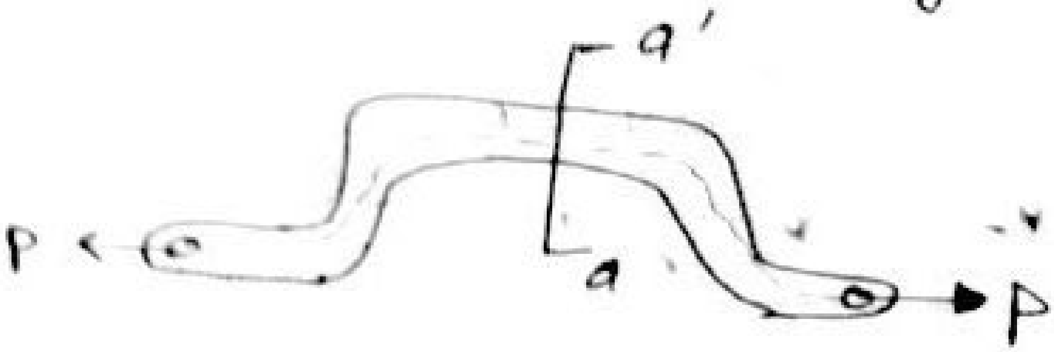
Frome Fig 1 $k = 1.5$

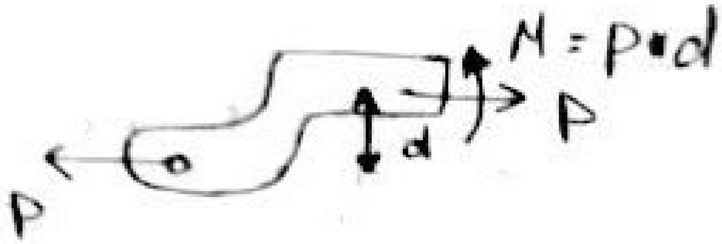
$I_z = \frac{1}{12}(8)(40)^3 = 42.67 \times 10^{-9}\,m^4$

$(8 \to \times 10^{-3}, \; 40 \to \times 10^{-3})$

$M = \frac{\sigma_{max} I}{k c} = \frac{90 \times 10^{6} \times 24.67 \times 10^{-9}}{1.5 \times 20 \times 10^{-3}} = 128\,N.m$

Eccentric axial loading in plane symmetry....





