



Design



* Introduction :-

$$\sigma_{\text{working}} = \frac{\sigma_{\text{yield}}}{n}$$

n :- Yield factor safety

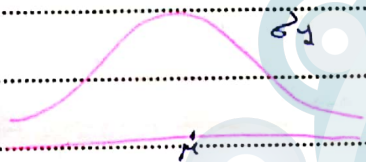
$n > 1$ (max.)

σ_{working} : Max value of stress σ should be less than σ_{yield} .

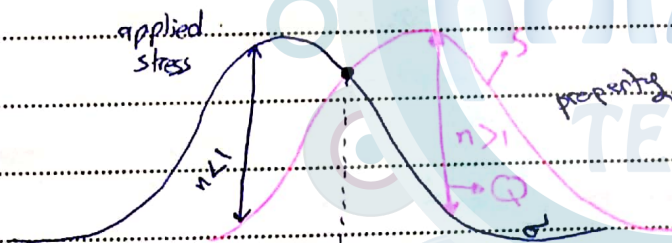
* Deterministic $\rightarrow n = 2$ (number)

* Probabilistic $\rightarrow n = 0.1$

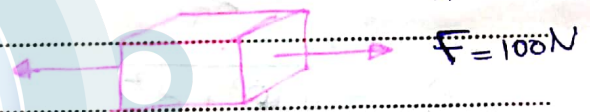
- Dile material :-



(μ_{property} , σ_{property})



* Normal stress (σ) = $\frac{F}{A}$



μ (avg. stress).

Failure $\leftarrow n=1 \rightarrow$ Survive

* $n = \frac{\sigma_y}{\sigma_{\text{applied stress}}}$; $n \neq 1$

- If $n < 1$

$\rightarrow$ pro. of failure 100%

$\rightarrow$ pro. of Survive 0%

* $Q = S - \sigma$
 margin strength Applied stress

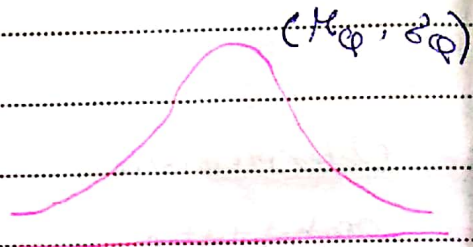
* $\phi \rightarrow (-)$: Failure
 $\phi \rightarrow (+)$: Survive

• Distribution of margin $\rightarrow$ Normal

$$* Z = \frac{\phi - \mu_\phi}{\sigma_\phi}$$

$$* \mu_\phi = \mu_s - \mu_d$$

$\swarrow$ M. property $\searrow$ M. load



* $\phi = 0$

$$Z_0 = -\frac{\mu_\phi}{\sigma_\phi}$$

**

التأنيق

$$* \sigma_\phi = \sqrt{\sigma_s^2 + \sigma_d^2}$$

* Example:

$$S (\mu_s = 40, \sigma_s = 6)$$

$$d (\mu_d = 30, \sigma_d = 8)$$

Find: probability ?

Solve:

$$n = \frac{\mu_s}{\sigma_s} = \frac{40}{30} = \frac{4}{3} > 1 \quad \text{So Survival}$$

$$\begin{aligned} Z &= \frac{-\mu_\phi}{\sigma_\phi} = \frac{-(\mu_s - \mu_d)}{\sqrt{\sigma_s^2 + \sigma_d^2}} \\ &= \frac{-(40 - 30)}{\sqrt{6^2 + 8^2}} \\ &= \frac{-10}{10} \\ &= -1 \end{aligned}$$

Pro. F = 0.1587

Pro. S = 1 - 0.1587

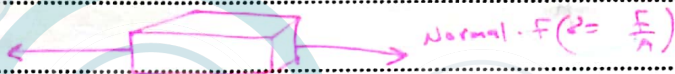
i. $n = \frac{Y}{3}$, Pro. F = 0.1587

* probability factor of failure.

★ CH:3 8- Load & Stress Analysis :-

- Normal stress:

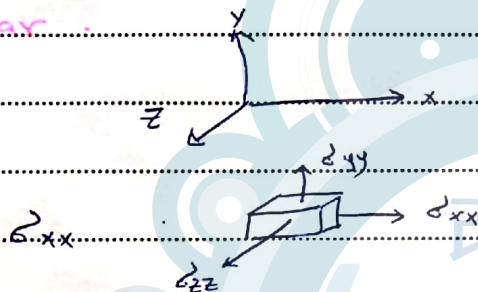
عاصري cross sec.



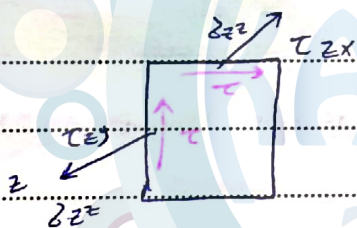
- Shear:

* Stress Unit:

N/m² or lb/in²



(Ex: Normal stress)



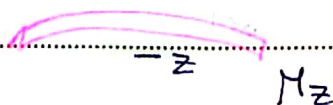
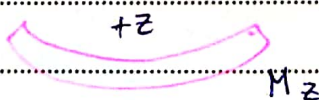
(Ex: Shear stress)

نبدأ المساحة بنات الحاصري على السطح

* Any surface have 3 stress components.

one perpendicular & Two shear stress
(Normal stress) τ σ

- Bending



① (الداخل)

+

② (الخارج)

-

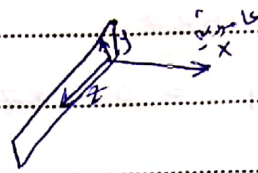
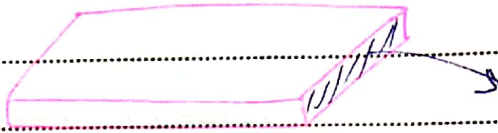
* Bending

عادية

يكون على مسرف

y & z

► Subject :



2b) y, z (H_y or H_z just)

- Torsion

⇒ Torque → torsional moment:



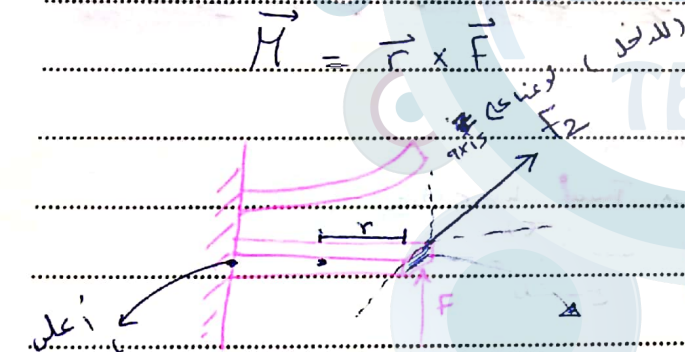
* Stress $\rightarrow p\alpha$ (JLSW)

(اسکا)

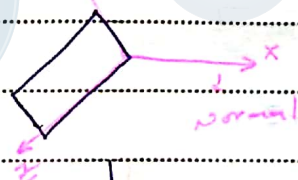
* Bending Moment

cross sec 2-axis dep.

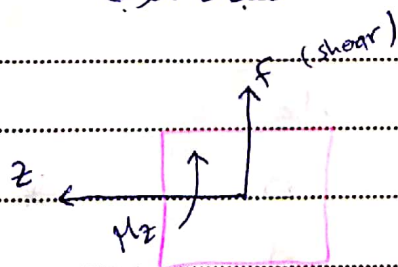
$$\vec{M} = \vec{r} \times \vec{F} \quad (\text{اللاخط})$$



$$\vec{H} = \hat{i} \times \hat{j} = +\hat{k}$$



مطلوبہ



cc, w +

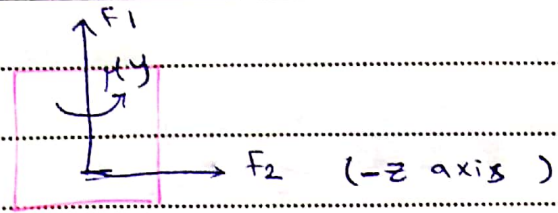
ح -

Subject : (y-axis) / /

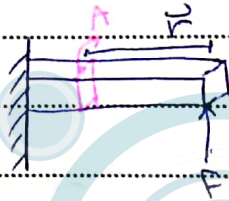
$$\vec{M} = \vec{r} \times \vec{F}_2$$

$$= +\hat{i} \times -\hat{k}$$

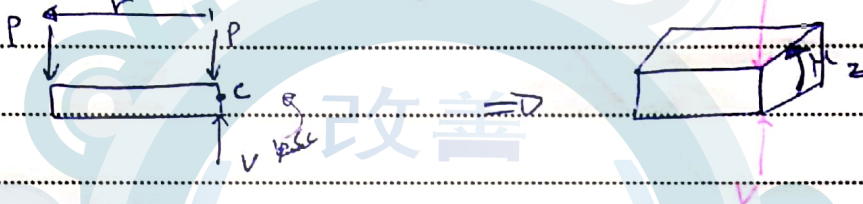
$$= +\hat{j}$$



* $r \Rightarrow$ from point to force.



* Shear & Bending Diagram:



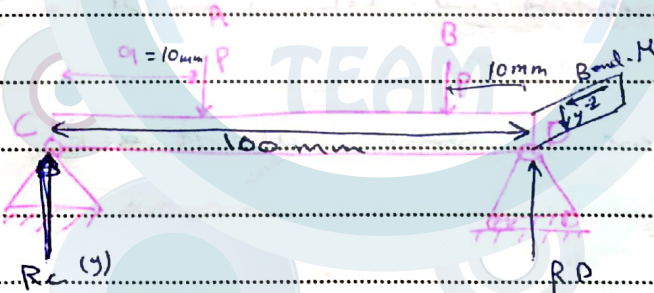
$$M = \vec{r} \times \vec{F}$$

$$= -\hat{i} \times -\hat{j}$$

$$= +\hat{k}$$

* Ex:-

$$P = 20 \text{ N}$$



$$\sum M_z = -R_c \times 100 + P_A \times 90 + P \times 10 \Rightarrow \sum M_z = 0$$

$$= -100 R_c^{(y)} + 100(20) = 0$$

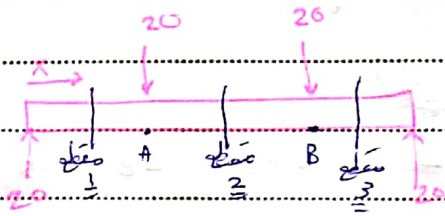
$$R_c = 20 \text{ N}$$

$$\sum F_y = 0$$

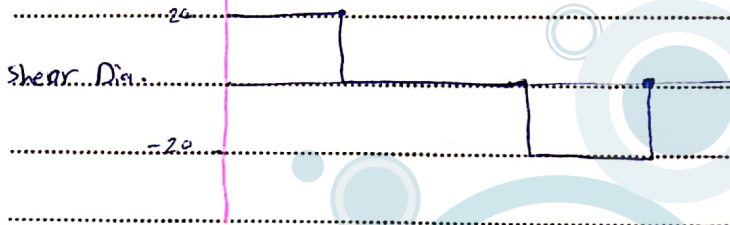
$$-2P + 20 + R_D^{(y)} = 0$$

$$R_D^{(y)} = 20$$

Subject : _____



المدرسة تأخذ مساحات ونرى عند هذا القوى
على ال beam (هذه القوى)



Bending

Dist.

($\vec{r} \times \vec{F}$) (x)



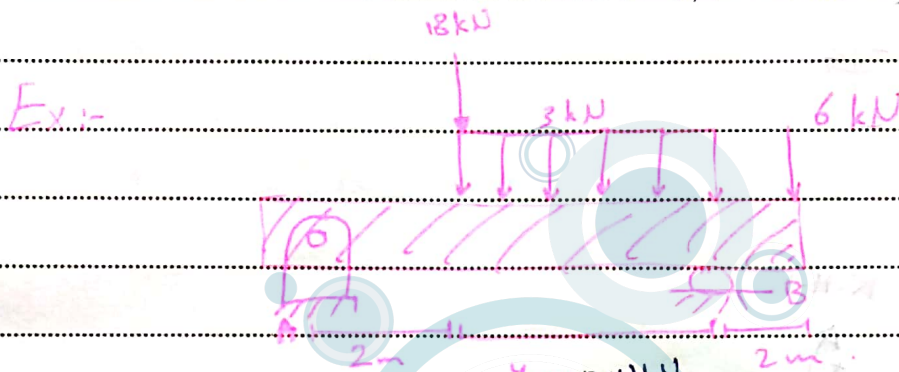
$$* V = \frac{dM}{dx}$$

* $\frac{dM}{dx}$ Bending Moment (M) and shear (V) are related.

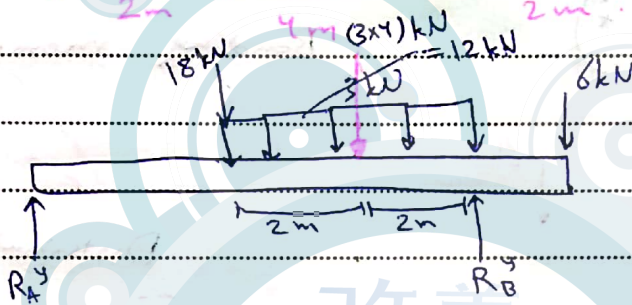
(reaction to material) and External force. It is a reaction to material.

* Max Bending Moment & Shear at A & B

أي section ينفصله رأس القوة ويسمى بـ Right hand
ولو نظرنا من اليسار يسمى بـ left hand.



F.B.D



$$\sum M_A = 0$$

$$-18 \times 2 - 12 \times 4 + R_B \times 6 - 6 \times 8 = 0$$

$$-36 - 48 + 6R_B - 48 = 0$$

$$-132 + 6R_B = 0$$

$$R_B = 22 \text{ kN}$$

* Normal & Bending Moment axis (الأسلاك)

$$\sum F_y = 0$$

$$R_A - 18 - 12 + 22 - 6 = 0$$

$$R_A = -14 \text{ kN}$$

$$\sum M_B = 0$$

عند B رأس القوى الذي على اليسار عن اليد اليمنى والقوى التي على
اليمنى عن اليد اليسرى.

$$\sum M_{B \text{ R.H.S}} = \sum M_{B \text{ L.H.S}}$$



Subject :

$$\text{L.H.S } \sum M_B = \sum M_B \quad \text{R.H.S}$$

$$(+ R_y \times 6) - (18 \times 4) - (12 \times 2) = - (6 \times 2)$$

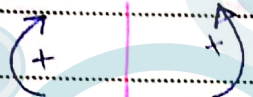
$$6 R_y - 72 - 24 = -12$$

$$6 R_y - 96 = -12$$

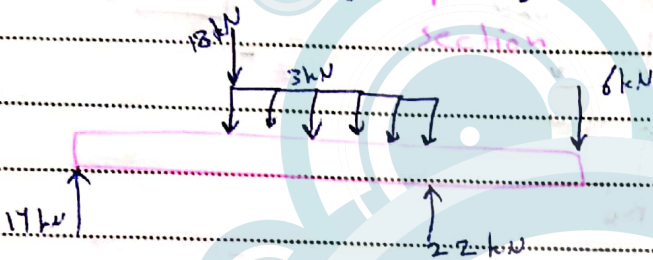
$$R_y = 14 \text{ kN}$$

* Note:

L.H.S R.H.S



Bending moment.



Distributed force

توزيع القوة الموزعة

خطان نقطة الحركة



$$\frac{dV}{dx} = -q$$

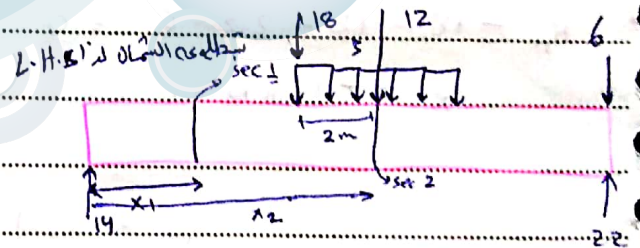
$$\frac{dM}{dx} = V$$

-16

-16 Max Shear

$$|-16| = 16$$

28



$$M_{\text{sec 1}} = 14 \times r \quad M = +J$$

linear $\rightarrow$ parabolic

if constant $\rightarrow$ linear

Subject :

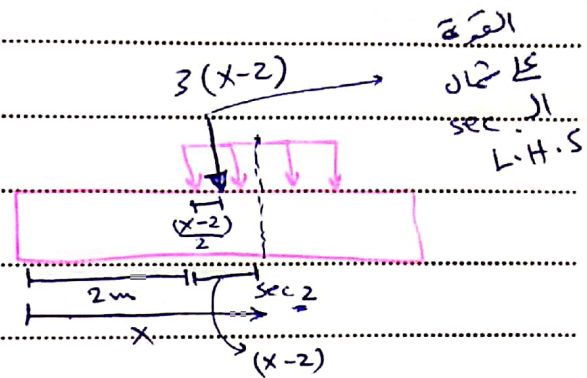
$$M = 14x(x) - 18(x-2) - \frac{3(x-2) \times (x-2)}{2}$$

$$M = 14x - 18(x-2) - \frac{3(x-2)^2}{2}$$

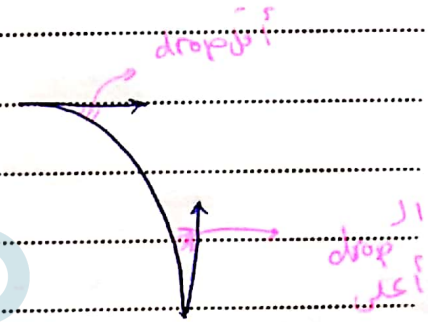
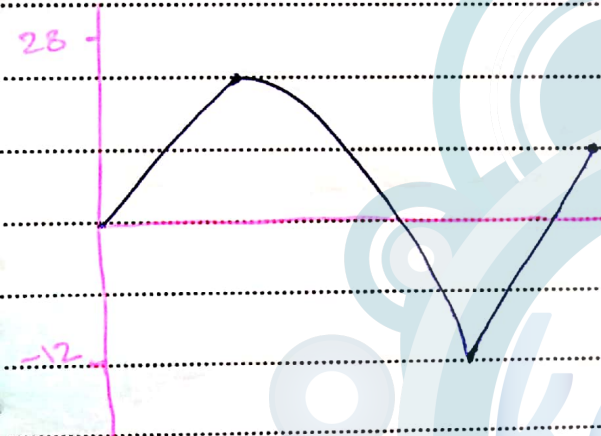
x ($0 \rightarrow 6m$)

as a value

in equation x ($2 \rightarrow 6$)



$$F = \text{Concentrated load} = 3 \times (x-2)$$

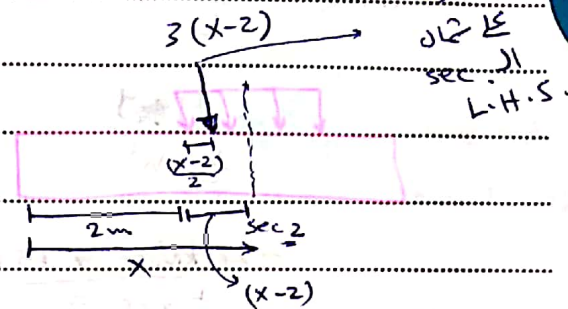


والجهد القصي، حيث هو 14 ك.ج. في القسم الأول.
 في القسم الثاني، الجهد القصي يبدأ من 0 ك.ج. عند x=2م.
 ال drop، أي على أنه 14 ك.ج. عند x=2م.
 ()

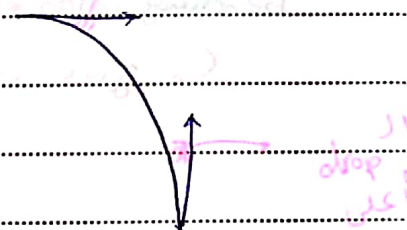
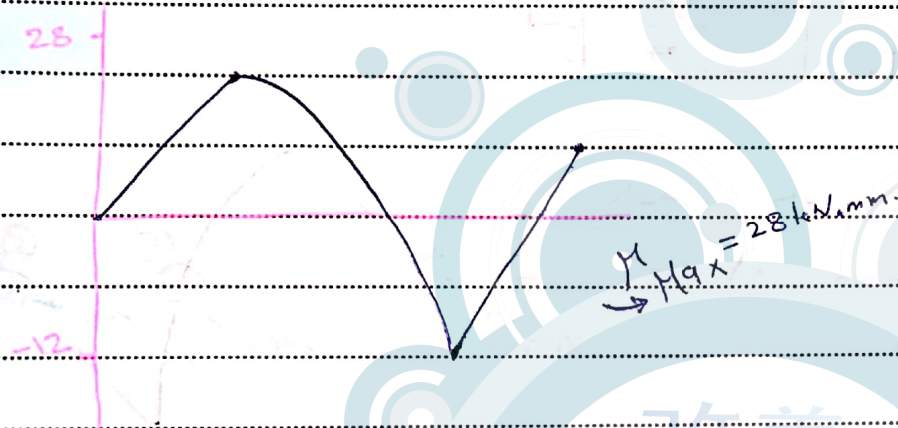
$$\mu = 14x - 18(x-2) - \frac{3(x-2)^2}{2}$$

as a value

in equation X (2 → 6) :

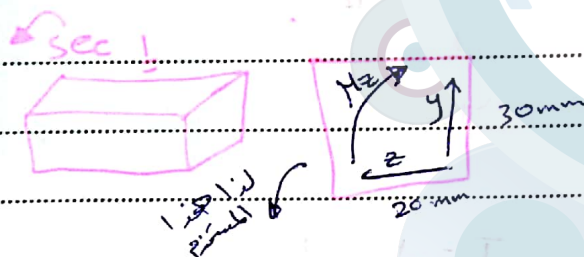
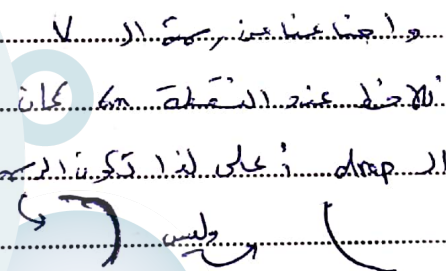


$$F = \text{concentrated load} = 3 \times (x-2)$$



* Review:

$M \rightarrow \sigma$ (normal stress).