$\circlearrowleft + \; \Sigma F_x = 0$

$\Sigma M = 0 \qquad M - P*d = 0$

$M = Pd$

section $a\,\bar{a}$

$\sigma = \pm \sigma_{axial} \mp \sigma_{bending}$

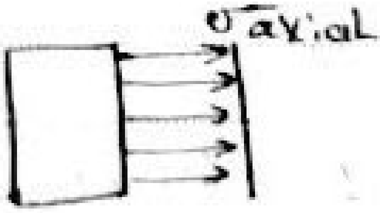
$\pm \dfrac{P}{A} \mp \dfrac{Mc}{I}$

يتغير موضعه

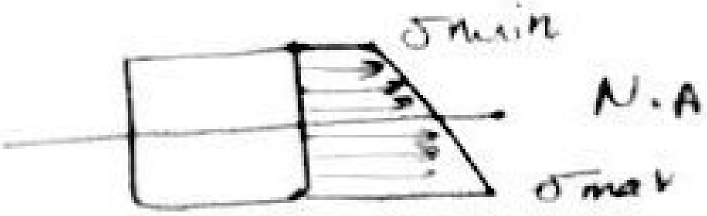
حسب الوضع

$- / +$

axial load



Bending moment

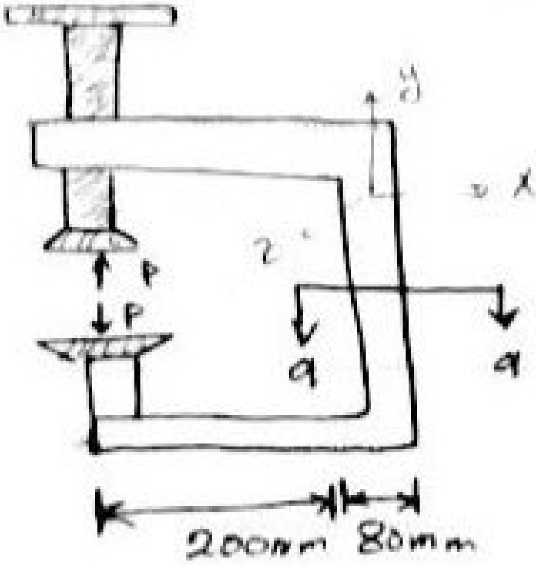


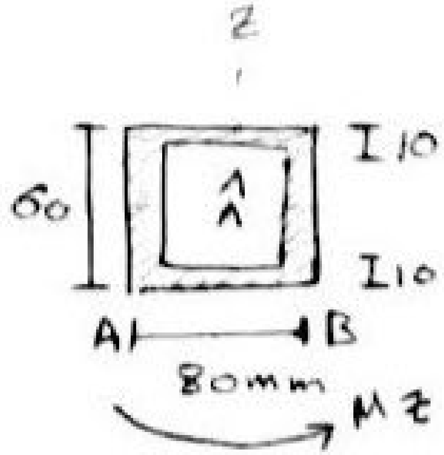
bending parallel axes

Example:-

$P = 20\ kN$

Determine the stress at point A & B

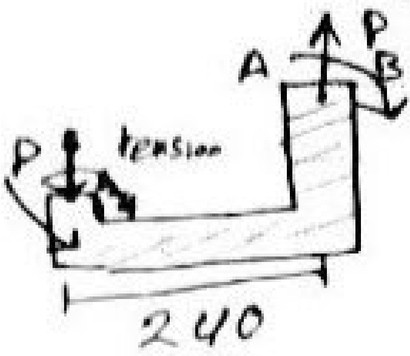




section aa

solve:-

F.B.D:-



$$\sigma_A = \frac{P}{A} + \frac{Mc}{I}$$

$$A = (80*60) - (40*60) = 2.4\times10^{-3}$$

$$A = 2.4 \times 10^{-3}$$

$$M = 20\times10^{3} \times 240\times10^{-3} = 4800\ N.m$$

Moment حول ← z

$$I_z = \frac{1}{12}(60)(80)^3 - \frac{1}{12}(40)(60)^3$$

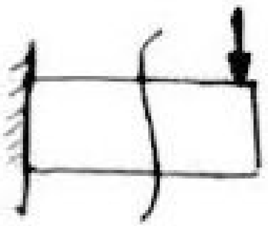
الكبير - الصغير

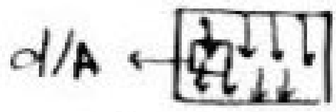
$$\sigma_A = \frac{20\times10^{3}}{2.4\times10^{-3}} + \frac{4.8\times10^{3} * 40\times10^{-3}}{1.84\times10^{-6}} = 112.7\ MPa$$

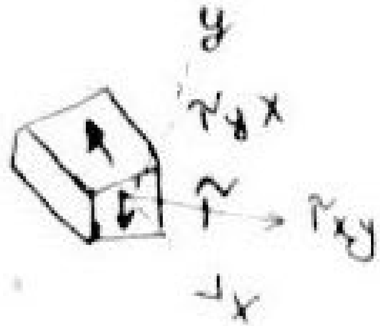
$$\sigma_B = \frac{20\times10^{3}}{2.4\times10^{-3}} - \frac{4.8\times10^{3} * 40\times10^{-3}}{1.84\times10^{-6}} = -96\ MPa$$

Scanned with CamScanner

chapter 6 shearing stresses in beam







$\tau_{Avg} = \frac{V}{A}$

$\tau = \lim \frac{\Delta V}{\Delta A}$

$\tau_{yx} \rightarrow$ Longitudinal shear stress

$\tau_{xy} \rightarrow$ Transeve shear stress

$\tau_{xy} = \tau_{yx}$

At any where of (y)

$* \ \tau = \frac{VQ}{It}$

$V \rightarrow$ shear Force (Internal) N

$I \rightarrow$ second moment Inertia about N. Axis m^4

$Q \rightarrow$ First moment of Inertia above intrest point m^3

$t \rightarrow$ thicknis of intrest point m

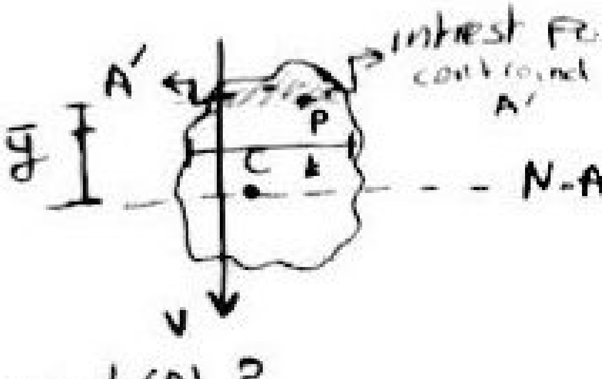
$* \ I = \int_A y^2 \, dA$

$Q = \int_A y \, dA$

$* \ Q = A' \bar{y}'$

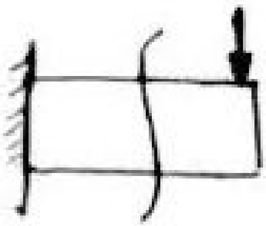
$t \rightarrow$ بالعمودي على

موازي لل N.A



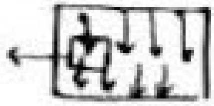
τ at (P) ?

chapter 6 shearing stresses in beam



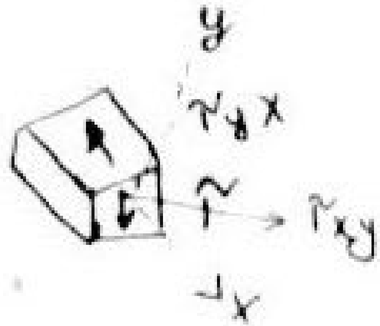
$\tau_{Avg} = \frac{V}{A}$

d/A



section a-a

$\tau = \lim \frac{\Delta V}{\Delta A}$



τ_{yx} → Longitudinal shear stress

τ_{xy} → Transeve shear stress

$\tau_{xy} = \tau_{yx}$

At any where of (y)

$$* \ \tau = \frac{VQ}{It}$$

V → shear Force (Internal) N

I → second moment Inertia about N. Axis m^4

Q → First moment of Inertia above intrest point m^3

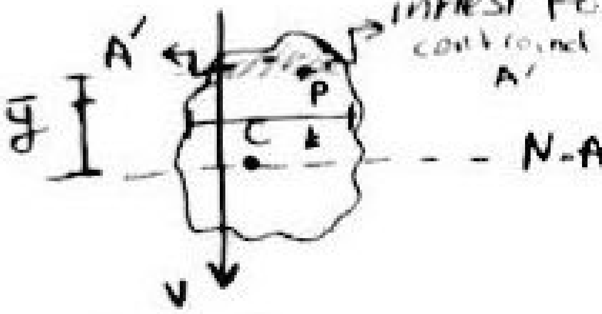
t → thickness of interest point m

$$* I = \int_A y^2 dA$$

$$Q = \int_A y \, dA$$

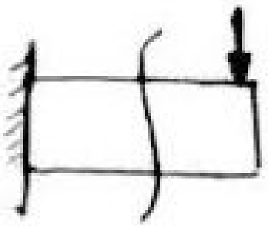
$$* \ Q = A' \bar{y}'$$

t → طول الخط الموازي N.A

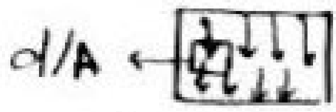


τ at (P) ?

chapter 6 shearing stresses in beam

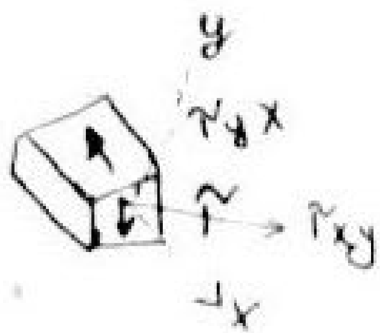


$\tau = \frac{V}{A}$



section a-a

$\tau_{Avg} = \lim \frac{\Delta V}{\Delta A}$



$\tau_{yx} \rightarrow$ Longitudinal shear stress

At any where of (y)