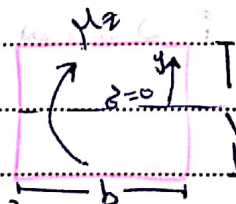


$$G_{xx} = - \frac{M_{zy}}{I}$$

$$M_{yz}^{xx} = \frac{M_y z}{I}$$

- σ $\propto$ $\frac{1}{r}$ (Resisting to Bending)

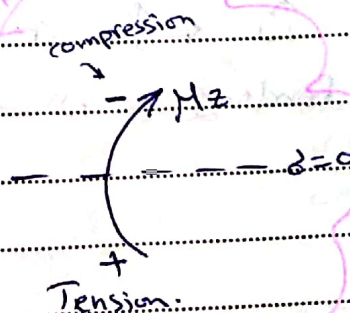
$$C.A = N.A$$



$$I_{\square} = \frac{1}{12} bh^3$$

(Moment of inertia)

*Note: ✓

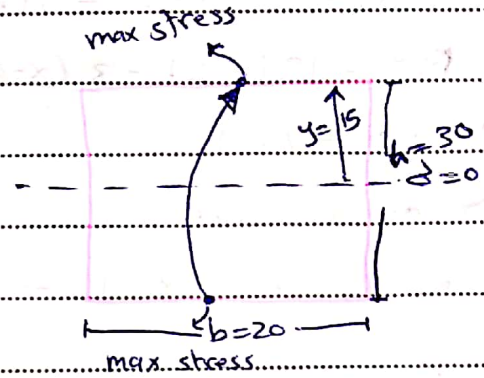
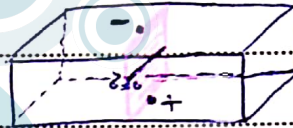


$$\sigma_{xx} (max) = -\frac{My_z}{I}$$

$$= -\frac{M_z y}{\frac{1}{2}bh^3}$$

$$= -\frac{28 \text{ kN.m} \times 15 \text{ mm}}{\frac{1}{2} \times 20 \times 30^3 \text{ mm}^4}$$

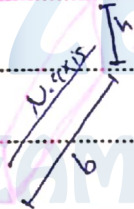
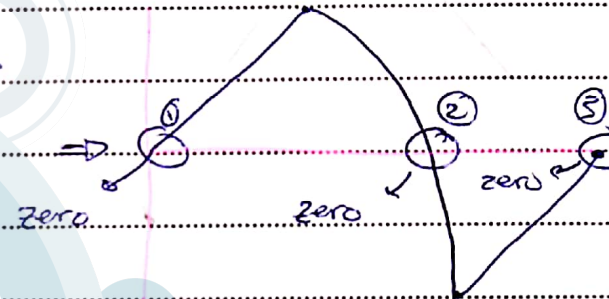
Compression.



* Max Normal stress at (2m).

Bending Moment = 0 $\Rightarrow$...

Give me minimum stress $\Rightarrow$...



M_z (around z-axis)
N. axis (...)

$$I = \frac{1}{12}bh^3$$

M_z

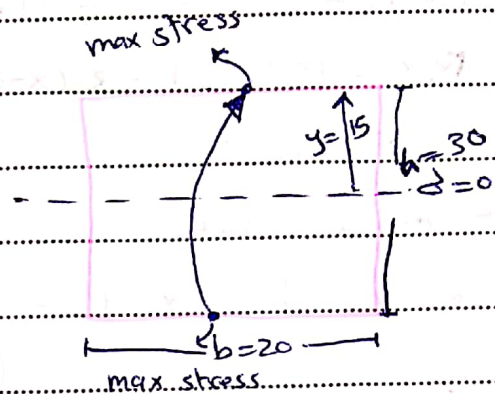
$$I = \frac{1}{12}bh^3$$

* ... $I = \frac{1}{12}bh^3$...
Bending Moment ...

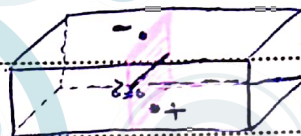
$$\sigma_x (\max) = -\frac{My_z}{I}$$

$$= -\frac{M_z y}{\frac{1}{2}bh^3}$$

$$= -\frac{28 \text{ kNmm} \times 15 \text{ mm}}{\frac{1}{2} \times 20 \times 30^3 \text{ mm}^4}$$



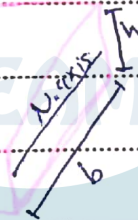
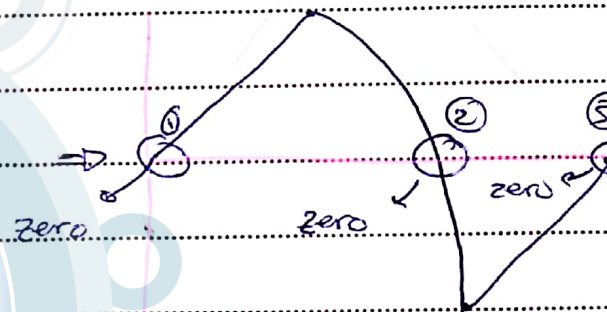
Compression :



* Max Normal stress at (2m).

Bending Moment = 0 $\Rightarrow$ zero

$\hookrightarrow$ give me minimum stress $\Rightarrow$ zero

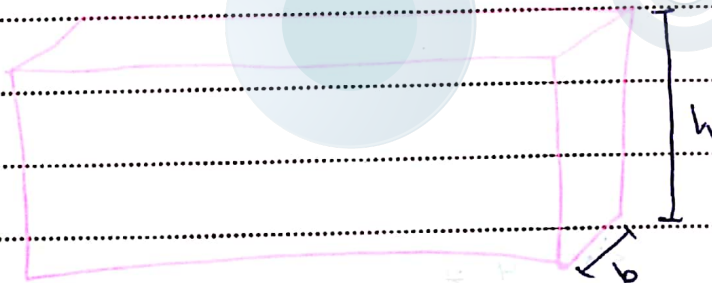


M_z (around z-axis)
N. axis (neutral axis)

$$I = \frac{1}{12}bh^3$$

M_z

$$I = \frac{1}{12}bh^3$$



* لإيجاد أقصى إجهاد في الألياف البعيدة عن المحور الثاني والثالث $I = \frac{1}{12}bh^3$
لذا يمكننا الثاني للإجهاد أن يكون لدينا سعة من الجهد لجعل من (Bending Moment)

Subject :

8/3/2022 Tue

المادة : ميكانيكا



* V is equally distributed on the cross section (C.S.)

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

بكونه متساوية
لذا في كل مساحة أخرى

$$\tau_{xy} = -\frac{16}{20 \times 30}$$

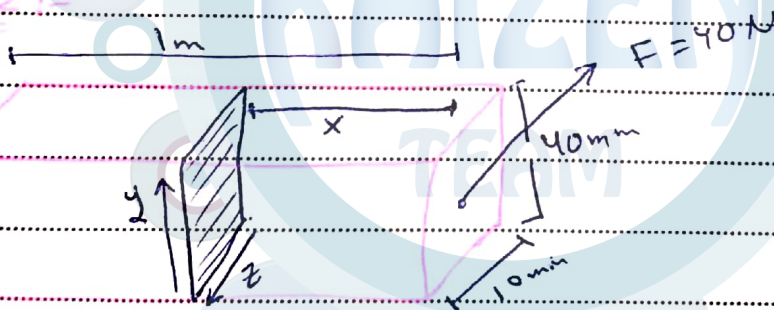
Max shear stress (at B)

* at $x=2$, $V=14$

(at A.)

$$\tau_{xy} = \frac{14}{20 \times 30}$$

* $F_x = 2$:-



* Bending axis (المحور الكرنكي)

بكونه متساوية (N.axis) (محور نيوتن)

axis

* Find the Max normal stress?

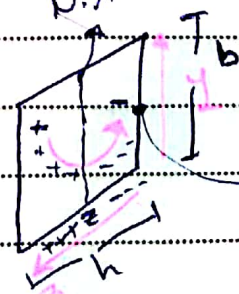
$$M_y = x F$$

$$\text{Max} \Rightarrow M_y = 1 \times 40 = 40 \text{ N.m}$$

$$\sigma_{max} = \frac{M_y z}{I}$$

$$\sigma_{xx} = \frac{40 \times -5/1000}{\frac{1}{12} \times \left(\frac{40}{1000}\right) \left(\frac{10}{1000}\right)^3}$$

(محاور y و z)



$M \rightarrow z$ دور

الضغط
الشد

$$s_{xx} = \frac{40 \times 2}{1000} \\ \frac{1}{12} \left(\frac{40}{1000} \right) \left(\frac{16}{1000} \right)^3$$

لرینتاجی



$$* \text{Max shear} = \frac{40}{10 \times 40} = \frac{V}{A}$$

改善

KAIZEN

TEAM

Subject: Creo

10 / 3 / 2022 Thurs

- use default x

mmns - part - solid (mm)

mm Newton sec.

→ sketch

→ Extrude

→ select plane → sketch → sketch view → circle

→ click in center → click → دائرة → ok

→ 3D → Extrude → scroll → 3D → 3D

* * Shift + scroll (تغيير المساحة)

* * Ctrl + scroll (تغيير الحجم)
(أكثر وأقل)

* * Click on surface → sketch → circle → center & point → ok → sketch 2 → extrude → ok

* Extrude 2 → pattern → Dimension → Axis

* → $\theta = 90^\circ$ → 90 درجة

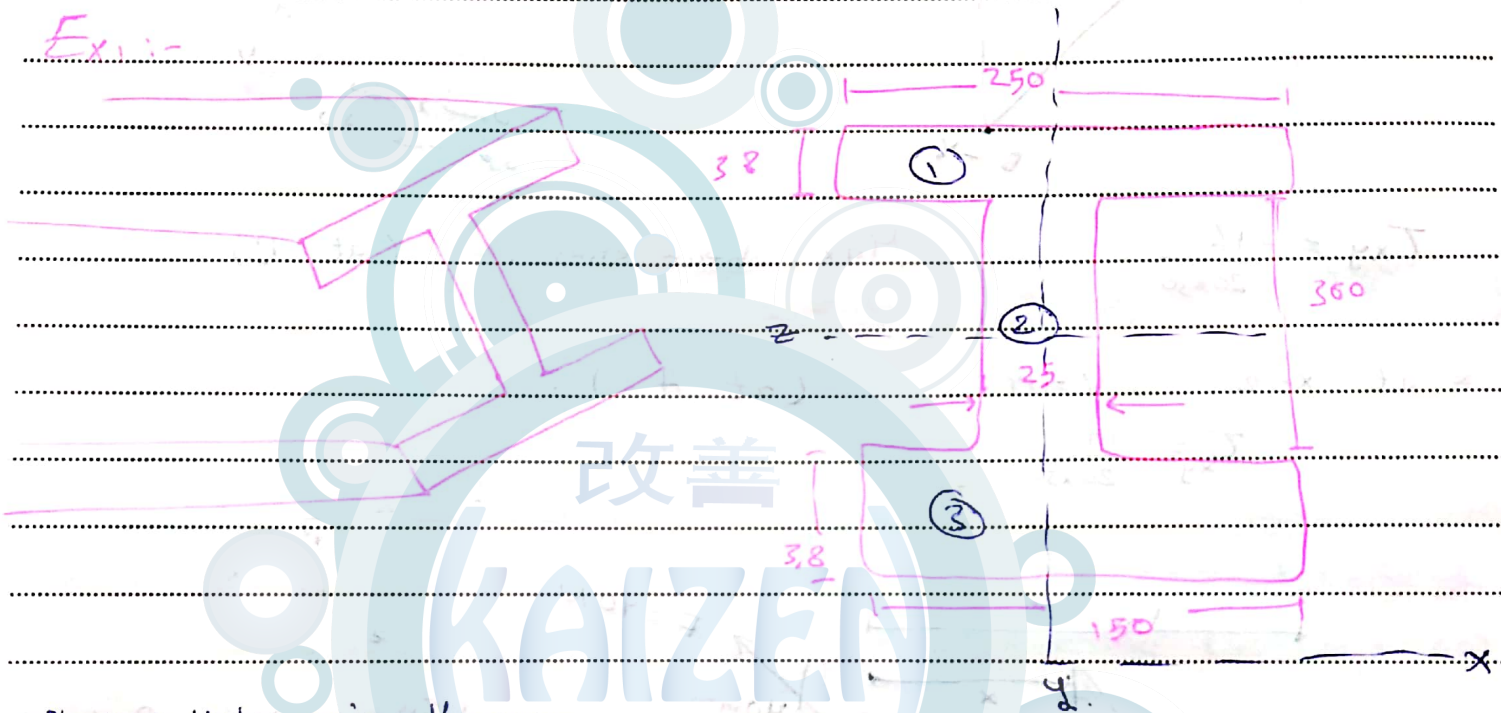
$$s_{xx} = \frac{40 \times 2}{1000} \cdot \frac{1}{12} \left(\frac{40}{1000} \right) \left(\frac{16}{1000} \right)^3$$

نقطه ثقل



$$* \text{Max shear} = \frac{40}{10 \times 40} = \frac{V}{A}$$

Ex: 1-



* parallel axis theorem

$$A_1 = 38 \times 250$$

$$I_1 = \frac{1}{2} \times 250 \times 38^3$$

d1 btw cross area to cross section in all body

Centroid $C(\bar{x}, \bar{y})$

$$\bar{x} = \frac{\sum \bar{x}_i A_i}{\sum A_i} = 0$$

$$\bar{y} = \frac{\sum \bar{y}_i A_i}{\sum A_i} = \frac{(38 + 300 + \frac{38}{2}) \times (250 \times 38) + (38 + 150) \times (300 \times 25) + (\frac{38}{2}) \times (150 \times 38)}{(38 \times 250) + (25 \times 300) + (150 \times 38)}$$

centroid from $y=0 \rightarrow$ to midpoint in section

$$\bar{y} = 216.29 \text{ mm}$$

أجزاء الأجزاء إلى المحاور

$$C(0, 216.29)$$

Subject :

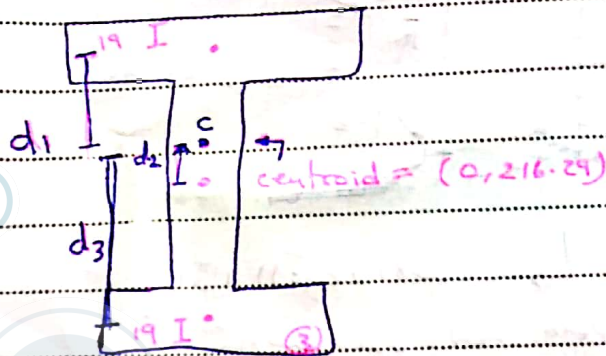
13 / 3 / 2022 Sun

$$d_1 = (38 + 300 + \frac{38}{2}) - 216.29$$

$$(2) A_2 = 25 \times 300$$

$$I_2 = \frac{1}{12} \times 25 \times 300^3$$

$$d_2 = 216.29 - (150 + 38)$$



$$(3) A_3 = 150 \times 38$$

$$I_3 = \frac{1}{12} \times 150 \times 38^3$$

$$d_3 = 216.29 - 19$$

$$I_{C.A} \text{ (Inertia for composet area)} = \sum (I_i + A_i d_i^2)$$

$$= (I_1 + A_1 d_1^2) + (I_2 + A_2 d_2^2) + (I_3 + A_3 d_3^2)$$

$$* \text{ If } M_z = 200 \text{ N.m}$$

$$= 4.74 \times 10^8 \text{ mm}^4 = 4.74 \times 10^8 \times 10^{-12} \text{ m}^4$$

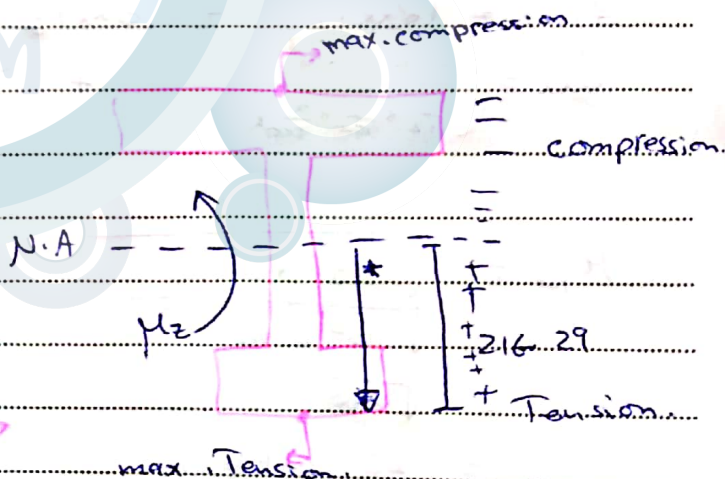
What is the Max. Tensile of compression stresses.

Ans:-

$$\sigma_{xx} = - \frac{M_z y}{I_z}$$

$$= - \frac{200 \times (38 + 300 + \frac{38}{2} - 216.29)}{4.74 \times 10^8 \times 10^{-12} \text{ m}^4}$$

$$\sigma_{xx} = -200 \times \left(\frac{-216.29}{1000} \right) \frac{1}{4.74 \times 10^8 \times 10^{-12}}$$



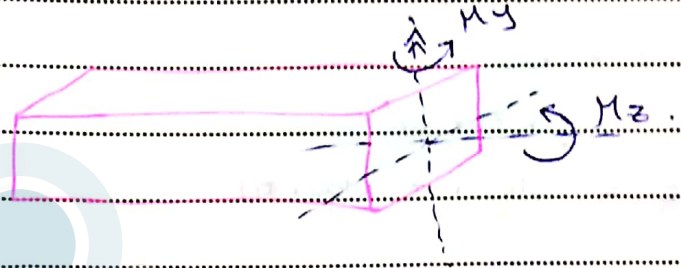
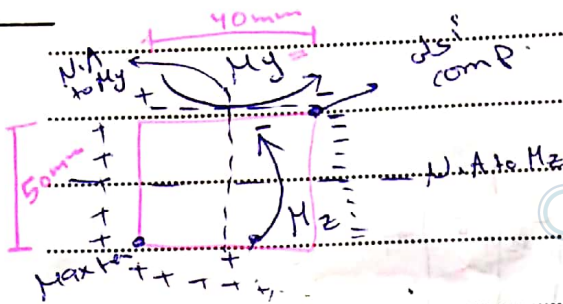
الاسامي
الركن
الفرق

$$\sigma_{xx} = (+) 200 \times \left(\frac{216.29}{1000} \right) \frac{1}{4.74 \times 10^8 \times 10^{-12}}$$

الفرق بين الاسامي والركن

Moment fait (+)

* Two plane Bending :-



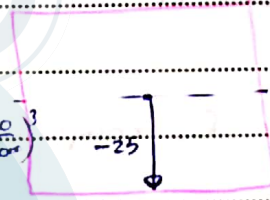
→ Given data :-
Zero twist is assumed

$$M_y = 10 \text{ kN.m}$$

$$M_z = 20 \text{ kN.m}$$

$$\textcircled{1} \sigma_{xx} = -\frac{20 \times 25 \times 10^3}{\frac{1}{12} \times \frac{40}{1000} \times \frac{50^3}{1000^3}}$$

$$\text{or } = +\frac{20 \times 25}{1000}$$

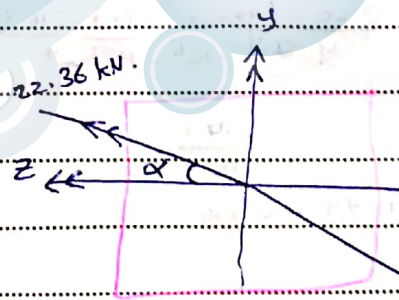


$$\textcircled{2} \sigma_{xx} = 10 \times \frac{20}{1000} \times \frac{\frac{1}{12} \times \frac{50}{1000} \times (\frac{40}{1000})^3}{\frac{1}{12} \times \frac{40}{1000} \times \frac{50^3}{1000^3}}$$

$$\sigma_{xx} = (\sigma_{xx})_z + (\sigma_{xx})_y$$

$$\sigma_{xx} = \left(\frac{-20 \times 25 \times 10^3}{\frac{1}{12} \times \frac{40}{1000} \times \frac{50^3}{1000^3}} + \frac{10 \times 10^3 \times \frac{20}{1000}}{\frac{1}{12} \times \frac{50}{1000} \times (\frac{40}{1000})^3} \right)$$

$$\begin{aligned} \vec{M}_{\text{tot}} &= \sqrt{M_y^2 + M_z^2} \\ &= \sqrt{10^2 + 20^2} \\ &= \sqrt{500} \\ &= 22.36 \text{ kN.m} \end{aligned}$$



(سیکنٹ اقرباً M_z کا ہے)

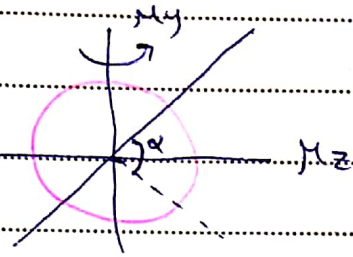
$$\begin{aligned} \alpha &= \tan^{-1} \left(\frac{M_y}{M_z} \right) \\ &= \tan^{-1} \left(\frac{10}{20} \right) \end{aligned}$$

► Subject :

* If circular cross section :

هبل کو ج α بیضا طه نسبت دادنا کانه زیر

قبل ☐ بنویسوی بنجل وجوده و جده



改善

KAIZEN

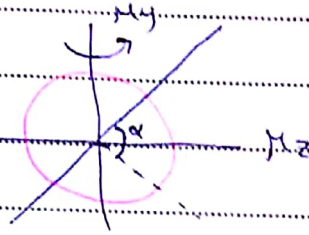
TEAM

* عند استخدام قانون I تذكرى أنه
b هي الموازية لمحط N.A وأن h القاعدية
Ex  $I = \frac{1}{12} b h^3$
القاعدية h

15 / 3 / 2022 Tues.

* If circular cross section:

كل شيء $\propto$ ببساطة حسب قانون كاني نزي
قبل  يتولى يتولى بجد وحدة وحدة.



3-11: Shear Stresses for Beams in Bending:

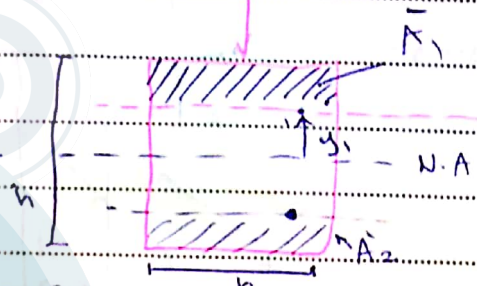
$V \rightarrow$ shear force $\rightarrow \tau$ shear stress

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

shear force $\rightarrow$ First moment of area
 $\rightarrow$ width of gross section.
 $\rightarrow$ second moment of area

* $\tau = \frac{V}{A}$ * avg. value

ما يستخدم في العلاقة



* نطلق ان area منقطة النقطة (منقطة دائما للخارج سواء من تحت أو فوق)

$$I = \frac{1}{12} b h^3$$

b $\rightarrow$ width of cross section (البعد العرضي)

$V \rightarrow$ shear force.

$y \rightarrow$ from centroid to A' in center (من المركز الى centroid)

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

$y \rightarrow$ from centroid to located point.

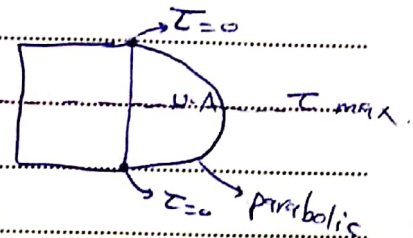
$$\tau = \frac{3V}{2A} \left[1 - \frac{y^2}{c^2} \right]$$

just for rectangular C.S

$\rightarrow$ Max at $y=0 \rightarrow$ in N.A

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

$$\tau_{max} = 1.5 \tau_{avg. value}$$

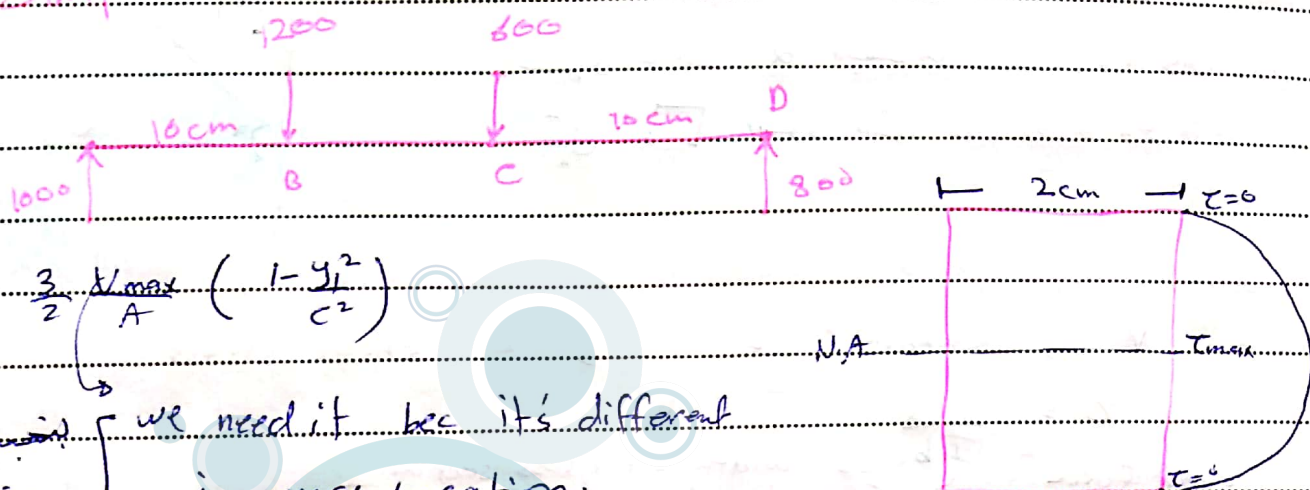


$\rightarrow$ Note:

$\tau_{max} \neq \tau_{avg}$ so we can't use $\tau = \frac{V}{A}$ to calculate τ_{max} or τ XX we use $\tau = \frac{V}{A}$ just to calculate τ_{avg}

S T A R S N O T E B O O K

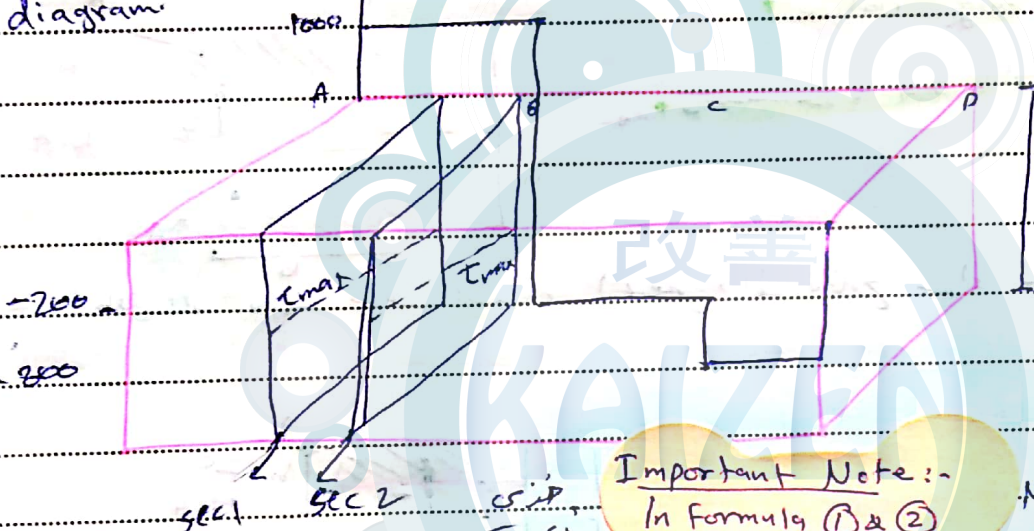
Ex:- Simple 1-



$$T_{max} = \frac{3}{2} \frac{V_{max}}{A} \left(1 - \frac{y^2}{c^2} \right)$$

we need it bec it's different in every location.

diagram



$$8cm \Rightarrow c = \frac{8}{2} = 4cm$$

Important Note:-

In formula ① & ②

$$① \tau = \frac{VQ}{Ib}$$

$$② T_{max} = \frac{3V}{2A}$$

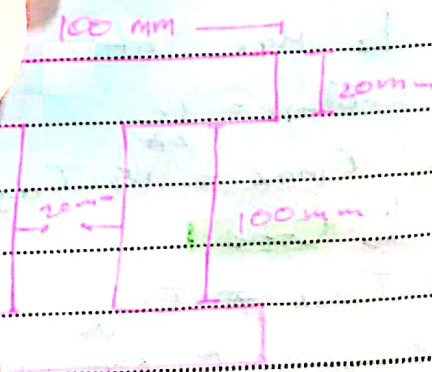
We need to solve Questions find value for $V \Rightarrow$ it's V_{max} we calculate it from shear diagram & we take Max Value.

$$T_{max} = \frac{3}{2} \times \frac{1000}{A}$$

$$= \frac{93.75 \times 10^4}{100 \times 100} \frac{N}{m^2}$$

$$T_{min} = 0$$

Ex: Composet :-



Subject :

15 / 3 / 2022 Tues

* هذا الارتفاع مناسب لنا

(N.A) center of mass Axis

$$\bar{y} = \frac{\sum y}{2} = \frac{20 + 100 + 20}{2} = \frac{140}{2} = 70 \text{ mm}$$

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

(to all cross sections)

$$b = 100 \text{ mm}$$

$$I_{\text{tot}} = \frac{1}{12} \times 0.02 \text{ m} \times (0.100)^3 + 2 \left(\frac{1}{12} \times (0.1) (0.02)^3 \right) + 20 \times 100 \times 60^2$$

two flange equal geometry
lower flange
upper

$$2(I + Ad^2)$$

$$I_{\text{tot}} = 16.2 \times 10^{-6} \text{ m}^4$$

$$b = 100 \text{ mm}$$

$$\bar{y} = 50 + 10 = 60 \text{ mm}$$

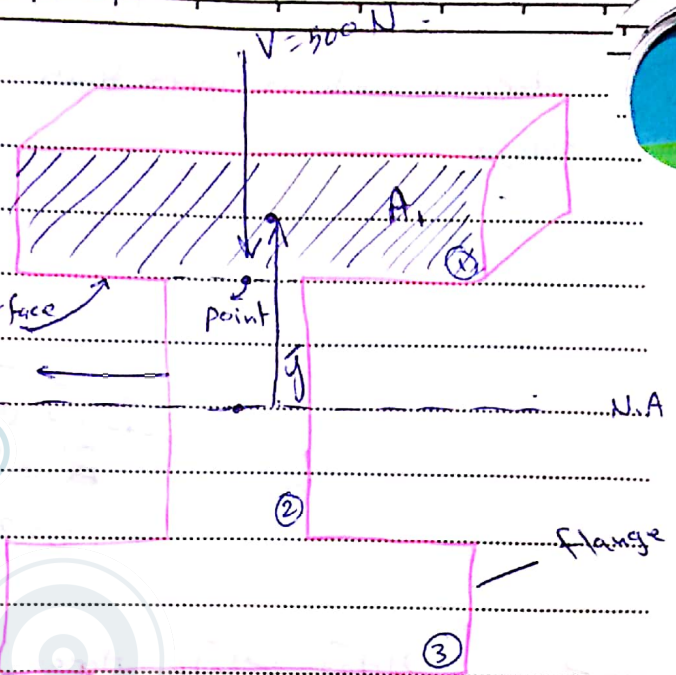
$$A' = 20 \times 100$$

$$Q = \bar{y} A = \left(\frac{60}{1000} \right) \left(\frac{20}{1000} \times \frac{100}{1000} \right) = 120 \times 10^{-6} \text{ m}^3$$

$$\tau = \frac{500 \times 120 \times 10^{-6}}{160 \times 10^{-6} \times 0.1}$$

at the upper surface of the web?

ولا يتغير مع الارتفاع هو متغير ال



* لا يكون عنا ارتفاع مناسب
center of mass (N.A)
فوق نقطة عطفنا إذا لم تكن مناسبة
center Axis &
بيننا إذا لم تكن مناسبة
y = \sum y_i A_i / \sum A_i
(1) القطعة فوق أكبر من تحتها
لذلك نأخذ (اللي فوقت)
بالوسط (اللي تحت)
العقل متساوية
(2) (اللي فوق)

$$b_1 = 0.06 \text{ m}, b_2 = 0, A_1 = 0.1 \times 0.02 = A_2$$

$$A_2 = 0.02 \times 0.1, I_1 = \frac{1}{12} \times 0.1 \times 0.02^3 = I_2$$

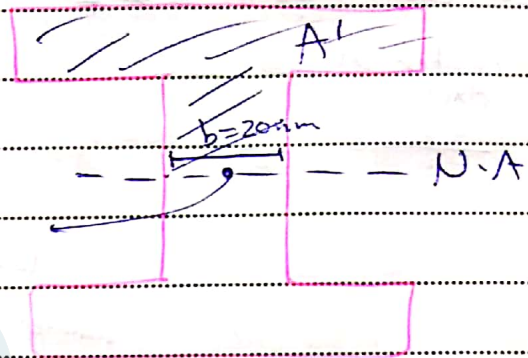
$$I_2 = \frac{1}{12} \times 0.02 \times 0.1^3 = 1.67 \times 10^{-6} \text{ m}^4$$

$$I_{\text{tot}} = \sum I_i + A_i d_i^2$$

$$= 2(0.066 \times 10^{-6} \times 0.02 \times 0.1 \times 0.06^2) +$$

$$I_1 = I_2 (1.67 \times 10^{-6} \times 0.02 \times 0.1 \times 0^2) = 16.2 \times 10^{-6}$$

Stress in web is more than flange -



if point here
like as
بالتالي
A1 & b
b=20mm

* Stress in flanges is less than in web Areas of flanges is less than in web
 $\sigma = \frac{My}{I} \Rightarrow I \uparrow \sigma \downarrow$

* Shear stresses in circular section:-

$$\tau = \frac{4V(R^2 - y_1^2)}{3\pi R^4}$$

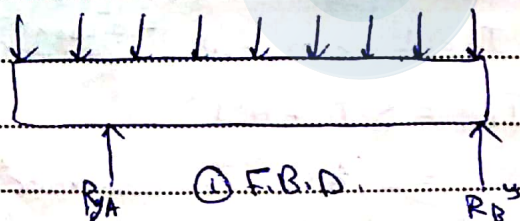
less than in web

Max in N.A $y=0$

Min in Edge $y=R$

Solve:- 3-35 to 3-38 (Ex: 3-38) ***

Ex: 3-38:-



(2) Find R_A & R_B .

Subject :

Take R_B (at B.) $\rightarrow$

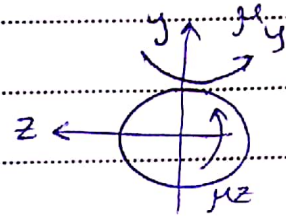
* عكس الناحية (Left hand side).

② $\sum M_B = 0$

$\frac{4}{3}$

$$R_A^y \times \frac{300}{1000} + -(8 \times 400) \left(\frac{200}{1000} \right) = 0$$

$$R_A^y = \frac{6400}{3}$$



* القوى على y

لذا (z) على y

$$\sum F_y = 0$$

$$\frac{6400}{3} - 3200 + R_B^y = 0$$

$$R_B^y = 3200 - \frac{6400}{3}$$

改善

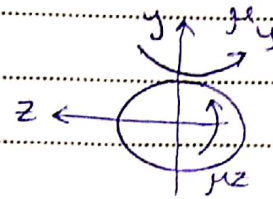
KAIZEN

TEAM

Take R_B (at B.) $\rightarrow$

Left hand side.

(2) $\sum M_B = 0$



$$R_A^y \times \frac{300}{1000} + -(8 \times 400) \left(\frac{200}{1000} \right) = 0$$

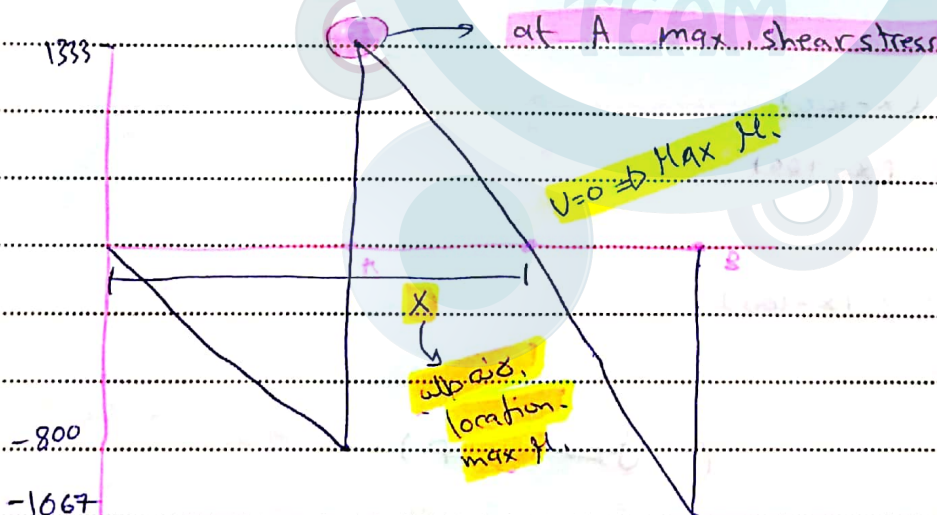
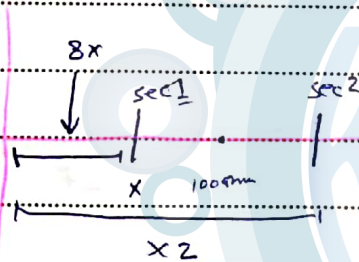
$$R_A^y = \frac{6400}{3}$$

$\sum F^y = 0$

$$\frac{6400}{3} - 3200 + R_B^y = 0$$

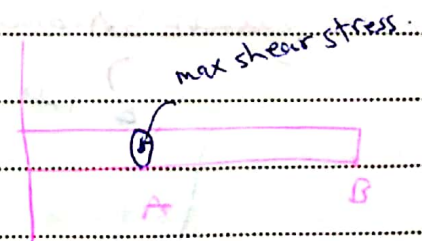
$$R_B^y = 3200 - \frac{6400}{3}$$

$R_A = 2133.3 \text{ kN}$, $R_B = 1067 \text{ kN}$



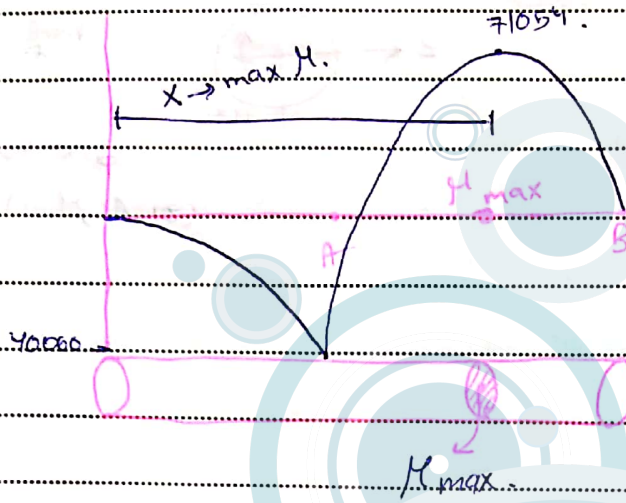
$$\tau_{max} = \frac{4}{3} \times \frac{1333}{\frac{\pi}{4} \left(\frac{30}{1000} \right)^2}$$

$V_{max} = 1333 \text{ kN}$ at $x=1000$

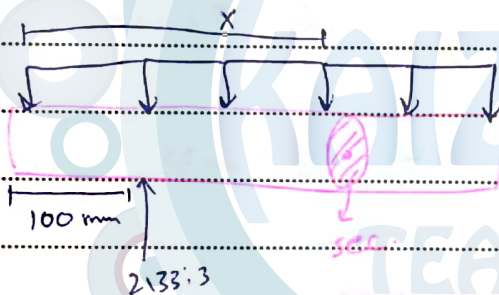
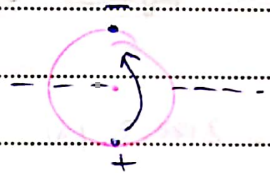


$$\frac{dM}{dx} = V$$

if $V=0 \rightarrow M_{max}$



$$\sigma_{xx} = \frac{Mz}{I_z} = \frac{7105.4 / 1000 \times 15 / 1000}{\frac{\pi}{64} \left(\frac{30}{1000} \right)^4}$$



! $x \rightarrow$ limit *

$\leq b$

$$M = -8 \left(\frac{x}{2} \right) + 2133.3 (x - 100)$$

$$M = -4x^2 + 2133.3 (x - 100)$$

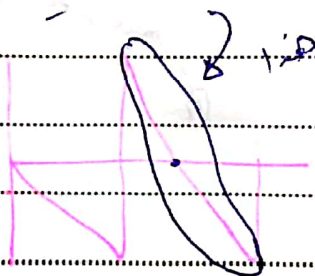
$$M_{max} = 7105.4$$

$$7105.4 = -4x^2 + 2133.3 (x - 100)$$

$\leq b$

nicht bis 0 bis

(-12.15 m)



3-12 :- Torsion :-

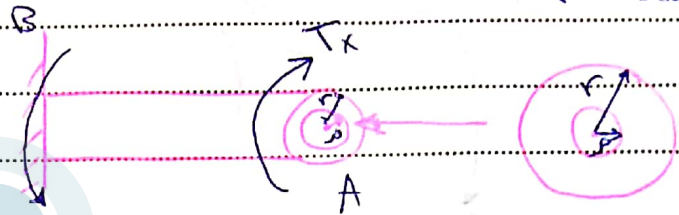
Torque $\rightarrow$ always τ (shear stress)

B.M. $\rightarrow$ (Bending Moment)

$$\sum T = 0$$

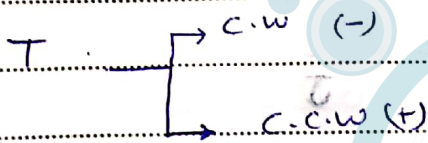
$$-T_A + T_B = 0$$

$$T_B = T_A$$



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

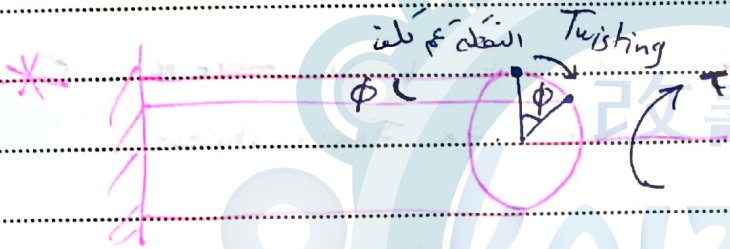
J : Polar moment of area.



$$J = \frac{\pi}{32} D^4$$

body dist. $\rightarrow$ (body distance)

shear stress (in Twisting)



ρ : Distance from shaft axis to point of interest.

r : radius (to outer surface), or shaft radius.