$* \ \tau = \frac{VQ}{It}$

$\tau_{xy} \rightarrow$ Transeve shear stress

$\tau_{xy} = \tau_{yx}$

$V \rightarrow$ shear Force (Internal) N

$I \rightarrow$ second moment Inertia about N. Axis m^4

$Q \rightarrow$ First moment of Inertia above intrest point m^3

$t \rightarrow$ thicknis of intrest point m

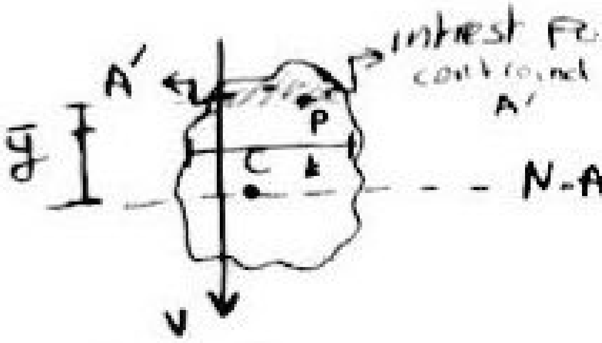
$* I = \int_A y^2 dA$

$Q = \int_A y \, dA$

$* \ Q = A' \bar{y}'$

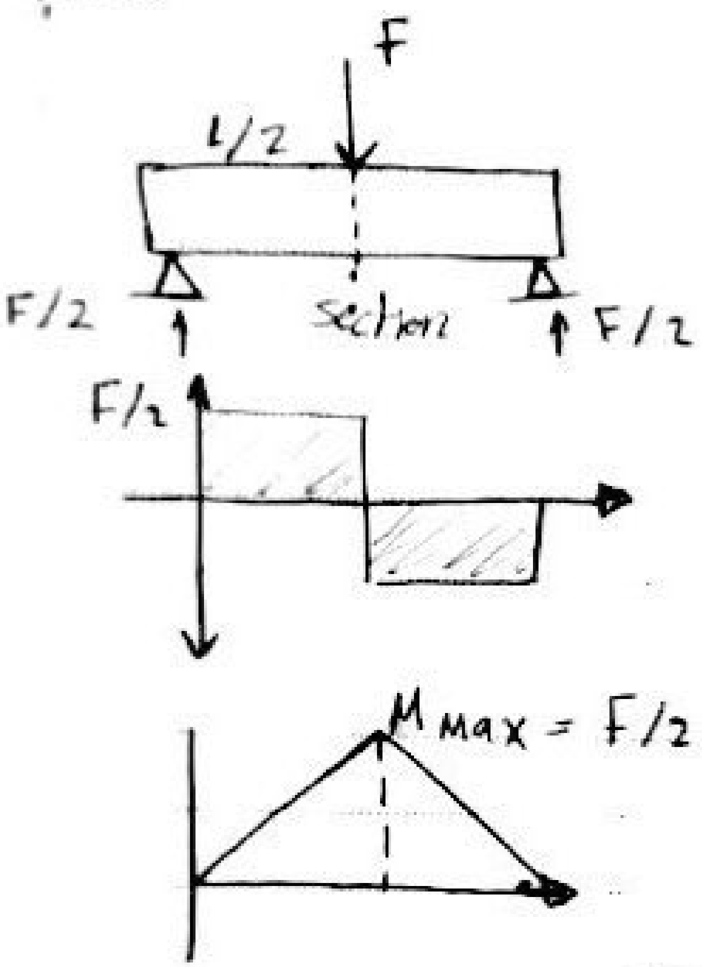
$t \rightarrow$ طول خط

موازي لـ N.A



τ at (P) ?

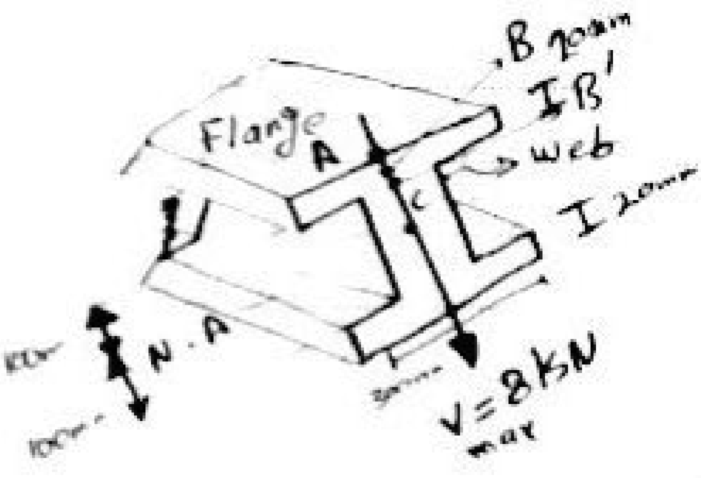
Example:



شكل الشير ← مهمة

$M_{max} = F/2 * L/2$

*



Find shear stress at:-

A = 0 ← ع1ع

B, B', C →

solution:-

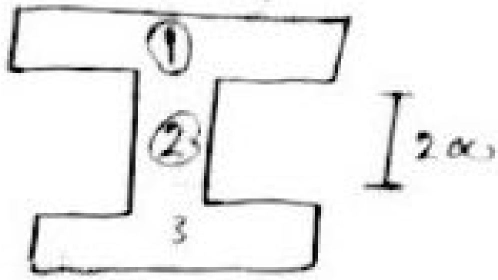
$$\tau = \frac{VQ}{It}$$

Q = zero

دايرت تحت N.A + فوق

- NA تحت

at point (B)



$$\tau_B = \frac{V\,Q_B}{I_{N.A}\,t}$$

$$I_{N.A} \rightarrow \left(\frac{1}{12}(300)(20)^3 + 300 * 20 \times 110^2\right)2 \longrightarrow$$ صوره مش $N.A^2$