Or ϕ : Twisting angle



A with respect to C (shear strain)

γ : shear stress (strain) , θ : angle of twist

$$\theta = \frac{TL}{GJ}$$

G : Modulus of rigidity

modulus of rigidity

if T, G, J constant

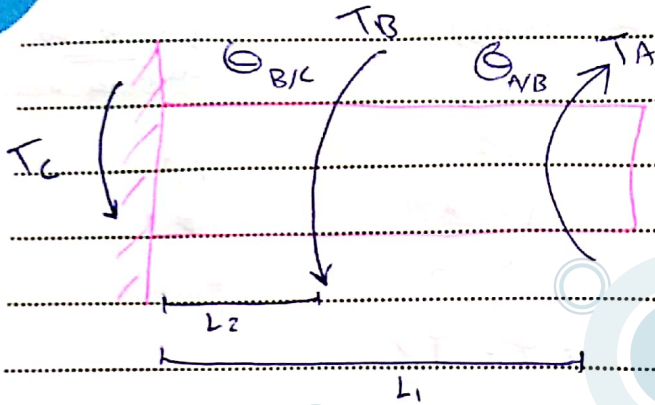
$L \uparrow$

$\theta \uparrow$

This formula at Torque constant

modulus of rigidity (modulus of rigidity)

* Ex. :-



$$\sum T = 0$$

$$-T_A + T_B + T_C = 0$$

$$\theta_{A/B} = \frac{T_B L_1}{GJ}$$

A respect to B

$$\theta_{B/C} = \frac{T_C L_2}{GJ}$$

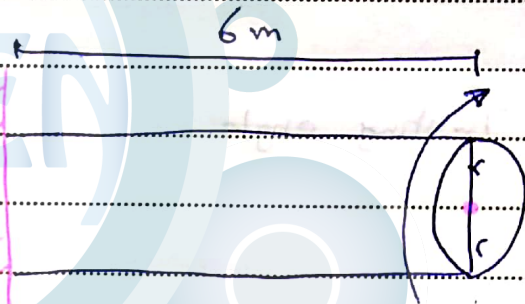
$$\theta_{A/C} = \theta_{A/B} + \theta_{B/C} = \theta_{A/C}$$

Ex. What is max. diameter if it will not twist more than 3° if $L = 6\text{m}$ & Torque = 12 kN-m . what Max Shear stress use $G = 82\text{ GPa}$.

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

$$\theta = \frac{TL}{GL}$$

$$J = \frac{\pi}{32} D^4$$



$$T = 12\text{ kN-m}$$

* Max shear stress at $\rho = r$

$$J = \frac{I_r}{r}$$

$$J = \frac{TL}{G\theta} = \frac{12 \times 10^3 \times 6}{82 \times 10^9 \times \frac{3}{180} \pi}$$

$$\theta = 3^\circ$$

$$180^\circ \rightarrow \pi$$

$$3^\circ \rightarrow \frac{3}{180} \pi$$

$$\frac{3 \times \pi}{180}$$

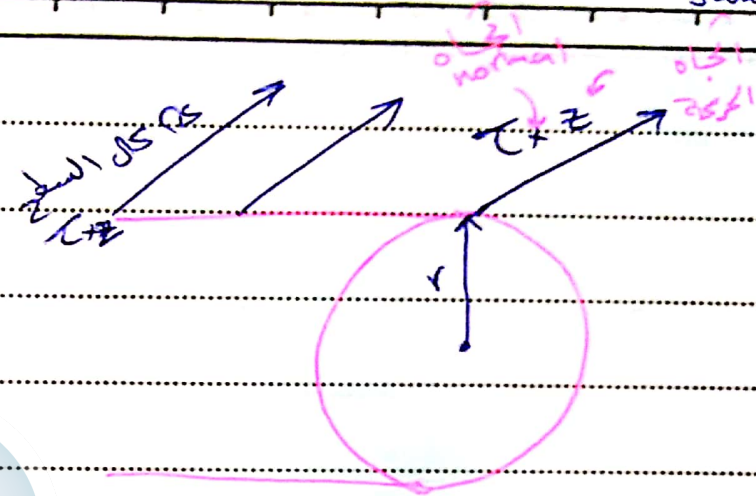
$$J = \frac{\pi D^4}{32} = \frac{12 \times 10^3 \times 6}{82 \times 10^9 \times \frac{3}{180} \pi}$$

$$D = 114.32\text{ mm}$$

► Subject :

20 / 3 / 2022 Sun

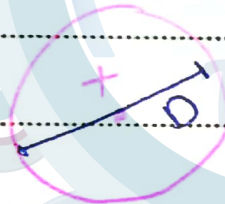
$$\tau_{max} = \frac{T}{J} r = \frac{12 \times 10^3 \times \frac{114.32}{1000}}{\frac{\pi}{32} \cdot (114.32)^4} = 40.9 \text{ Pa}$$



Note:-

Solid

①



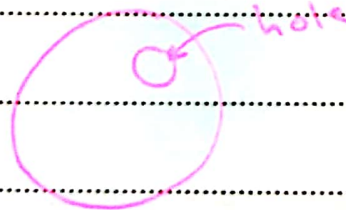
if same center.

we use

$$J = \frac{\pi}{32} D^4 - \frac{\pi}{32} d^4$$

* ملاحظة : إذا ما كان الـ two center
للشكلين نفس الـ axis ما يعني استخدم قانون
(الرقيق) - (الصغير)

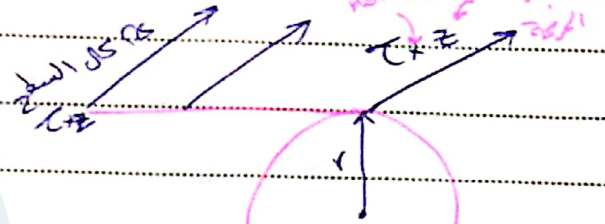
②



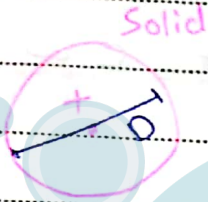
not in center (limited center theorem).

* ينسحب أول بديع ينسحب

$$\tau_{max} = \frac{T r}{J} = \frac{12 \times 10^3 \times \frac{114.32}{2}}{\frac{\pi}{32} \cdot (114.32)^4} = 40.9 \text{ Pa}$$



Notes:-



if same center:

we use

$$J = \frac{\pi}{32} D^4 - \frac{\pi}{32} d^4$$

* ملاحظة : إذا كان الـ two center للشيء نفسه الـ xix ماربير استخدم قانون (الرعي) - (الصغير)

2



not in center (limited center theorem)

* ينشأ أول بديع ينشأ

Ex:- Calc. Angle of twist at

(C) with respect to A: G=32

GP921

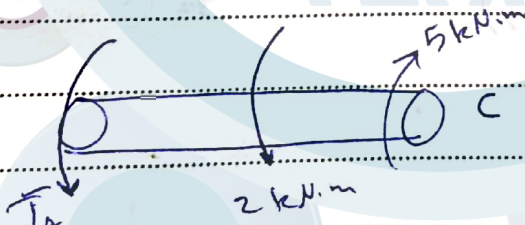
D=75mm

d=60mm



Solu:

FBD:



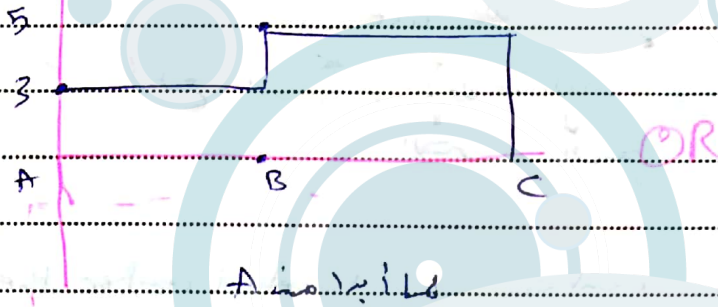
$$\sum T = 0$$

$$-5 + 2 + T_A = 0$$

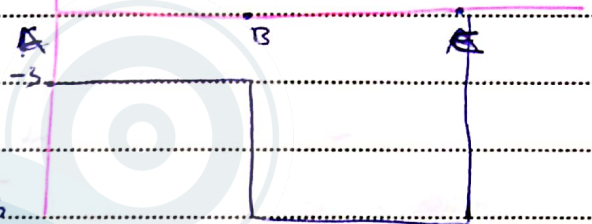
$$\Rightarrow T_A = 3 \text{ kN.m.}$$



$$\Theta : C.W = (-)$$



①



②

Clockwise

②

$$\Theta_{C/A} = \Theta_{C/B} + \Theta_{B/A} \quad \checkmark$$

$$\textcircled{1} \quad \Theta_{A/C} = \Theta_{A/B} + \Theta_{B/C} \quad \checkmark$$

$$* \textcircled{2} \quad \Theta_{C/A} = \Theta_{C/B} + \Theta_{B/A}$$

$$= -5 \times \frac{500}{1000} \times 10^3$$

$$+ \frac{82 \times \frac{\pi}{32} \left(\left(\frac{75}{1000} \right)^4 - \left(\frac{60}{1000} \right)^4 \right)}{}$$

$$+ \frac{-3 \times 10^3 \times \frac{400}{1000}}{}$$

$$\frac{82 \times \frac{\pi}{32} \left(\left(\frac{75}{1000} \right)^4 - \left(\frac{60}{1000} \right)^4 \right)}{}$$

$$= -0.0252 \text{ rad.}$$

(Clockwise, as go)



$$* \textcircled{1} \quad \Theta_{A/C} = \Theta_{A/B} + \Theta_{B/C}$$

$$= 3 \times \frac{400}{1000} \times 10^3$$

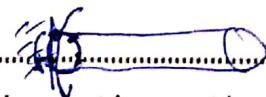
$$+ \frac{82 \times \frac{\pi}{32} \left(\left(\frac{75}{1000} \right)^4 - \left(\frac{60}{1000} \right)^4 \right)}{}$$

$$+ \frac{5 \times 10^3 \times \frac{500}{1000}}{}$$

$$\frac{82 \times \frac{\pi}{32} \left(\left(\frac{75}{1000} \right)^4 - \left(\frac{60}{1000} \right)^4 \right)}{}$$

$$= +0.0252 \text{ rad}$$

(+) (Clockwise, as go)



3-18 :- Curved Beams in Bending :-

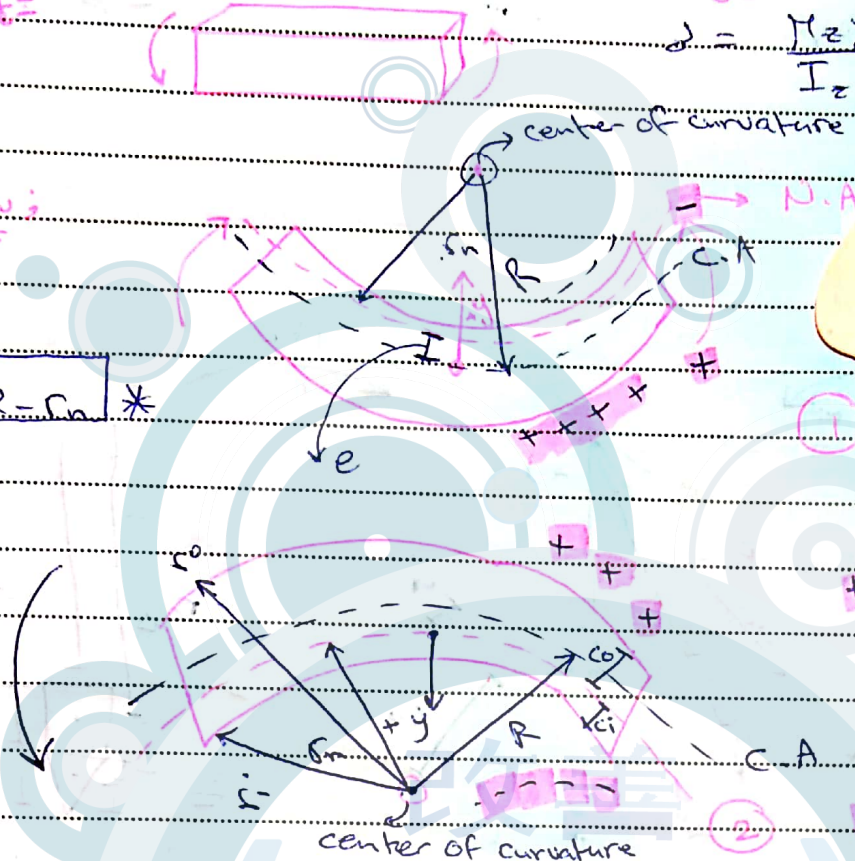
* $\delta =$

$$\delta = \frac{Mz}{I_z}$$

* Now:

$$* e = R - r_n *$$

في هذا الشكل
نرى أن مركز
الكتلة (C.A) في
ب.م.م



$$* r_n - c_i = r_i$$

$$* r_n + c_o = r_o$$

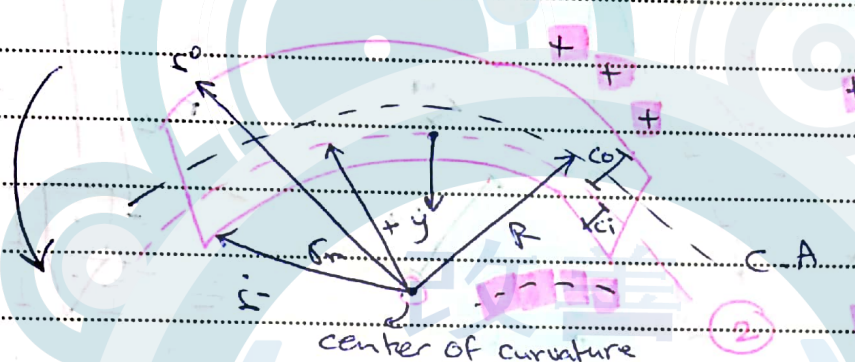
$$* e = R - r_n$$

↳ Radius of center Axis (C.A)

N.A. في هذا الشكل : مركز
center of curvature

C.A. في هذا الشكل : مركز

في هذا الشكل
نرى أن مركز
الكتلة (C.A) في
ب.م.م



$$* \text{Let Outer Surface (O.S)} = -c_o$$

$$* \text{Let Inner " (I.S)} = +c_i$$

$$* \delta = \frac{My}{Ae(r_n - y)}$$

* استمرارية

$$\delta (\text{outer surface}) = \frac{M(-c_o)}{Ae(r_n - y)}$$

$$= \frac{M(-c_o)}{Ae(r_n - (-c_o))}$$

$$= \frac{-M c_o}{Ae(r_n + c_o)}$$

$$\delta (\text{inner surface}) = \frac{M(c_i)}{Ae(r_n - c_i)}$$

R: radius of center Axis.
r_n: radius of neutral Axis.

r_o: Outer radius of curvature.
r_i: Inner " " of curvature.

c_o: distance from N.A. to " outer radius.
c_i: " " " " inner " "

e: distance from C.A. to the N.A. ; measured towards centre of curvature.

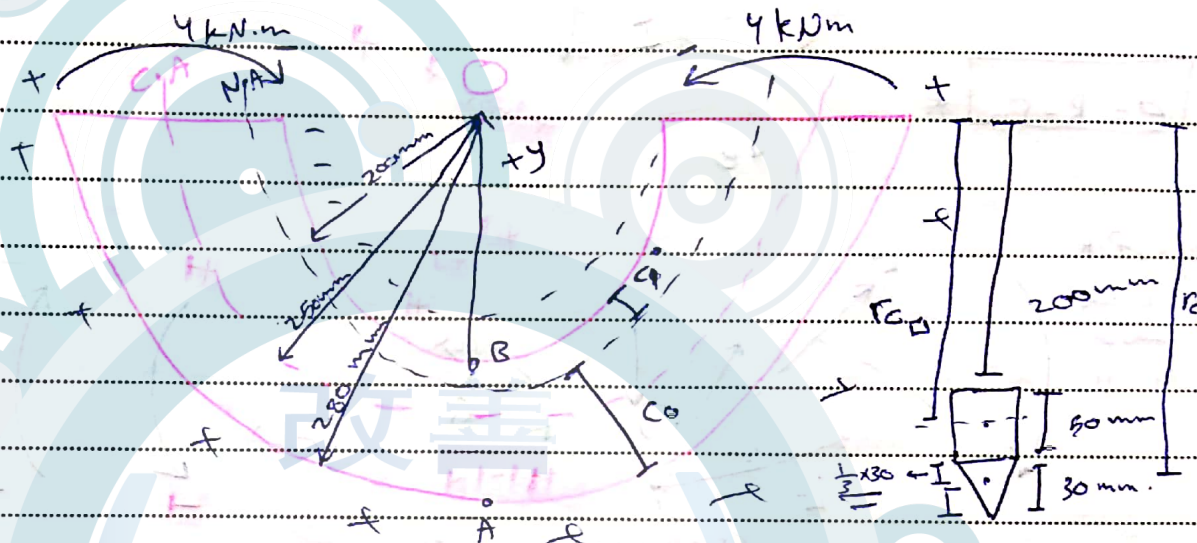
* Note: N.A. btw C.A. & center of curvature (always)

$$* r_n = \frac{\sum A}{\sum \int dA/r}$$

from table

$$r_c = \frac{\sum \bar{r} A}{\sum A}$$

Ex:- The curved bar has a cross-sec. if it is subjected to bending moment of 4 kNm, det: the Max normal stress developed in the bar?



$$\sigma = \frac{My}{Ae(r_n - y)}$$

البار منحنى
المنطقة المقطعية
كلت الأضلاع

$$\sum A = 50 \times 50 + \frac{1}{2} \times 50 \times 30 = 3.25 \times 10^{-3} \text{ m}^2$$

$$r_c = \frac{\sum \bar{r} A}{\sum A} = \frac{225 (50 \times 50) + (250 + 10) \times \frac{1}{2} \times 50 \times 30}{50 \times 50 + \frac{1}{2} \times 50 \times 30} \div 1000$$

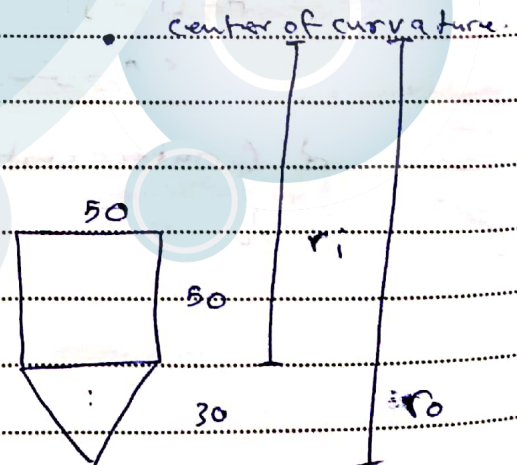
$$= 233.08 \text{ mm}$$

$$= 0.23308 \text{ m}$$

$$r_n = \frac{\sum A}{\sum \int \frac{dA}{r}}$$

$$Area \Delta = b (r_o - r_i) / 2$$

$$\begin{aligned} \int \frac{dA}{r} &= \frac{b r_o}{r_o - r_i} \ln \left(\frac{r_o}{r_i} \right) - b \\ &= \left(\frac{50 \times 280}{280 - 250} \right) \ln \left(\frac{280}{250} \right) - 50 \div 1000 \\ &= 0.20289 \text{ m} \end{aligned}$$



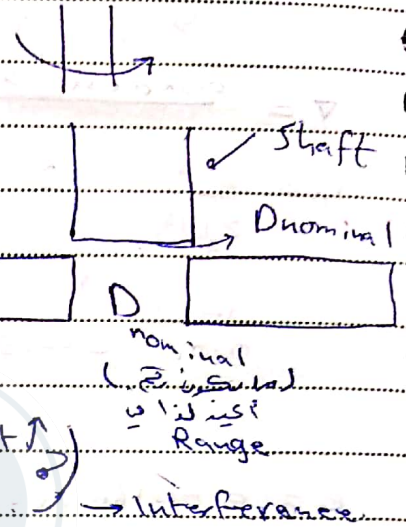
3-16 :- Press & shrink Fits :-

shaft →

Rotation & i.e. 1)



Hub
(gear
pulley)



(* Range shaft ↑
Range Hub ↓) → Interference

$$d_{shaft} = d_{nominal} \pm 0.001$$

* R: Outer radius to shaft

* r_i → if shaft hollow

$$D_{hub} = D_{nominal} + 0.0003$$

* if solid → $r_i = 0$

$$d_{min} = d_n - 0.001$$

* r_o : outer radius to hub

$$d_{max} = d_n + 0.001$$

$$D_{max} = D_n + 0.0003$$

$$D_{min} = D_n - 0.0003$$

shaft
hub

$$* d_{max} - D_{min} = \delta \rightarrow \text{Interference impossible (- or 0)}$$

↳ (+) Always bec. (pressure & friction)

* $P A_{circumference}$ (contact Area btw two surface)

$$* A_c = 2\pi R t \rightarrow \text{thickness (width, } t)$$

$$* M P A_c = F_H = F_{friction}$$

Hub → Steel Always.

(pressure (stress))

shaft radius

$$P = \frac{\delta E}{R} \left[\frac{(r_o^2 - R^2) \times (R^2 - r_i^2)}{2 R^2 (r_o^2 - r_i^2)} \right]$$

$d_{max} - D_{min}$

Same Material Hub & shaft.

(Steel (نحاس))

$E = 200 \text{ GPa}$
 (نحاس) $E = 200 \text{ GPa}$

R : radius to shaft

r_o : radius of hub

Ex: Solid shaft is to be press fit into a gear hub. Find max. stresses in the shaft & the hub. Both are made of carbon steel ($E = 30 \times 10^6 \text{ psi}$, $\nu = 0.3$)

$R = 0.5 \text{ in}$ (nominal)

solid

$\Rightarrow d = 1 \text{ in}$

$r_i = 0$ (not hole)

shaft

$$\delta = d_{max} - D_{min}$$

$r_o = 1 \text{ in}$, $R = 0.5 \text{ in}$

Tolerances: $+2.3 \times 10^{-3} / +1.8 \times 10^{-3} \text{ in}$

inner diameter

$$d_{shaft} = 1 + 2.3 \times 10^{-3} \rightarrow \text{max}$$

$$1 + 1.8 \times 10^{-3} \rightarrow \text{min}$$

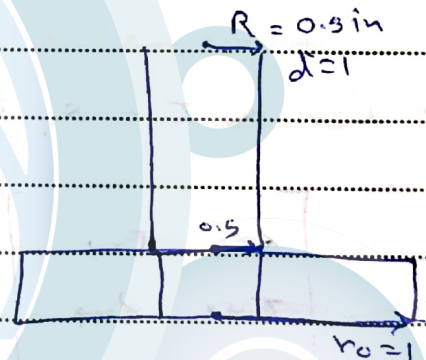
inner diameter

inner diameter

$$D_{hub} = 1 + 0 \rightarrow \text{min}$$

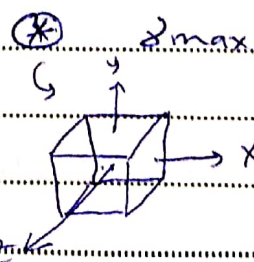
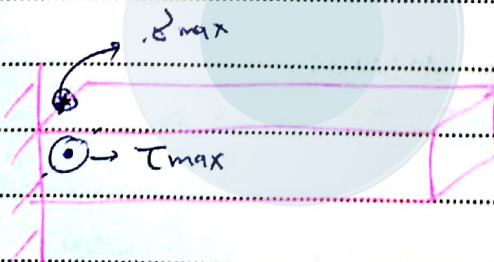
$$1 + 0.8 \times 10^{-3} \rightarrow \text{max}$$

$$\delta = (1 + 2.3 \times 10^{-3}) - (1) = 2.3 \times 10^{-3}$$



$$P = \frac{\delta E}{R} \left[\frac{(1^2 - 0.5^2) (0.5^2 - 0)}{(2 \times (0.5)^2 (1^2 - 0))} \right]$$

$F_f ? = \text{MPA in}$ OR $F = P 2 \pi R L$



كل السجلات

Subject : _____

$$\begin{bmatrix} \sigma_{xx} & \tau_{xy} & \tau_{xz} \\ \tau_{yx} & \sigma_{yy} & \tau_{yz} \\ \tau_{zx} & \tau_{zy} & \sigma_{zz} \end{bmatrix}$$



stresses $\rightarrow$ $3 \times 3 = 9$

* Order:

* كيف أكتبها؟ ما دلتج عدد نفسه

$$\tau_{yx} = \tau_{xy} \quad \text{دلتج ما دلتج حول (z)}$$

$$\tau_{yz} = \tau_{zy} \quad \text{دلتج ما دلتج حول (x)}$$

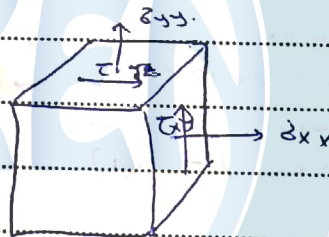
$$\tau_{xz} = \tau_{zx} \quad \text{دلتج ما دلتج حول (y)}$$

$$9 - 3 = 6 \quad \text{static Equilibrium}$$

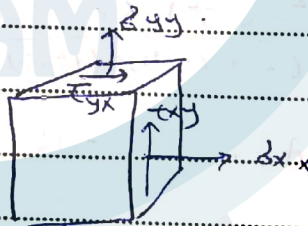
if $\sigma_{zz} \& \tau_{xz} \& \tau_{zy} = 0$

لكن ما دلتج (plane stress)

$$\begin{bmatrix} \sigma_{xx} & \tau_{xy} \\ \tau_{yx} & \sigma_{yy} \end{bmatrix}$$



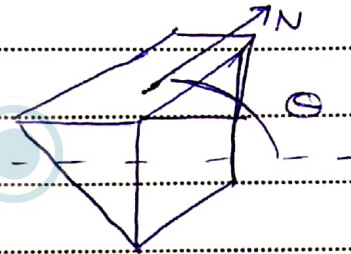
$$\begin{bmatrix} \sigma_{xx} & \tau_{xy} \\ \tau_{yx} & \sigma_{yy} \end{bmatrix}$$



plane stress

+ ← c.c.w (clockwise) *

- ← c.w

X-axis, line θ is normal to the plane *

(+) c.c.w (clockwise) *

(-) c.w

$$\sigma_{x_1x_1} = \frac{\sigma_{xx} + \sigma_{yy}}{2} + \frac{\sigma_{xx} - \sigma_{yy}}{2} \cos 2\theta + \tau_{xy} \sin 2\theta$$

$$\sigma_{y_1y_1} = \frac{\sigma_{xx} + \sigma_{yy}}{2} - \frac{\sigma_{xx} - \sigma_{yy}}{2} \cos 2\theta - \tau_{xy} \sin 2\theta$$

$$\tau_{x_1y_1} = \frac{\sigma_{xx} - \sigma_{yy}}{2} \sin 2\theta + \tau_{xy} \cos 2\theta$$

normal stress = Min. & Max. stress *
 direction of the plane

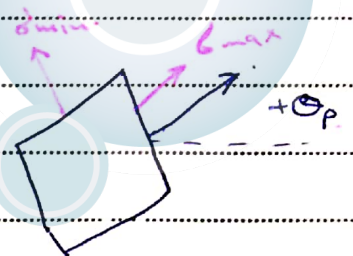
* direction of the plane *

$$\sigma_{\max/\min} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{\left(\frac{\sigma_x - \sigma_y}{2}\right)^2 + \tau_{xy}^2}$$

$$\tan 2\theta_p = \frac{2\tau_{xy}}{\sigma_x - \sigma_y}$$

principle plane

$$\theta_s = \theta_p + 45$$

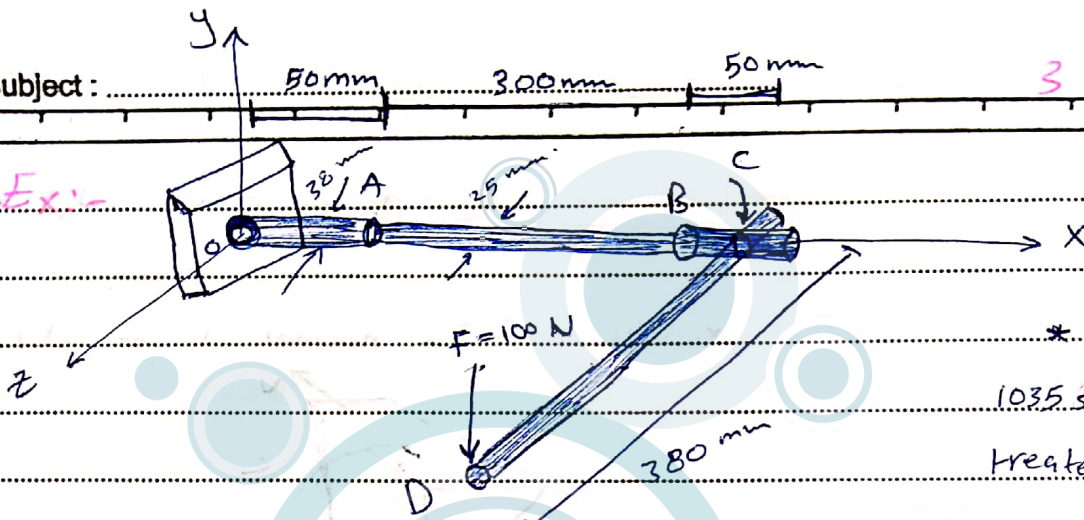


principle plane no relates with applied stresses

Subject :

3/4/2022

Ex:-



* Material : AISI

1035 steel, forged & heat treated.

applied $\tau_{max} = \sqrt{\left(\frac{\sigma_{xx} - \sigma_{yy}}{2}\right)^2 + \tau_{xy}^2} = \frac{\sigma_y}{2}$ yielding.

if $\tau_{max} < \frac{\sigma_y}{2}$ No yielding.

critical cross-section ← Max principal stress cross-section

(Torsion) & Bending (Load) → Normal Stress & Shear Stress

Bending & Torsion

* معرفة زاوية الحمل B.M و Torque في نقطة
 $M = F \times r$ (زاوية الحمل B.M و Torque في نقطة)
 Normal Stress (توتر) و Shear Stress (قص)
 Normal Stress (توتر) و Shear Stress (قص)
 Bending Moment (عزم انحناء) و Torque (عزم دوران)

$$T = r \times F$$

$$= \frac{380}{1000} \times 100 = 38 \text{ N.m}$$



Bending. Line (c)

radius (دائرة)

$$\sigma = \frac{M_z y}{I_z}, I_z = \frac{\pi D^4}{64}$$

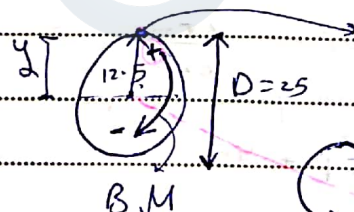
$$\sigma_{xx} = \left(\frac{380}{1000} \times 100\right) \times \frac{12.5}{1000}$$

(+)

$$\frac{\pi}{64} \times \left(\frac{25}{1000}\right)^4$$

$$= 22.8 \text{ MPa}$$

$$\tau = \frac{T r}{J} = \frac{38 \times \frac{12.5}{1000}}{\frac{\pi}{32} \left(\frac{25}{1000}\right)^4} = 12.39 \text{ MPa}$$



B.M

الخط A = نقطة

Subject :

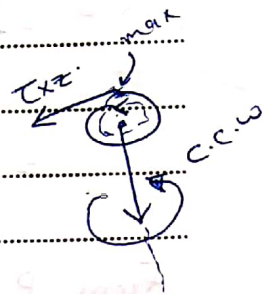
* At point A :-

$$\sigma_{xx} = 22.8$$

$$\sigma_{yy} = \text{zero}$$

$$\tau_{max} = \sqrt{\left(\frac{22.8 - 0}{2}\right)^2 + (12.39)^2} = 16.84 \text{ MPa}$$

σ_{xx} $\leftarrow$ T



generated σ_{xx}

applied σ_{xx}

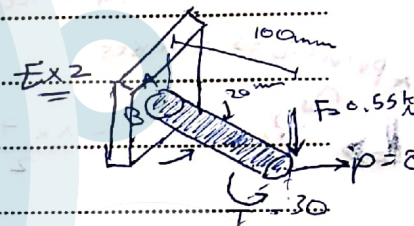
$$16.84 \leq \frac{55.8}{2}$$

$$16.84 < \frac{55.8}{2}$$

so it will not yield.

Weld SOF :- $n = \frac{\frac{55.8}{2}}{\tau_{max}} = \frac{\frac{\sigma_y}{2}}{\tau_{max}}$

Tresca



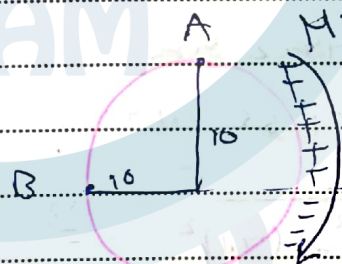
Ex: 2

$$\sigma_y = 331 \text{ MPa}$$

T at A or B

same

$$\tau = \frac{T_r}{J} \rightarrow \text{A or B}$$



$$M = 55 \text{ N.m}$$

Max shear stress at N.A.

We have distance r

$$r = \frac{100}{1000} \times 0.55 \times 10^3$$

calc. σ & τ

So Bending.

* σ (normal) from B.M from M at B = 0 w.A at B's

$$\tau = \frac{30 \times (10/1000)}{\frac{\pi}{32} \left(\frac{20}{1000}\right)^4} = 19.8 \text{ MPa}$$

Subject :

From $F =$

$$\sigma_{xx} = \frac{Mz}{I_z}$$

حساب
الضغط

$$= - \frac{55 \times \frac{10}{1000}}{\frac{\pi}{64} \left(\frac{20}{1000} \right)^4}$$

$$= +$$

B in N.A $\rightarrow$ so $M=0$
but at A $\rightarrow M_{\max}$.

or (+) bec. above N.A.

From P :- P on cross-sec. (axis // R)

$$\sigma = \frac{8 \times 10^3}{\frac{\pi}{4} \left(\frac{20}{1000} \right)^2}$$

Tension $\rightarrow$

(-) $\leftarrow$ compression

σ_{Total} at A :-

$$= \frac{55 \times \frac{10}{1000}}{\frac{\pi}{64} \left(\frac{20}{1000} \right)^4} + \frac{8 \times 10^3}{\frac{\pi}{4} \left(\frac{20}{1000} \right)^2} = 95.5 \text{ MPa}$$

* Principles stresses

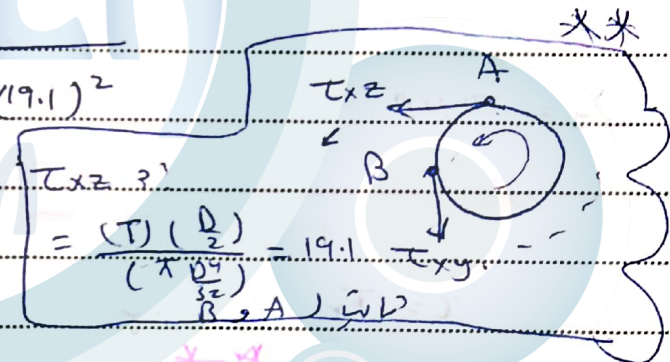
$$\sigma_{1,2} = \frac{\sigma_{xx} + \sigma_{yy}}{2} \pm \sqrt{\left(\frac{\sigma_{xx} - \sigma_{yy}}{2} \right)^2 + \tau_{xy}^2}$$

$\sigma_{yy} = \text{zero}$

$$= \frac{95.5 + 0}{2} \pm \sqrt{\left(\frac{95.5 - 0}{2} \right)^2 + (19.1)^2}$$

$$\sigma_1 \rightarrow \text{Max} = 99.2 \text{ MPa}$$

$$\sigma_2 \rightarrow \text{min} = -3.63 \text{ MPa}$$



$$\tau_{\max} = \sqrt{\left(\frac{95.5}{2} \right)^2 + (19.1)^2} \stackrel{!}{=} \frac{\sigma_y}{2}$$

if $= \rightarrow$ yielding
if not $\rightarrow$ not ~

3-7 General 2-Dimensional stress

Triaxial

حالت ثلاثية الأبعاد للضغط

* Method 1 : طريقة 1 - τ موجود في

$$\sigma_{x-y} = \frac{\sigma_{xx} + \sigma_{yy}}{2} \pm \sqrt{\left(\frac{\sigma_{xx} - \sigma_{yy}}{2}\right)^2 + \tau_{xy}^2}$$

$$\sigma_{y-z} = \frac{\sigma_{yy} + \sigma_{zz}}{2} \pm \sqrt{\left(\frac{\sigma_{yy} - \sigma_{zz}}{2}\right)^2 + \tau_{yz}^2}$$

$$\sigma_{z-x} = \frac{\sigma_{zz} + \sigma_{xx}}{2} \pm \sqrt{\left(\frac{\sigma_{zz} - \sigma_{xx}}{2}\right)^2 + \tau_{zx}^2}$$

σ_1 , σ_2 , σ_3
 $\swarrow$ $\downarrow$ $\searrow$
 min mid Max

$$\tau_{max} = \frac{\sigma_1 - \sigma_3}{2}$$

* Method 2

$$\sigma^3 - I_1 \sigma^2 + I_2 \sigma - I_3 = 0$$

$$I_1 = \sigma_x + \sigma_y + \sigma_z$$

$$I_2 = \sigma_x \sigma_y + \sigma_x \sigma_z + \sigma_y \sigma_z - \tau_{xy}^2 - \tau_{xz}^2 - \tau_{yz}^2$$

$$I_3 = \sigma_x \sigma_y \sigma_z + 2 \tau_{xy} \tau_{yz} \tau_{zx} - \sigma_x \tau_{yz}^2 - \sigma_y \tau_{zx}^2 - \sigma_z \tau_{xy}^2$$

Find the principle stresses!

كيف أحل 2D و 3D

$$\sigma_{ij} = \begin{bmatrix} 2 & 1 & 0 \\ 1 & 3 & -2 \\ 0 & -2 & 1 \end{bmatrix}$$

3D (diagonal) موجود في σ_{xx} , σ_{yy} , σ_{zz}

Symmetric σ_{ij} لا فرق في σ_{ij} و σ_{ji}

$$I_1 = 6$$

$$I_2 = 6$$

$$I_3 = -3$$

* from formula

method ② $\sigma^3 - 6\sigma^2 + 6\sigma - 3 = 0$

OR

method ①:

$$\begin{aligned} (x-y) \quad \sigma_{1,2} &= \frac{2+3}{2} \pm \sqrt{\left(\frac{2-3}{2}\right)^2 + 1^2} \\ (y-z) \quad \sigma_{1,2} &= \frac{3+1}{2} \pm \sqrt{\left(\frac{3-1}{2}\right)^2 + (-2)^2} \\ (z-x) \quad \sigma_{1,2} &= \frac{2+1}{2} \pm \sqrt{\left(\frac{2-1}{2}\right)^2 + 0} \end{aligned} \quad \left. \begin{array}{l} \\ \\ \end{array} \right\} \text{جز (۳) رج میگیریم}$$

$$\tau_{\max} = \frac{\sigma_1 - \sigma_3}{2}$$

* Tresca :-

$$\tau_{\max} = \frac{\sigma_y}{2} \rightarrow \text{failure}$$

$$n = \frac{\sigma_y}{\tau_{\max}}$$

* Von mises :-

$$\sigma_y = \frac{1}{\sqrt{2}} \sqrt{(\sigma_1 - \sigma_2)^2 + (\sigma_1 - \sigma_3)^2 + (\sigma_2 - \sigma_3)^2}$$

$$n = \frac{\sigma_y}{\frac{1}{\sqrt{2}} \dots}$$

if equal $\rightarrow$ deformation (failure).

* Ex :-

• Det. Max. principal stresses & the max shear stress for the following

• Will the material yield:

↳ von Mises & Tresca

Solve:-

$$I_1 =$$

$$= 20 + 30 - 10 = 40 \text{ MPa.}$$

$$I_2 =$$

$$= -3025 \text{ MPa}$$

$$I_3 =$$

$$= -89500 \text{ MPa}$$

$$\sigma = \begin{bmatrix} 20 & 40 & -30 \\ 40 & 30 & 25 \\ -30 & 25 & -10 \end{bmatrix}$$

$$\sigma^3 - 40\sigma^2 - 3025\sigma - 89500 = 0.$$

$$\sigma_1 = 65.3$$

$$\sigma_2 = 26.5$$

$$\sigma_3 = -51.8$$

$$\tau_{\max} = \frac{\sigma_1 - \sigma_3}{2} = \frac{65.3 + 51.8}{2} = 58.5 \text{ MPa.}$$

if $\sigma_y = 300$.

→ (Tresca):

$$58.5 \stackrel{?}{=} \frac{300}{2} \quad \text{No.} \quad \therefore n = \frac{150}{58.5}$$

→ (Von Mises):

$$300 \stackrel{?}{=} \frac{1}{\sqrt{2}} \sqrt{(65.3 - 26.5)^2 + (65.3 + 51.8)^2 + (26.5 + 51.8)^2}$$

$$300 \stackrel{?}{\geq} 103.31 \quad \text{No.}$$

$$n \text{ (von mises)} = \frac{300}{103.31} \quad \text{sure} > 1$$

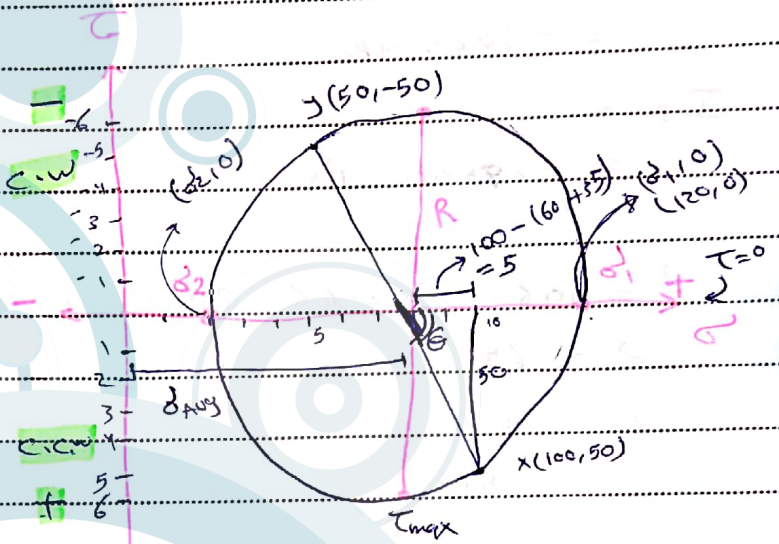
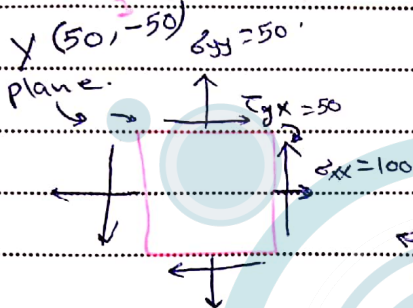
Subject :

* Mohr Circles:-

G plane stress

→ 2-D (Principal stress)

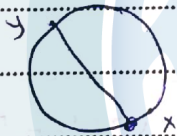
c.w.