$$+ \frac{1}{12}(15)(200)^3 \longrightarrow$$ هادع مركزي لانه مصمول ال NA

$$155.6 \times 10^{-6}\ m^4$$

$$Q_B = 300 * 20 \times \underset{N.A \rightarrow B}{\underline{110}} = 660 \times 10^{-3} \longrightarrow A * \bar{y}$$

$$\tau_B = \frac{80 \times 10^3 * 660 \times 10^{-3}}{155.6 \times 10^{-6} * 300 \times 10^{-3}}$$

$$= 1.13\ Mpa$$

B → طالع ال Flang

يعني t ← ال Flang

Subject

at Point (B')

$$\tau_B = \frac{V Q_{B'}}{I_{N.A} t_{B'}} = \frac{80 * 10^3 * 660 \times 10^{-3}}{155.6 * 10^6 \times 15 * 10^{-3}} = 22.6 \text{ MPa}$$

*

$$\tau_c = \frac{V Q_c}{I_{N.A} t_c}$$

$$Q_c = Q_1 + Q_2 =$$

$$(20)(110)(300) + (50)(100)(15) = 73.5 \times 10^6$$

$$\tau_c = \frac{80 \times 10^3 * 735 \times 10^{-6}}{15 \times 10^{-3} * 155.6 \times 10^{-6}} = 25.2 \text{ MPa}$$

$$\tau = \frac{V Q}{I t}$$

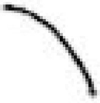
$\tau = V Q$

$\tau = V A y$

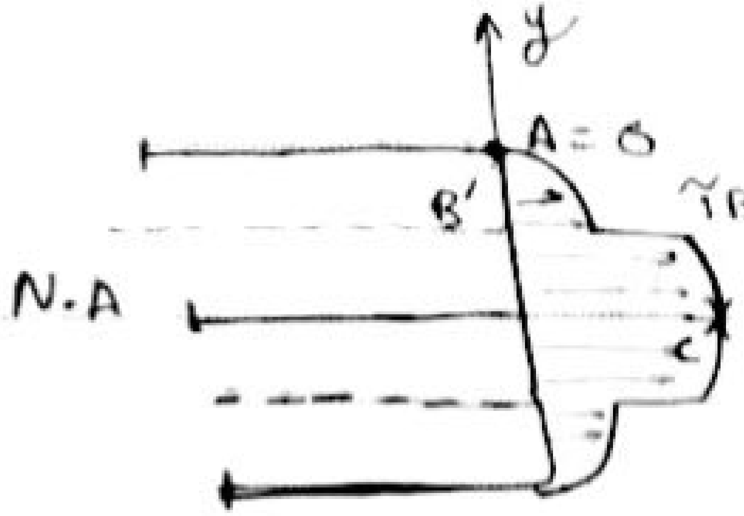
$\tau = V x y^2$

العلاقة طردية

$\tau \leftarrow y$ مع تربيع

 → متغيرة

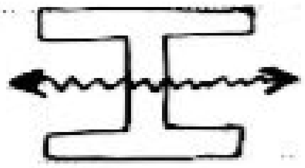
$\ddot{x} \to y$

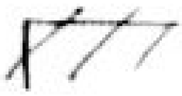


* لان الشكل symmetry

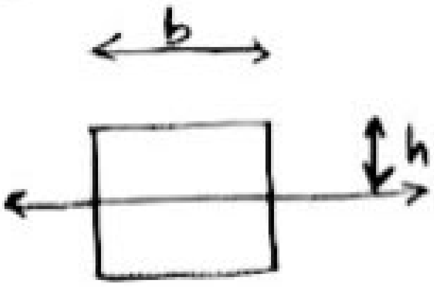
case 1 → common shape

I Beam → $\tau_{max} \approx \frac{V}{A} = \frac{80 \times 10^{3}}{(15 \times 200) \times 10^{-6}} = 26.6$





case 2 →

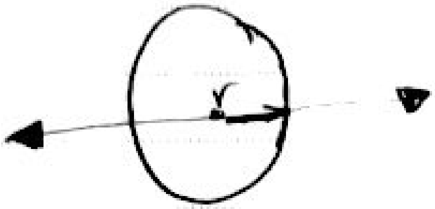


$\tau_{max} = \frac{3}{2} \frac{V}{A}$

3)

$\tau_{B'}$

x

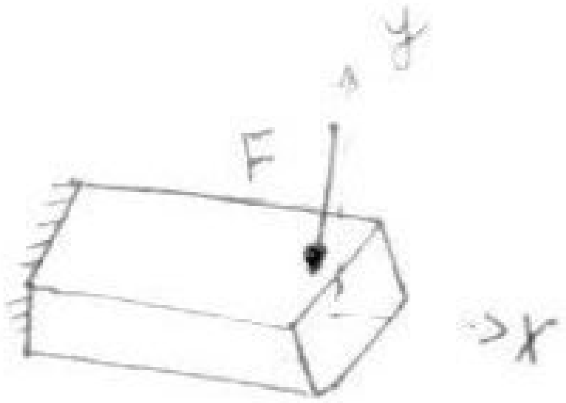


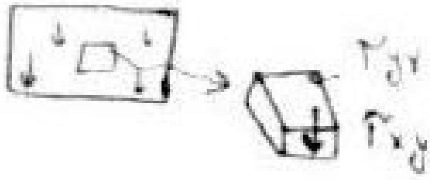
$$\tau_{max} = \frac{4}{3}\frac{V}{\pi r^2}$$

بالمركز يكون

*

26.6



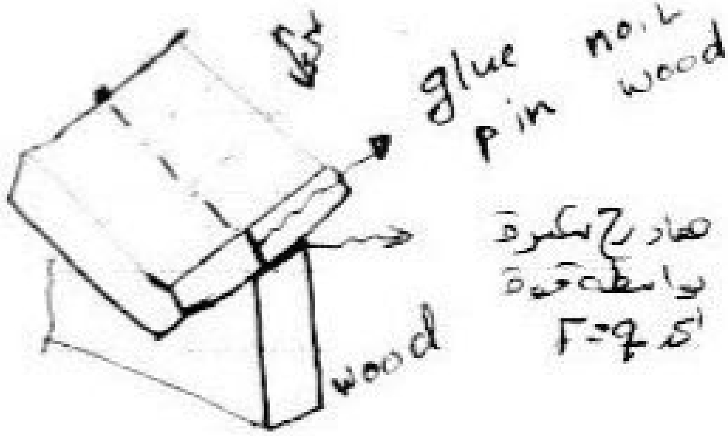


shear Flow ~~> q unit length (N/m)

$q = \frac{VQ}{I}$

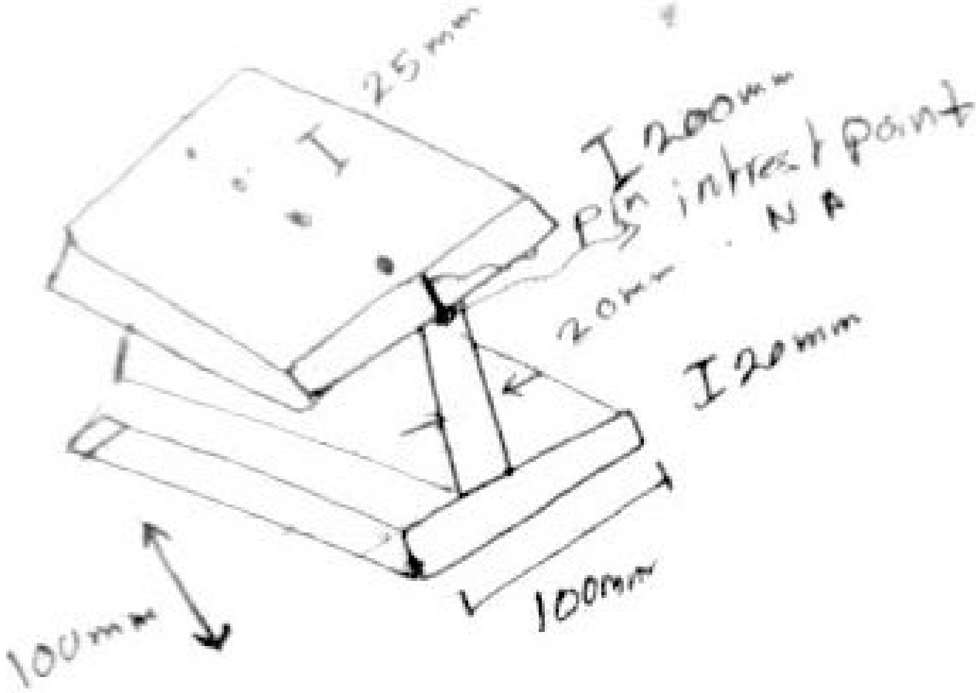
$F = q \times s'$

shear Force in each pin



صار في تكسيرة
بواسطة
$F = q\, s'$

6%   Examples



-harForce V = 500N   Find the shering Force in eachpin??