① Scale : 1 cm = 10 MPa

② Dir. com -
Tens +

Couple c.c.w +
c.w -



scale

$$\sigma_2 = 3.5 \times 10 = 35 \text{ MPa}$$

$$\sigma_1 = 1.2 \times 10 = 120 \text{ MPa}$$

$$\tau_{max} = 6 \times 10 = 60 \text{ MPa}$$

(sigma_avg, tau_max)

(35+60, 60)

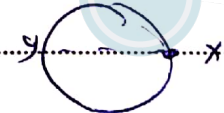
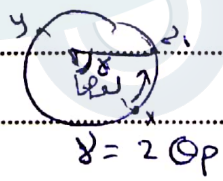
$$\tau_{max} \text{ or } \frac{\sigma_1 - \sigma_2}{2}$$

⊙ b/w x & y ? 90° at

⊙ b/w x & y ? 180° at

$$\frac{\sigma_1}{2} = 90^\circ$$

⊙ element



$$\tan 2\theta_p = \frac{50}{100 - \sigma_{avg}} = \frac{50}{100 - (60 + 35)}$$

$$\tan 2\theta_p = \frac{50}{5} \Rightarrow \theta = \tan^{-1}(10) = + ()$$

S T A R S S N O P T E 2 B O O K

(c.c.w +
c.w -)

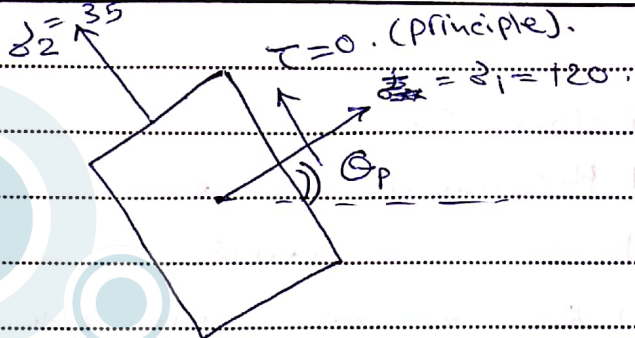
Subject :

/ /

* Note :-

Scale 1:1

$$1 \text{ MPa} = 10 \text{ MPa} = \underline{\underline{10^6}}$$



$$\sigma_{avg} = \frac{\sigma_{xx} + \sigma_{yy}}{2} + \sqrt{\left(\frac{\sigma_{xx} - \sigma_{yy}}{2}\right)^2 + \tau_{xy}^2}$$

$$\sigma_{avg} = \frac{\sigma_{xx} + \sigma_{yy}}{2}$$

$$\sigma_{avg} + R = \sigma_1$$

$$\sigma_{avg} - R = \sigma_2$$

* Stress in a body is given by σ_1 and σ_2 (principal stresses).

$$2\theta_s = 2\theta_p + 90^\circ$$

$$2\theta_s = 2\theta_p + 90^\circ$$

$$\text{if } \theta_p = 60^\circ$$

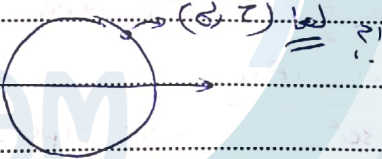
$$2\theta_s = 30^\circ$$



Stress

Circle

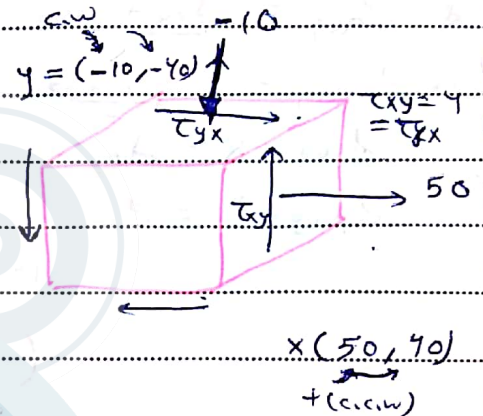
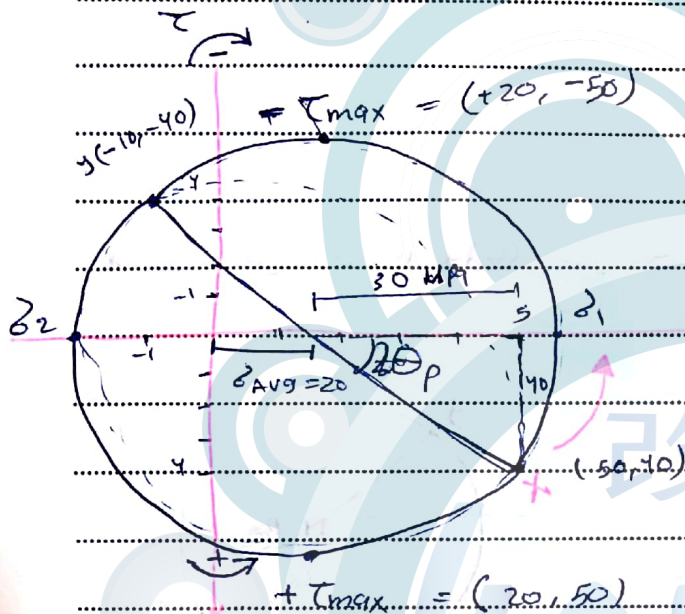
Stress in a body



Ex :-

- Mohr's Circle
- The principle planes
- ~ ~ stress
- The Max. Shearing stress & the corresponding normal stress.

σ_{xx}	τ_{xy}	
50	40	0
τ_{yx}	σ_{yy}	
40	-10	0
0	0	0



Scale 1 cm = 10 MPa.

X (50, 40)

Y (-10, -40)

σ_{AVG} → from (0,0) to center of circle.

$$\sigma_{AVG} = \frac{50 + (-10)}{2} = 20 \text{ MPa} \quad \Rightarrow \text{at scale } 2 \text{ cm}$$

$$\sigma_x - \sigma_{AVG} = 30 \text{ MPa}$$

$$R = \sqrt{40^2 + 30^2} = 50 \text{ MPa}$$

$$\sigma_1 = 20 + 50 = 70 \text{ MPa}$$

$$\sigma_2 = 20 - 50 = -30 \text{ MPa}$$

$$\tau_{max} = R = 50 \text{ MPa}$$

$$\hookrightarrow (20, -50) \quad \text{c.w.}$$

$$(20, 50) \quad \text{c.c.w.}$$

→ If we need move X to $\sigma_1 \Rightarrow$ c.c.w. (anticlockwise)

$$\tan 2\theta_p = \frac{40}{30}$$

$$\theta_p = \tan^{-1}\left(\frac{4}{3}\right) / 2 = +21.6^\circ \quad \text{c.c.w.}$$

Be careful not $2\theta_p$.

$$2Q_s = 2Q_p + 90 \quad (\times 2) \leftarrow$$

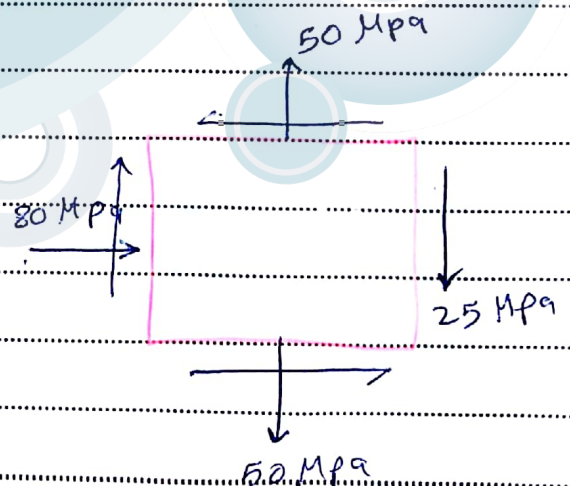
$\ominus \Rightarrow (+)$ c.c.w

$T_{\max} (4p) \Rightarrow (-)$

c.w. ω $\rightarrow$ $\ominus$



Ex:- Find the stresses on an element inclined at 30° clock wise?



► Subject :

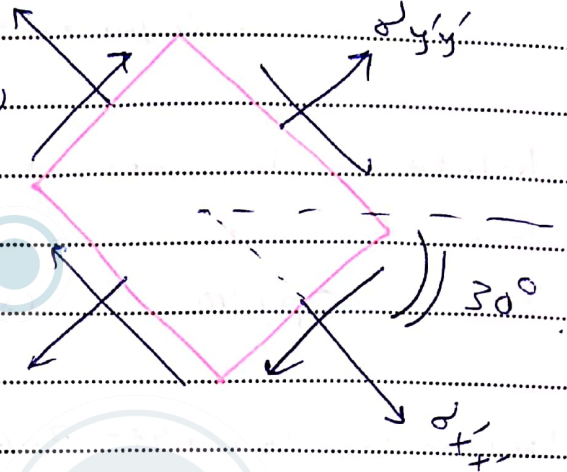
12/4/1 Tues

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

$$= \frac{-80 + 50}{2} + \frac{-80 - 50}{2} \cos(-60) + 25 \sin(-60)$$

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

$$= \frac{-80 + 50}{2} - \frac{-80 - 50}{2} \cos(-60) - 25 \sin(-60)$$



* في أي حال نعطيه إضاحه الجسم
بإحدى حلي مع العواصف دائماً
حقاً لو أنطوان Mohr's sin في باقي السب
مع تواج ضفلة (روما مونا) ١١
* * * لو أنطوان رسته



3-12 is + CH 5: (5-2) stress concentration.

k_e = normal stress.

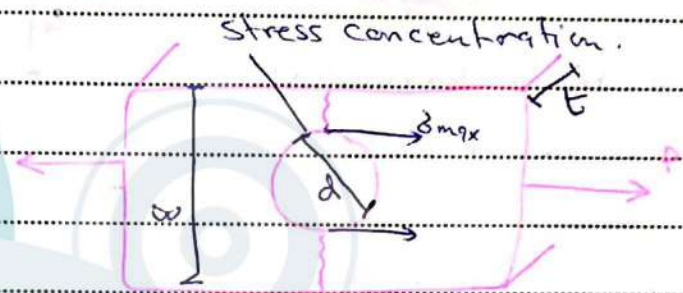
$k_{15} = \text{shear stress}$

spatial stress $\rightarrow \sigma_{max}$ ~~is~~ not principle = $k_t \sigma_0$

$$T_{max} \rightarrow r = r' = k \log 20$$

$$\text{Nominale } g_a = \frac{p}{A_{\text{net}}}$$

$$\Delta_{max} = k_t \frac{P}{A_{net}}$$



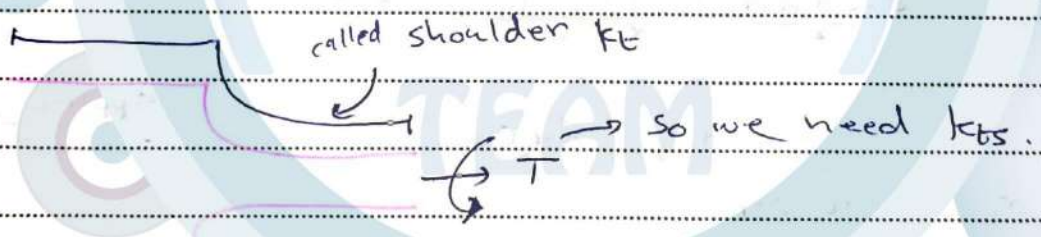
$$\epsilon_0 = \frac{p}{A_{\text{net}}} = \frac{p}{(w-d)t}$$

$$\epsilon_{\text{max}} = k_L \epsilon_0$$

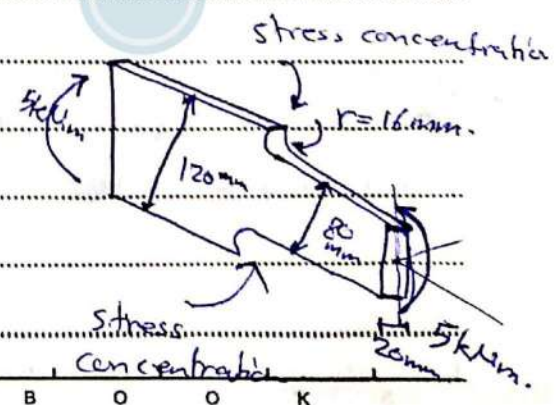
لا يتم زخار نفس السد من الAppendix. هـاي جافه العلاقة بكون الAppendix

بناءً على الشكل فإليك بحاجة واحدة
وتخرج الـ A من الشكل وتطرح على 10

$\Delta_{\max}$ ↑ from Δ_0 (always.)



Ex. - The transition in the cross-sectional area of steel bar is achieved using shoulder fillets. If the bar is subjected to bending moment of 5 kN, determine the max. Normal stress developed in the steel. The yield stress is $\sigma_y = 500 \text{ MPa}$.



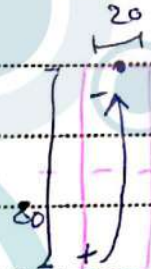
استخدام القانون
 (-) ← compression
 (+) ← Tension
 absolute value بالقيمة
 Factor of safety. فاجاب

17/4/1 Sun

$$\sigma_{xx} = -\frac{My}{I_z}$$

b const. ✓
 h 120
 h = 80

$$\sigma_a = \sigma_{xx} = -\frac{5 \times 10^3 \left(\frac{40}{1000}\right)}{\frac{1}{12} \times \left(\frac{20}{100}\right) \left(\frac{80}{100}\right)^3}$$



الضغط في الأعلى
 الضغط في الأسفل
 الضغط في الأعلى
 الضغط في الأسفل

bec. Normal stress

we need k_t

4-15-6

$$\frac{D}{d} = \frac{120}{80} = 1.5$$

$$\frac{r}{d} = \frac{16}{80} = 0.2$$

$$k_t \approx 1.45$$

applied max principle

$$\sigma_{max} = k_t \sigma_a = 1.45 \times \left(\frac{-5 \times \left(\frac{40}{1000}\right)}{\left(\frac{1}{12} \times \frac{20}{1000} \times \frac{80}{1000}\right)} \right) = -340 \text{ MPa}$$

principle stress = σ_{max} bec we don't have shear

$$\sigma_{1,2} = \frac{\sigma_{xx} + \sigma_{yy}}{2} \pm \sqrt{\left(\frac{\sigma_{xx} - \sigma_{yy}}{2}\right)^2 + \tau_{xy}^2}$$

$$= \frac{340 + 0}{2} \pm \sqrt{\left(\frac{340}{2}\right)^2 + 0}$$

No shear. (applied)

(principle)

Max Normal stress

$$\sigma_1 = 340 \text{ MPa}$$

$$\sigma_2 = 0 \text{ MPa}$$

$$\tau_{max} = \frac{\sigma_1 - \sigma_2}{2} = \frac{340}{2} = 170 \text{ MPa}$$

* $\sigma_{max} \text{ (principle)} = \sigma_{max} \text{ (applied)}$ bec we don't have applied shear τ_{xy}

هذا السؤال الذي حل بس وصلنا بل 50 Kt حسب

Subject: Force و Stress و Gmax و Force و Stress و Gmax و Force و Stress و Gmax

17/4/1 Sun.

Ex: $\Delta x = \frac{My}{I} = \frac{M}{\pi d^4/64}$ bec. cross section is circle

$M = \frac{350 \times 100}{1000} = 35 \text{ Nm}$

$\Delta x = \frac{35 \times \frac{12.5}{1000}}{\frac{\pi}{64} (25/1000)^4} = 22.8$

$\Delta_{max} = 20 \text{ kL}$

Applied stress = 22.8×1.7

= 38.76 MPa

$\tau_o = \frac{T r}{J} = 12.39 \text{ MPa}$

$\tau_{max} = 1.35 \tau_o$

Applied stress = 1.35×12.39

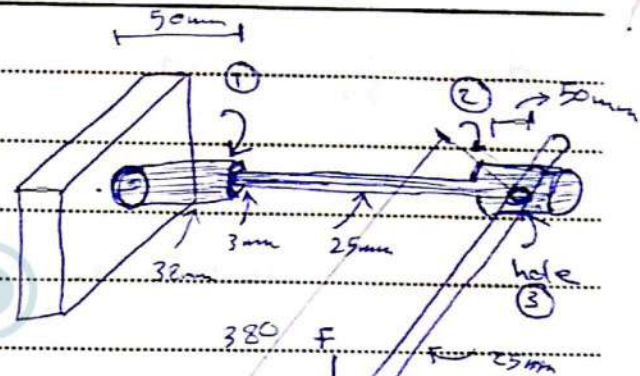
= 16.73 MPa

* kts

$r/d = \frac{3}{25} = 0.12$

$D/d = 38.8/25 = 1.52$

$kts = 1.35$



* 3 stress concentration *

هذا السؤال الذي حل بس وصلنا بل 50 Kt حسب

هذا السؤال الذي حل بس وصلنا بل 50 Kt حسب

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هذا السؤال الذي حل بس وصلنا بل 50 Kt حسب

Ex: Exam Ques: The steel bar is loaded by two axial loads of 1 kN

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

& two axial loads of 1 kN

A at hole & so &

* a critical stress element: det. Principle

Δ_{max} at Hole

Stresses & max shear stress?

stress concentration (discontinuity) → hole

* b. FOS, based upon

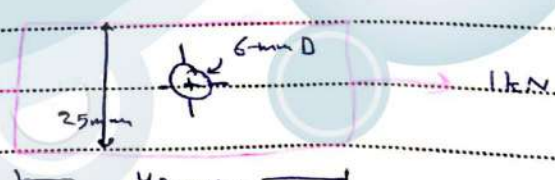
distortion energy theorem

1 kN - given & F

$\Delta x = \Delta_o = \frac{F}{A} = \frac{1 \times 10^3}{(25 - 6) \frac{10}{1000}}$

= $\frac{1 \times 10^3}{(25 - 6) \frac{10}{1000}}$

= 5.263 MPa



Normal force → give Normal stress we need

kts

T A R S N O T E B O O K

Subject :

17 / 4 / 2020

$$\frac{d}{w} = \frac{6}{25} = 0.24$$

$$k_t = 2.42$$

$$\sigma_{max} = 2.42 \times 5.263 = 12.7$$

type of concentration :-
* any different in diameter

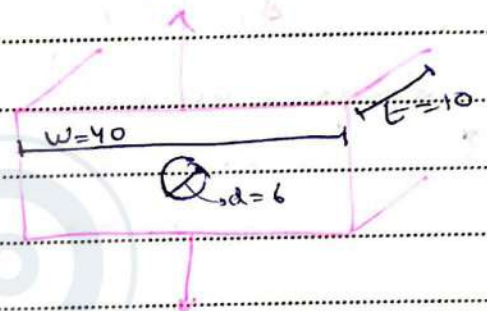
* any hole

* any section

$$200 \text{ N} \leftarrow F \quad \text{القوة (N) } *$$

$$\sigma_{avg} = \frac{F}{A} = \frac{200}{\left(\frac{40}{1000} - \frac{60}{1000}\right) \left(\frac{10}{1000}\right)} = 0.59 \text{ MPa}$$

$(w-d) \cdot t$



$$\frac{d}{w} = \frac{6}{40} = 0.15$$

$$k_t \approx 2.58$$

$$\sigma_{max} = k_t \sigma_{avg}$$

$$= 2.58 (0.59)$$

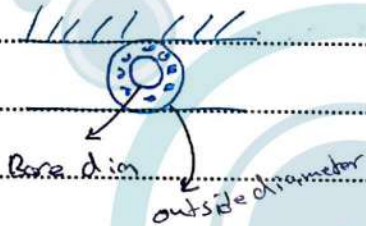
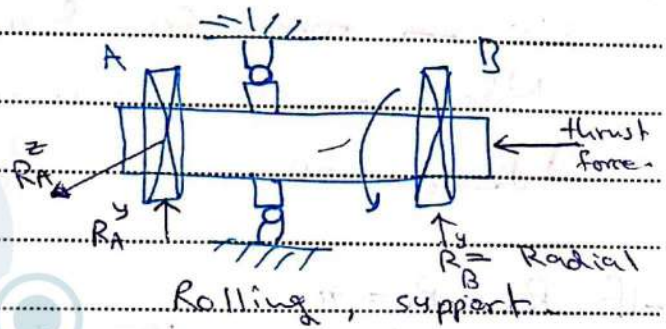
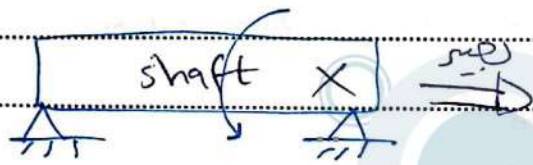
$$= 1.52 \text{ MPa}$$

* استخرج الـ σ_{avg} الـ W الـ t

بـ $\frac{F}{A}$ الـ d الـ W

الـ t الـ d الـ W الـ t

* Rolling - contact Bearing :-



Ball (cylindrical roller bearing)
bearing (SKF)

→ force $\perp$ on it → Radial force
→ force $\parallel$ it → Thrust force

* $\sum F = 0$, $\sum M = 0$, $\sum T = 0$ → & equation & table

→ Ball bearing → SKF → L : rated life
→ Trapped → Timken → $L_{10} = 10^6$ rev.
 $L_{10} = 90 \times 10^6$ rev.

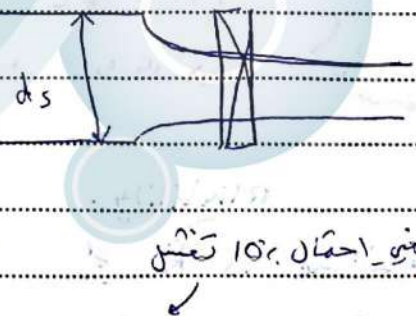
* Table :

if Bore 40 mm

→ C_{10} → load (kN)
 $= 33.2$ kN
→ rated speed → 1300 r.p.m.

$L_{10} = 10^6$ rev → $C_{10} = 33.2$
 $C_{10} = 33.2$

Reliability = 90%
rated



→ revolution to it → life = 10^6 rev if 2- $\square$ are same C_{10} (related to each other).