solution $q = \frac{VQ}{I}$ → abov intrest point

$\int y = A\bar{y}$

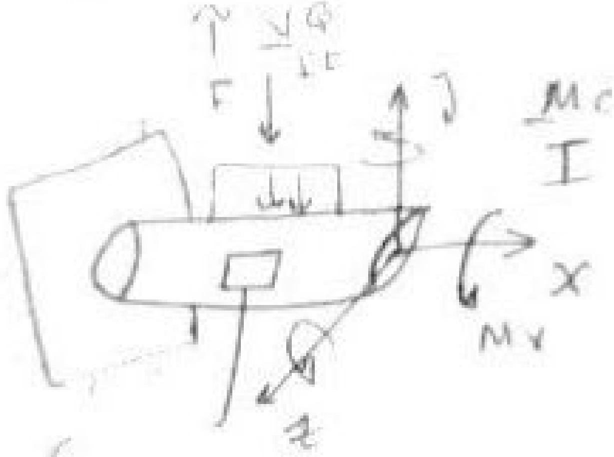
$Q = (100\times20)(60\times10^{9}) = 120\times10^{-6}\ m^3$

$I = 16.2\times10^{-6}$ $q = \frac{1500\times120\times10^{-6}}{16.2\times10^{-6}} = 3704\ N/m$

$F = 3704\times25\times10^{-3} = 926$

لكل مسمار

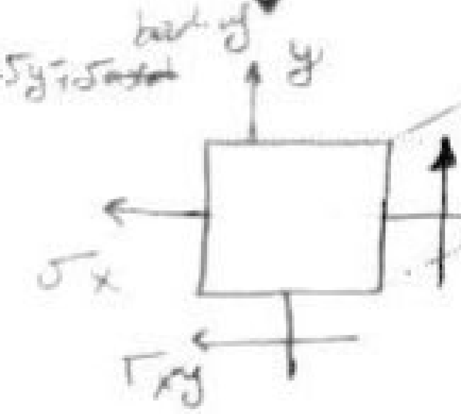
chapter (7) Transformation of stresses and strain



torque $\frac{Tc}{J}$

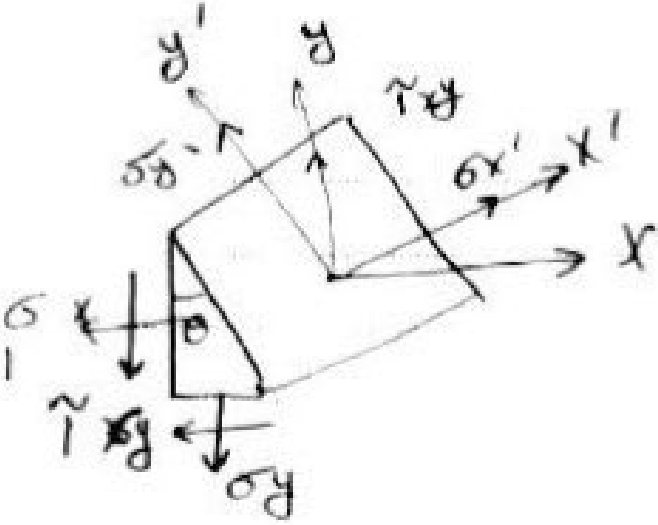
axial Load

$\sigma = \frac{Mc}{I}$ $\quad$ $\sigma = \frac{P}{A}$



$\tau_{xy} = \tau_{torque} + \tau_{shear\ Force}$

σ_x , $\sigma_{bending}$, σ_{axial}



$\Sigma F_{x'} = 0$

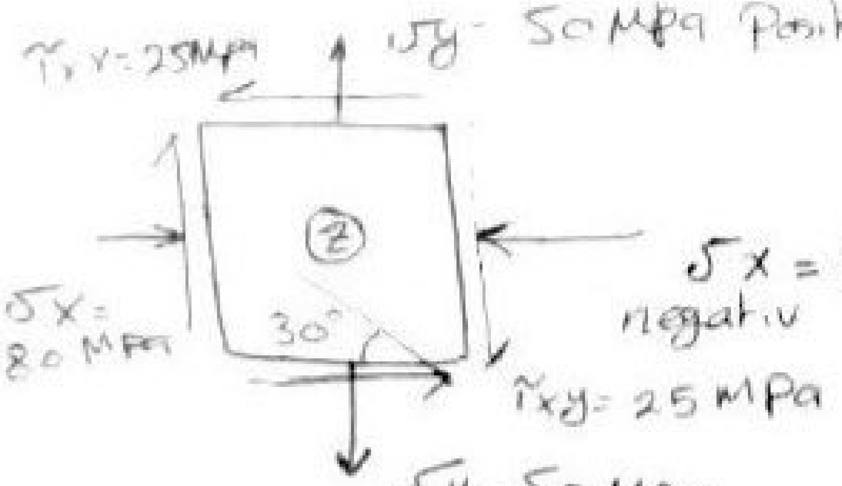
$\Sigma F_{y'} = 0$

$$\sigma_{x'} = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x - \sigma_y}{2} \cos(2\theta) + \tau_{xy} \sin 2\theta$$