► Subject : _____

$N_r \rightarrow$ speed from firm = 1300 rpm

$N_{desire} \rightarrow$ if I change it's value = 2000 rpm

$F_{desired} = 50 \rightarrow R_{desired} = 95\%$

- If $R_d = R_r = 90\%$

$$C_{10} (L_{10})^{1/9} = F_d (L_d)^{1/9} \rightarrow \text{to Ball Bearing} = 3.$$

Ex:-

$$L_d = 5000 \text{ hr} \rightarrow \text{rev ?} \quad \begin{array}{l} \text{rev/min} \quad \text{speed rpm} \quad \text{hr/hr} \\ \downarrow \quad \downarrow \quad \downarrow \\ 5000 \times 1725 \times 60 = (\quad) \text{ rev} \end{array}$$

$$N_d = 1725 \quad \therefore L_{10} = 10^6 \text{ rev} \quad \therefore a = 3.$$

$$R_d = 90\%$$

$$F_d = 400 \text{ lb}$$

$\rightarrow$ deep groove ball bearing C_{10}

$$C_{10} * (L_{10})^{1/3} = F_d (L_d)^{1/9}$$

$$C_{10} = 400 \left[\frac{5000 (1725) \times 60}{10^6} \right]^{1/3}$$

$$= 14.3 \text{ kN}$$

بجانب قطر المحاور
بجانب قطر المحاور $\rightarrow 19.5$ so $\phi D = 62 \text{ mm}$

$$\text{Bore dia} = 30 \text{ mm}$$

reliability:

* What is R ?

$$C_{10} \text{ to } R = 90\% = 14.3$$

$$C_{10} \rightarrow \text{we selected} = 19.5 \quad \text{so } R > R = 90\%$$

$$\text{if we choose } C_{10} = 14 \rightarrow \text{ass} \quad R < R = 90\%$$

S T A R S N O T E B O O K

Subject :

24 / 4 / 2022 Sun.

11-6 :-

Radial. $\frac{F_a}{V F_r}$ $\rightarrow$ thrust force.

$$F_{eq} = x_1 V F_r + y_1 F_a$$

Tables :

$\rightarrow$ outer race rotating $V = 1.20$

$\rightarrow$ inner rotating $V = 1$

$\rightarrow$ inner rotating $V = 1$

$V = 1$

$$i = 1 \rightarrow F_e = F_r$$

$$i = 2 \rightarrow F_e = x_2 V + y_2 F_a$$

* Table :-

$$\frac{F_a}{V F_r} \leq e \rightarrow i = 1$$

$$\frac{F_a}{V F_r} > 1 \rightarrow i = 2$$

$\rightarrow$ If peaking attention (تفتيش) $C_o \rightarrow$ from table
 $\hookrightarrow$ check $\frac{F_a}{C_o}$

* If C_o not given :-

1) assume $i = 2$

2) Start $y_2 = 1.63$

3) Find $F_{eq} \Rightarrow F_e = 0.56 V F_r + 1.63 F_a$

$$4) C_{10} = 9.9 F_e \left[\frac{\frac{L_D}{L_{10}}}{x_0 + (18 - x_0)(1 - R)^{1/y_2}} \right]^{1/y_2}$$

5) Tables: C_o

$$6) \frac{F_a}{C_o} \rightarrow e$$

$\rightarrow$ then check

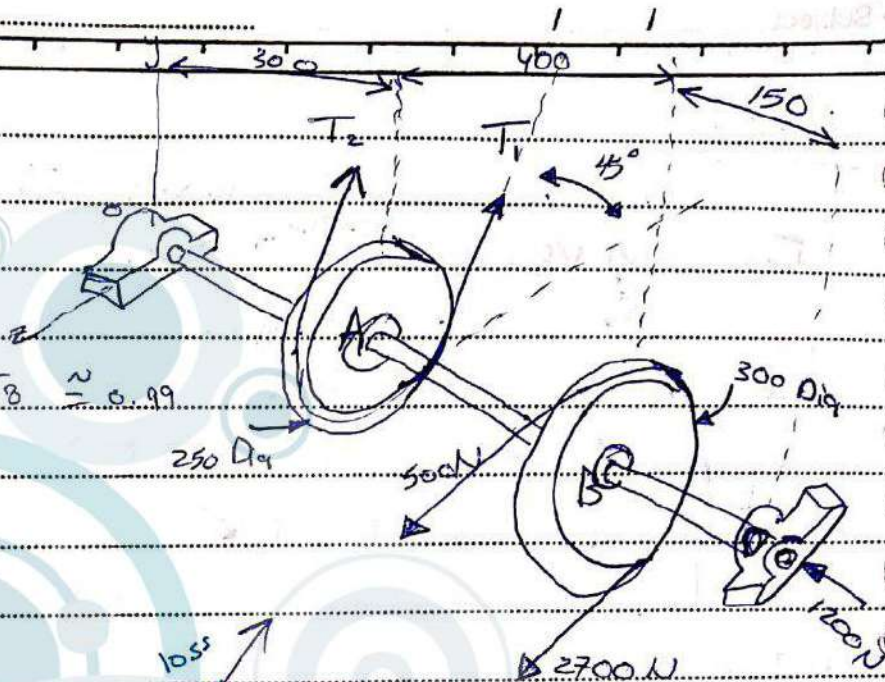
$i = 2$

if $C_{10} \text{ old} = C_{10} \text{ new} \rightarrow$ stop

Ex: The counter shaft runs at 1200 r/min & the bearings are to have a life of 10 kh. a. b. combined reliability of 0.98 for the weibull parameters are $b = 1.485$, $x_0 = 0.2$, $\theta = 4.439 + 0.2$

The application factor is to be 1.2. The belt tension on the loose side of Pulley A is 15 percent of the tension on the tight side.

► Subject :

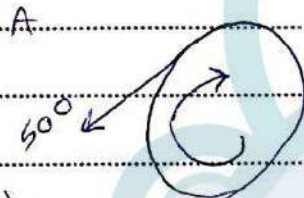


$$L_D = 10. \text{ kb}$$

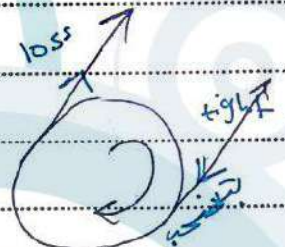
$$R_{\text{cam}} = 0.98 \Rightarrow R = \sqrt{0.98} \approx 0.99$$

$$q_p = 1.2$$

application factor



عجلة
= D



$$T_2 = 0.15 T_1$$

Torque $\rightarrow r \times \text{force}$ T $\leftarrow$ Tangential

$$\sum T = 0$$

$$-2700 \times \frac{300}{2} + 500 \times \frac{300}{2} + T_1 \times \frac{250}{2} - 0.15 T_1 \times \frac{250}{2} = 0$$

$$T_1 = 310.6 \text{ N}$$

$$T_2 = 46.6 \text{ N}$$

* Reactions

$$R_c^y = -891 \text{ N}$$

$$R_o^z = 2418.3 \text{ N}$$

$$R_o^y = -1634.7 \text{ N}$$

$$R_c^z = -1744 \text{ N}$$

$$R_c = \sqrt{891^2 + 2418.3^2} \approx 1958 \text{ N}$$

$$R_o = \sqrt{1634.7^2 + 1744^2} \approx 2919 \text{ N}$$

L_c

* Thrust force 1200 N

$\rightarrow R_c \rightarrow$

Fig. k.

$$i = 2, \gamma_2 = 1.63$$

$$F_c = 1.56(11)(1958.4) + 1.63 \times 1200 = 3052.8 \text{ N}$$

$$X_D = \frac{1200 \times 10 \times 10^3 \times 60}{10^6} = 720$$

Subject :

24/4/1

Sun.

$$C_{10} = (1.2)(3652.8) \times \left[\frac{10 \times 10^3 \times 655 \times 60}{10^6} \right]^{1/3} \cdot \left[\frac{0.02 + 4.439(1-0.99)^{1.482}}{1} \right]^{1/3}$$

$$= 44.52 \text{ kN}$$

⇒ from table $C_{10} = 46.2 \text{ kN}$

angular contact.

$$C_0 = 28.5 \text{ kN}$$

$$\Rightarrow \frac{F_a}{C_0} = \frac{1200}{28.5 \times 10^3} = \frac{1.2 \times 10^3}{28.5} = 0.0421$$

⇒ (e) from table

$$e = 0.24$$

→ check ?

$$\frac{F_a}{V_{Fr}} > e \quad \text{or} \quad \leftarrow$$

$$\frac{F_a}{V_{Fr}} = \frac{1200}{(1)(1958.4)} = 0.61 > e, \quad \text{so } i = 2$$

when $e = 0.24$ & $\frac{F_a}{V_{Fr}} > e$ so from table :

$$x_2 = 0.56, \quad y_2 = 1.85$$

Repeat same $y = 1.85$

$$\frac{F_e}{V_{Fr}} = x + \frac{y}{V} \frac{F_a}{F_r} = 1.69$$

$$F_e = 3316.82$$

$$C_{10} = (1.2)(3316.82) \left[\frac{10 \times 10^3 \times 720 \times 60}{10^6} \right]^{1/3} \cdot \left[\frac{0.02 + 4.439(1-0.99)^{1.482}}{1} \right]^{1/3} = 48.35 \text{ kN}$$

from table 11-2 angular contact bearing ⇒ $C_{10} = 55.9 \text{ kN}$ & $C_0 = 35.5 \text{ kN}$

$$\frac{F_a}{C_0} = \frac{1200}{35.5} = 0.034 \quad \rightarrow \text{(interpolation) line 11 shell 62}$$

$$\frac{F_a}{V_{Fr}} = 0.61 > e = 0.23$$

$$\Rightarrow e = 0.23$$

$$y_2 = 1.93$$

then :

$$F_e = 0.56(1)(1958.4) + 1.93(1200) = 3412.82 \text{ N}$$

$$C_{10} = 1.2 \times 3412.82 \times 12.15 = 49.75 \text{ kN}$$

from table $C_{10} = 55.9$

$$C_0 = 35.5$$

(OD = 110 mm & D = 60 mm) note "line 11 shell 62"

CH: 8

- single screw:

- double r

* General scr



* Metric

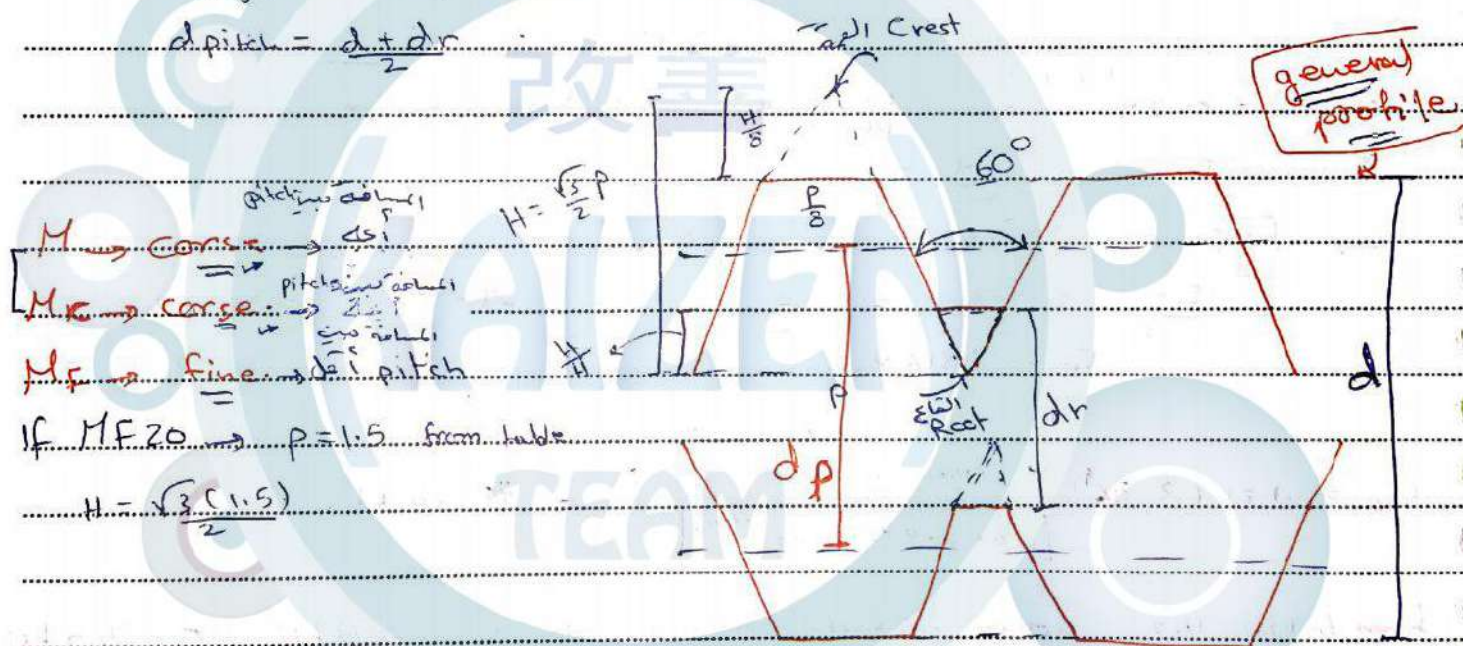
* UN

→ Single screw = μp

→ Double screw = 2.0 p

→ Triple screw = 3 p

...significant.

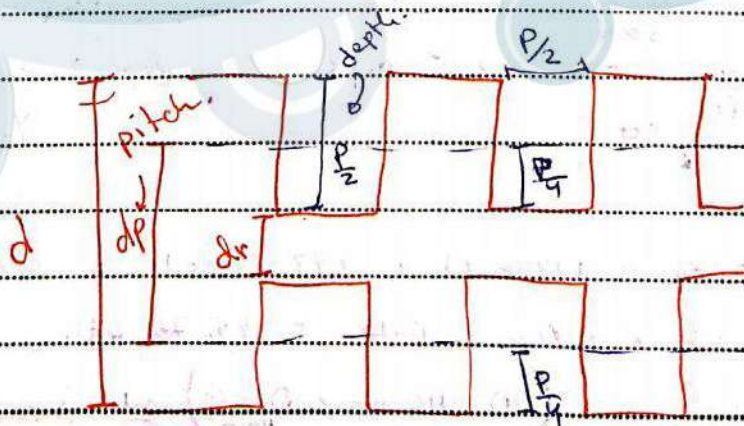
$$d_{\text{major}} = d_{\text{root}}$$
$$d_{\text{pitch}} = \frac{d + d_r}{2}$$


in square. major

if $d = 25$

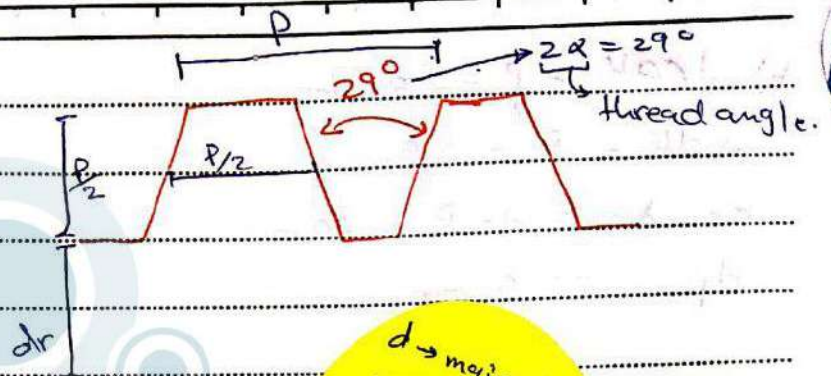
$$dx = d - \frac{P}{2} - \frac{P}{2} = d - P$$

$$d_p = d - \frac{p}{4} - \frac{p}{4} = d - \frac{p}{2}$$



→ له جدول خاص
مربعه.

ACME
جدول 8-3
UN → inch.



* Thread standards:-

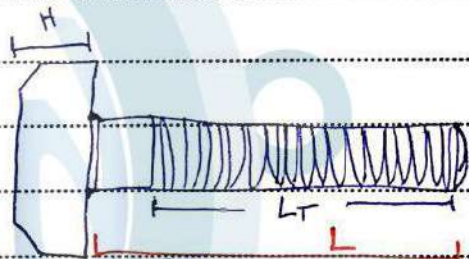
UN 8/16 → major dia. ✓
UN 8/16 → minor dia. ✓
UN 8/16 → significant

UN 8 → not major dia. ✓
UN 8" → major dia. ✓
UN 8/16 → major dia. ✓

* Threads / in = $\frac{1}{P}$
 $P = \frac{1}{18}$

* Threaded lengths:-

English
LT $\begin{cases} 2d + \frac{1}{4} \text{ in} & L \leq 6 \text{ in} \\ 2d + \frac{1}{2} \text{ in} & L > 6 \text{ in} \end{cases}$



Metric
LT $\begin{cases} 2d + 6 & L \leq 125, d \leq 48 \\ 2d + 12 & 125 < L \leq 200 \\ 2d + 25 & L > 200 \end{cases}$

* Nuts:- A-31

Bot $\begin{cases} H \rightarrow \text{from table} \\ W \rightarrow \sim \sim \end{cases}$ A-29.

P (8-1) :- power screw is 25 mm in dia & has a thread pitch of 5 mm. a) Find the thread depth, the thread width, the mean & root diameters, and the lead, provided square threads are used, b) Repeat a) for Acme threads?

$d = 25$, $P = 5$, width = $\frac{P}{2} = \frac{5}{2} = 2.5 \text{ mm}$, = depth.

(root dia) $dr = 25 - P = 20 \text{ mm}$

(mean dia) $dp = 25 - \frac{P}{2} = 22.5$ or $dm = \frac{d + dr}{2} = \frac{25 + 20}{2} = 22.5 \text{ mm}$

Lead = $1 \times P = 1 \times 5 = 5 \text{ mm}$

► Subject :

8, 5, 1 mm

b) $\text{depth} = \frac{P}{2} = 2.5 \text{ mm}$

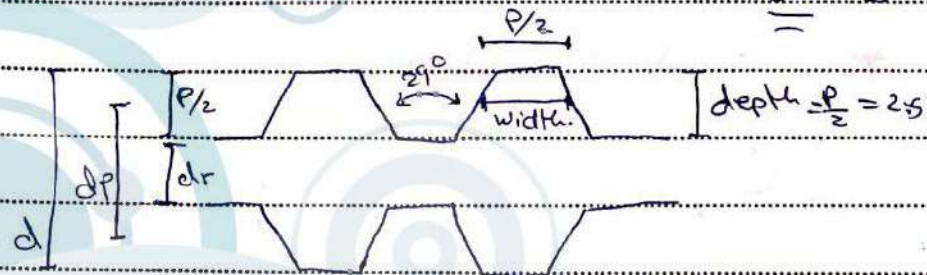
$\text{width} = \frac{P}{2} = 2.5 \text{ mm}$

so $d_r = d - P = 20 \text{ mm}$

$d_p = 22.5 \text{ mm}$

$$\left[\begin{array}{l} 2\alpha = 29^\circ \\ \alpha = \frac{29^\circ}{2} \end{array} \right]$$

in square $\rightarrow$ no $\odot$ etc



改善

KAIZEN
TEAM

Subject :

8/5/2020

b) $depth = \frac{P}{2} = 2.5 \text{ mm}$

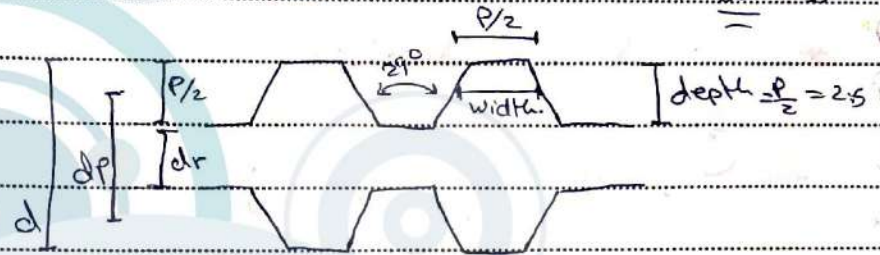
width = $\frac{P}{2} = 2.5 \text{ mm}$

so $dr = d - P = 20 \text{ mm}$

$dp = 22.5 \text{ mm}$

$$\left[\begin{array}{l} 2\alpha = 29^\circ \\ \alpha = \frac{29^\circ}{2} \end{array} \right]$$

in square $\rightarrow$ no $\odot$ in



* Power Screw :-

Screw $\rightarrow$ Nut $\rightarrow$ bearing in both collar.

* Raising $\rightarrow$ Highest load.

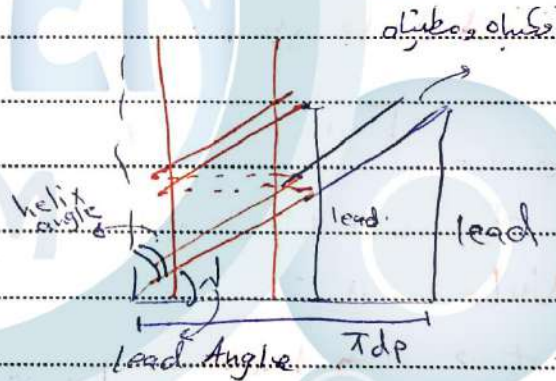
* Lowering $\rightarrow$ Lowest load.

① * Load Analysis :-

$$\tan \lambda = \frac{L}{\pi dp}$$

$\lambda + \text{helix angle} = 90^\circ$

$$\lambda = \tan^{-1} \left(\frac{L}{\pi dp} \right)$$



② $P_R = F \left[\frac{L}{\pi dp} + f \right]$ $\rightarrow$ lead $\rightarrow$ dp

high external force to move it upward raising

coefficient friction btw. screw material

* nut material (from tables.)