$$\sigma_{y'} = \frac{\sigma_x+\sigma_y}{2} - \frac{\sigma_x-\sigma_y}{2}\cos 2\theta - \tau_{xy}\sin 2\theta$$

$$\tau_{x'y'} = -\frac{\sigma_x-\sigma_y}{2}\sin 2\theta + \tau_{xy}\cos 2\theta$$

Examples



$\theta = 60$

داخلة مع بعض

Find $\sigma_{x'}, \sigma_{y'}, \tau_{x'y'}$?

$\sigma_{x'} =$

rotent الساعة

− C.W عكس

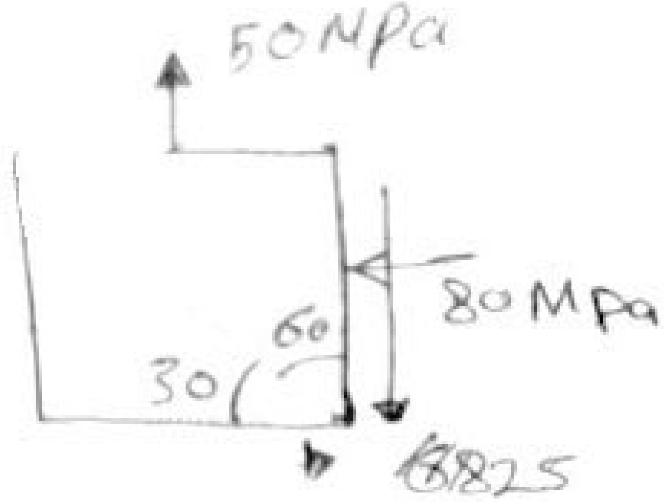
+ C.C.W

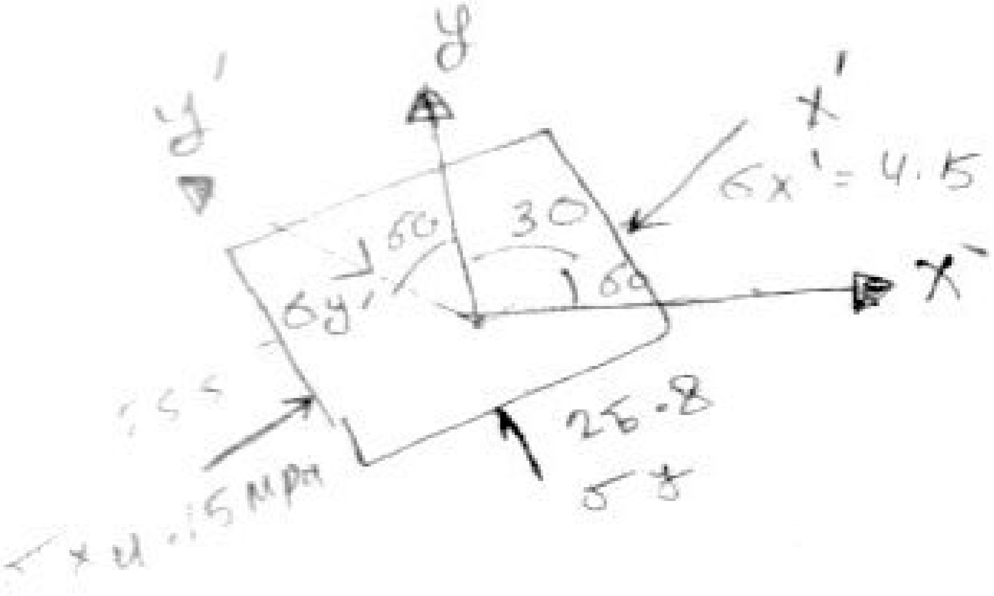
$$\frac{-80+50}{2} + \frac{(-80-50)}{2}\cos(120) + (-25)\sin 120 = -4.15\,MP$$

com stress

$$\sigma_{y'} = \frac{-80+50}{2} - \frac{(-80-50)}{2}\cos 120 + 25\sin 120 = -25.8$$

$$\tau_{x'y'} = -\frac{-80-50}{2}\sin(120) + (25)\cos(120) = 68.79$$





Britte → shear stress → max ⇒ [illegible]
Dctrule ⇒ normal " ⇒ " ⇒ "