③ $P_L = F \left[f - \frac{L}{\pi dp} \right]$

lowering

قوة الاحتكاك بين المادة
التي تتحرك في الأعلى
قوة الاحتكاك بين المادة
التي تتحرك في الأسفل

$P_L < P_R$

Subject : _____

طرق رفع ثبات P_R & P_L
 فنجدهم نبدأ مع فهم الحركة

→ P_R (Raising)

هو الذي يتم بديل
 عن طريق القوة لذا P_R

→ P_L : (lowering)

لا تحتاج دال قوة مثل P_R

* ليس لها علامة بأعلى وأسفل حيث
 عند القوة المحيطة لرفع الشئ على عمود يكون
 P_R بينما لو كانت القوة التي نساها
 لرفع الشئ لأعلى فليكن (صغيرة) يكون
 هذه P_L

$$T_R = \frac{F d_m}{2} \left(\frac{L + \pi f d_m}{\pi d_m - f L} \right)$$

$$T_L = \frac{F d_m}{2} \left(\frac{\pi f d_m - L}{\pi d_m + f L} \right)$$

Table (8-5), (8-6)

* Collar friction :- (table 8-6)

coeff. friction collar

$$T_C = \frac{F f_c d_c}{2}$$

diameter collar

given or from table (8-6)

$$T_R = \frac{F d_m}{2} \left(\frac{L + \pi f d_m}{\pi d_m - f L} \right) + \frac{F f_c d_c}{2}$$

* Self-locking condition :-

$$T_L = \frac{F d_m}{2} \left(\frac{\pi f d_m - L}{\pi d_m + f L} \right)$$

يجب أن تكون المسارية لا تكون صفرية

* فإذا كانت المسارية 0 أو أكبر

تكون T_L هي المسارية لارتفاع

→ $T_L = 0$ في المسارية

$$T_L = 0 \text{ or } (-)$$

$$\text{if } \pi f d_m = L \rightarrow T_L = 0$$

$$\text{so } \pi f d_m \text{ should be } > L$$

$$f > \frac{L}{\pi d_m} = \tan \alpha$$

$$f > \tan \alpha$$

self-locking is not possible * $\alpha < \phi$

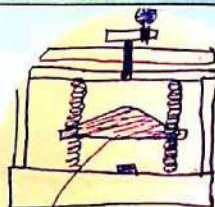


$$\alpha < \phi$$

* Efficiency :

$$e = \frac{T}{T_R}$$

Subject: Prob (8-6) in Book



* نظام حمل هذا
الحبار

* كيف نعرف ال R وال L

نفسه لانهم اختلفت في القوة

لا تسفل عنان ابيض القطعة

لا تسفل لدا R لا تسفل

ابتداءً من ال L أو رفعها

ما يسفل بعد ذلك كما أنزلها

لأنه اقل الفريشن لدا L

أما ال L أنزلها لا تسفل بله

أكبر مساحة الفريشن ال R تسفل

ل ال L

نبتل هذا الجزء
ال R تسفل حتى نضبط
القطعة التي بالأسفل
(ال press)

أما ال L أنزلها لا تسفل بله

أكبر مساحة الفريشن ال R تسفل

ل ال L

* Notes *

* كيف نرفع ال Tangent في السرعة

وذلك ال L في ال gear box

$P = T \omega$

omega

Torque

* Rotational head movement

* ال (brushing) (البرش)

بتسفل ال press هو ال L تسفل

* Linear movement

* ال pitch

1-lead

$d_m = d - p$

8-6 ACME

$d = 2 \text{ in.}$

a) $P = \frac{1}{4} \text{ in.}$

$f = 0.05$, $f_c = 0.08$, $d_c = 3.5 \text{ in.}$

Power motor $\rightarrow$ Power two screws

eff in

Torque

$N_{\text{screw}} = 1720$

$\rightarrow$ for two screws

ratio 1 $\leftarrow$ 60 $\leftarrow$ 60

V_{head}

head

1 rev screw = $\frac{1}{4} \text{ in.}$

$V_{\text{head}} = \frac{1720 \text{ rev}}{60 \text{ min}} \times \frac{1}{4} \text{ in.}$

$= 7.17 \text{ in/min}$

السرعة الخطية ال head

b) $H_p \rightarrow$ horse power

$P_R = \frac{F \left[\left(\frac{L}{\pi d_m} \right) + f \right]}{1 - \left(\frac{fL}{\pi d_m} \right)}$

$T_R' \rightarrow$ ACME

$T_R' = \frac{F d_m}{2} \left(\frac{L + \pi f d_m \sec \alpha}{\pi d_m - f L \sec \alpha} \right)$

lead $\Rightarrow$ pitch

T_L ال فرق

Horse power rating $\rightarrow$ هو أي power ممكن
motor $\rightarrow$ motor
max. power $\rightarrow$ max. power
rpm $\rightarrow$ rpm
output $\rightarrow$ output
TR screw $\rightarrow$ TR motor $\rightarrow$ Hp motor

$20^\circ = 29^\circ \rightarrow \alpha = 14.5^\circ$

$\frac{2500}{5000} \rightarrow$ screw is

$T_R = \frac{2500 (1.875)}{2} \left(\frac{0.25 + \pi (0.5) (1.875) (1.033)}{\pi (1.875) - 0.5 (0.25) (1.033)} \right)$

$= 221.1 \text{ lbf.in}$

$T_c = \frac{F f_c d_c}{2} = \frac{2500 \times 0.08 \times 3.5}{2} = 350 \text{ lbf.in/screw}$

$T_{\text{tot}} = T_c + T_R$

$= 350 + 221.0 = 571 \text{ lbf.in/screw}$

S T A R S N O T E B O O K

Subject :

10 / 5 / 2022

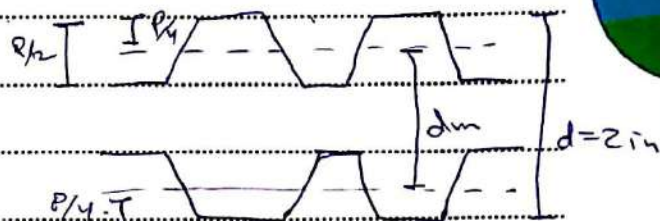
$$P = T \omega = T N$$

$$T_{\text{motor}} N_m = \frac{1}{0.95} T_{\text{2-screws}} N_{\text{screw}}$$

$$d_m = d - P/4 - P/4$$

$$\frac{N_{\text{screw}}}{N_{\text{motor}}} = \frac{1}{60} \quad] \text{ ratio in speed}$$

$$T_m = \frac{T_{\text{total}}}{60(0.95)} = \frac{571(2)}{60(0.95)} = 20.04 \text{ lbf.in.}$$



T_{screw} is *
at speed.

قانون
المكان

$$H_p = \frac{T_m}{63025} \rightarrow \text{constant.}$$

$$T_{\text{motor}} = \frac{2 \times T_{\text{R (2-screw)}}}{0.95} \times \frac{N_s}{N_m}$$

$\frac{N_s}{N_m} = \frac{1}{60}$

$$= \frac{(20.04)(1720)}{63025}$$

$$= 0.547 \text{ hp.}$$

改善

KAIZEN

TEAM

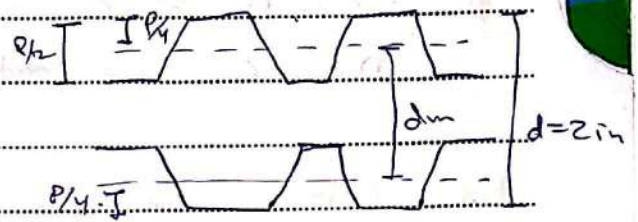
Subject :

10 / 5 / 2022

$$P = T\omega = T N$$

$$d_m = d - P/4 - P/4$$

$$T_{\text{motor}} N_m = \frac{1}{0.95} T_{\text{2-screws}} N_{\text{screw}}$$



$$\frac{N_{\text{screw}}}{N_{\text{motor}}} = \frac{1}{60} \quad \text{ratio in rev}$$

$$T_m = \frac{571(2)}{60(0.95)} = 20.04 \text{ lbf.in}$$

T_{screw} is *
at speed 20.

تورق $H = P = \frac{T_m}{63025} \rightarrow \text{constant}$

$$T_{\text{motor}} = \frac{2 \times T_R (\text{2-screw}) \times N_s}{0.95 \times \frac{N_s}{N_m} = \frac{1}{60}}$$

$$= \frac{(20.04)(1720)}{63025}$$

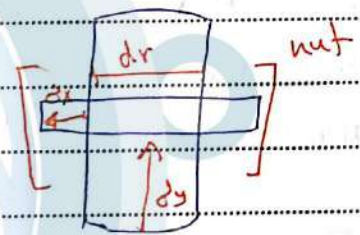
$$= 0.547 \text{ hp}$$

* Power screw: convert a rotary motion into a linear motion.

* Stresses in threads of power screws:-

1- σ_y (axial stress in body screw) = $-\frac{4F}{\pi d r^2}$ (compression)

2- $\sigma_x = \frac{6F}{\pi d r^3 n_t}$ (of threads (given))



3- $\tau_{yz} = \frac{T_x 16}{\pi d r^3}$ (shear stress)

4- Von mises: $\sigma' = \frac{1}{\sqrt{2}} \sqrt{(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_1 - \sigma_3)^2 + 6(\tau_{xy}^2 + \tau_{yz}^2 + \tau_{zx}^2)}$

4- Bearing stress in threads:

$$\sigma_{\text{bearing}} = \frac{2F}{\pi d p n_t P}$$

- Max stress on the first thread:

$$\sigma_b = \frac{2(0.38F)}{\pi d p (1) P}$$

- note: Max stress on threads 1st thread max

load 1st thread
max stress on 1st thread

* Note: if $n_f = 7$ or $n_f > 7$ → no load
 $n_f = 6$ → load $\dot{\theta}$ (load) $\dot{\theta}$

Ex: (Final Exam): prob (8-7)

① Material Aisi 1006

→ $\frac{3}{4}$ in → major

$$10 = \frac{1}{P}$$

$$T = r \times F = 3.5 \times F$$

dy → from tables.

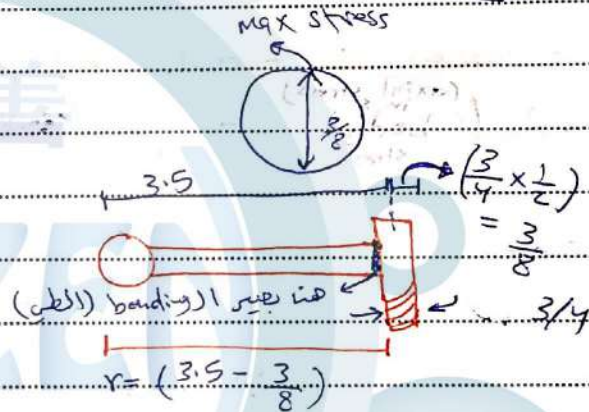
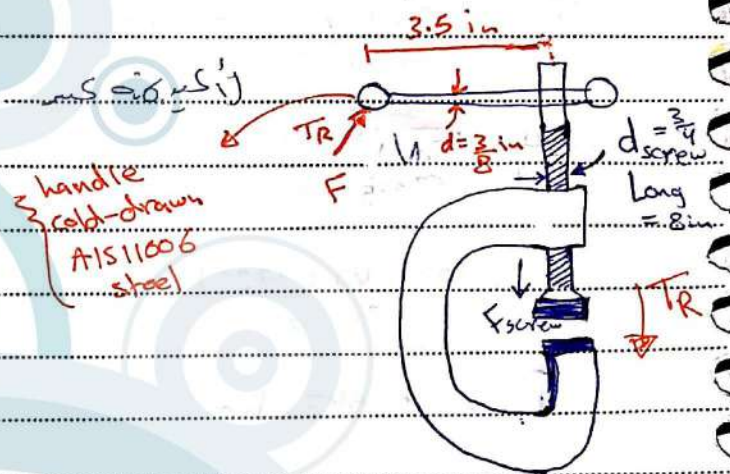
$$\vec{M} = \vec{r} \times \vec{F} = (3.5 - \frac{3}{8}) \vec{F}$$

$$S_y = S = \frac{\vec{M} \cdot \vec{r}}{I} = \frac{(3.5 - \frac{3}{8}) \vec{F} \times \frac{3}{16}}{\frac{\pi}{64} (\frac{3}{8})^4}$$

$$11000 = \frac{(3.5 - \frac{3}{8}) \vec{F} \times (\frac{3}{16})}{\frac{\pi}{64} (\frac{3}{8})^4}$$

$$\vec{F} = 8.5 \text{ lb. F}$$

$$T_R = 3.5 \times 8.5 = 30 \text{ lbf. in.}$$



② Force of clamping → from T_R to power screw is

$$T_R = \frac{F d_m (L + \pi f d_m \sec \alpha)}{2 \pi d_m - f L \sec \alpha}$$

$$d_m = d - \frac{P}{2} = \frac{3}{4} - \frac{0.1}{2} = 0.7 \quad ; \quad L = nP = 1(0.1) = 0.1$$

$$P = \frac{1}{10}$$

$$2\alpha = 29^\circ \Rightarrow \alpha = 14.5^\circ$$

f → from tables steel dry & steel nut. → $\mu_{avg} = \frac{0.15 + 0.25}{2} = 0.2$

بالقالب في سؤال عم
power screw.

Subject :

+ Factor of safety

17/5/2022 Tues.

$$30 = F_{clamp} \times 0.7 \left(\frac{0.1 + \pi \times 0.2 \times 0.7 \times \sec(14.5)}{\pi \times 0.7 - 0.2 \times 0.1 \sec(14.5)} \right) \rightarrow \text{power screw}$$

$$F_{clamp} (0.0891) = 30$$

$$F_{clamp} \approx 337.16 \text{ N}$$

* Note :-

في خطا بالسلامة
لا تستخدم الـ ACME
والسلامة في التوجيه

$$F_{clamp} = 309.38 \text{ N} \rightarrow$$

$\neq F_{handing}$ في التوجيه

$$\textcircled{3} d_x, d_y, T_{xy}, T_{yz}, n_t = 4$$

$$d_x = \frac{6F}{\pi d r n_t P} \rightarrow F_{clamp}$$

$$= \frac{6 \times 309.38}{\pi \times \left(\frac{3}{4} - 0.1\right) \times 4 \times \frac{1}{16}}$$

$$d_r = \frac{3}{4} - 0.1$$

$$n_t = 4 \text{ (given)}$$

$$d_y = \frac{-4F}{\pi d r^2} = \frac{-4 \times 309.38}{\pi \left(\frac{3}{4} - 0.1\right)^2}$$

$$T_{yz} = \frac{16T}{\pi d r^3} \rightarrow T_{rising}, T_{xy} = 0$$

$$= \frac{16 \times 30}{\pi \left(\frac{3}{4} - 0.1\right)^3}$$

Factor of safety FOS

$$n = \frac{\sigma_y}{\sigma_{eff}} \rightarrow \text{tables}$$

$$\sigma_{eff}$$

$$\sigma_{eff} \Rightarrow \text{(None mise)}$$

$$\rightarrow \text{if } n = 1$$

mean $\sigma_y = \sigma_{eff}$ it will be yield

$$\rightarrow \text{if } n < 1$$

means deform.

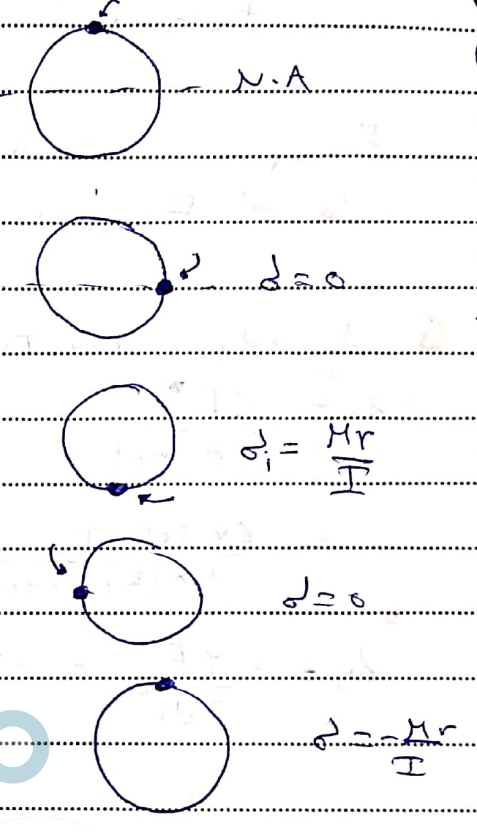
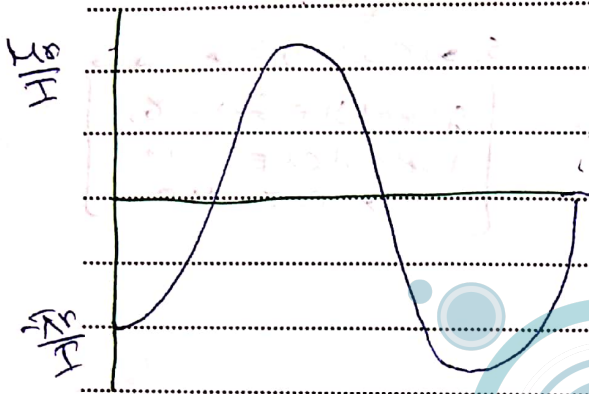
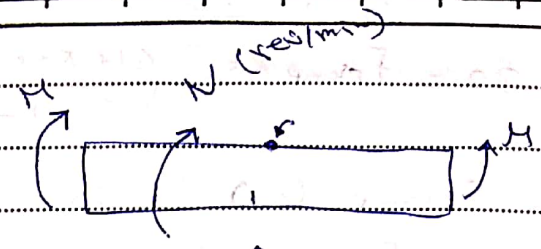
$$\rightarrow \text{if } n > 1$$

means safe.

V.V. Important Note

* Fatigue:-

- Dynamic loading
- cyclic loading



Cyclic

Fatigue is a process of failure

& Failure

(completely reversed) (not completely reversed)



not completely reversed

yielding is checked for failure

* Stress life Method:

1- σ_y + UTS

2- S_e (from equation) (Exp.) (* S_e → endurance limit)

(* S_{ut} → min tensile strength)

$$S_e = \begin{cases} 0.5 S_{ut} & ; S_{ut} \leq 200 \text{ kpsi} \quad (1400 \text{ MPa}) \\ 100 \text{ kpsi} & ; S_{ut} \geq 200 \text{ kpsi} \\ 700 \text{ MPa} & ; S_{ut} \geq 1400 \text{ MPa} \end{cases}$$

3- S_e (Actual)

$$S_e = k_a k_b k_c k_d k_f S_e'$$

Ex:- Estimate S_e' in kpsi

Note: $UTS \rightarrow S_{ut} \rightarrow$ Table A-20
Tensile strength

a) AISI 1035 CD steel

$$UTS = 80 < 200 \rightarrow (0.5 \times 80) = S_e' = 40 \text{ kpsi}$$

b) AISI 1050 HR steel

$$UTS = 90 < 200 \rightarrow S_e' = 0.5 \times 90 = 45 \text{ kpsi}$$

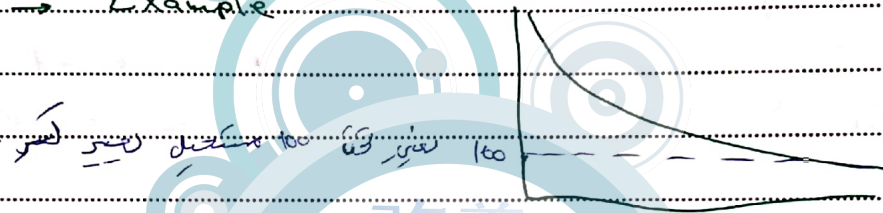
c) 2024 T4 aluminum

AL has no endurance limit.

d) AISI 4130 steel - treated to a tensile strength of 235 kpsi

$$UTS = 235 > 200 ; S_e' = 100 \text{ kpsi}$$

$S_e' = 100 \rightarrow$ Example



* If failure occurs

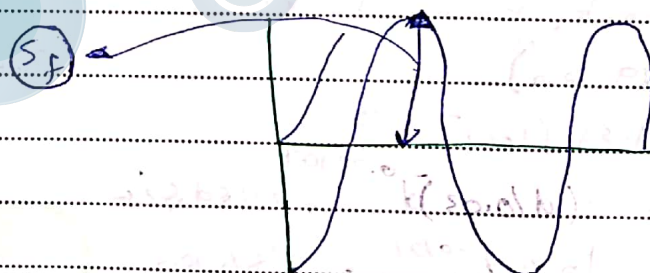
4- $N_f \rightarrow$ # of cyc to failure

5- $S_f \rightarrow$ fatigue strength = $a N_f^b$

$$f \text{ from figure (6-18)} \quad a = \left(\frac{f S_{ut}}{S_e} \right)^2 \quad b = -\frac{1}{3} \log \left(\frac{f S_{ut}}{S_e} \right)$$

* Completely reversed:

$$S_f = \sigma_a = \frac{\sigma_{max} - \sigma_{min}}{2} \\ = \frac{\sigma_a + \sigma_a}{2} \\ = \sigma_a$$



Subject :

22 / 5 / Sun.

Ex: (6-4) Shaft $\rightarrow$ means completely reversed

A steel rotating-beam test specimen has an ultimate strength of 1600 MPa. Estimate the life of the specimen if it's tested at a completely reversed stress amplitude of 900 MPa. $\rightarrow$ mean σ has failure.

1- UTS = 1600 MPa

2- $S_e' = 700$ MPa

3- $S_e = k_a \dots S_e'$

$S_e = S_e'$ (tested) $\rightarrow$ $S_e = 700$ MPa

4- $S_a = S_f = 9$ MPa

$9 N_f^b = 900$

$\rightarrow N = \left(\frac{S_e}{9}\right)^{1/b}$

$[* f = 0.77]$
200 in 1000

$N = 46400$ cycles

السؤال

change material $\rightarrow$ S_e' change $\rightarrow$ S_e change $\rightarrow$ S_f change
Applied load $\rightarrow$

3- $S_e = k_a k_b k_c k_d k_e k_f S_e'$

$\rightarrow k_a = a(S_{UTS})^b$

if ground $= 1.34 (180)^{-0.085}$

$\rightarrow k_b = \begin{cases} 0.879 d^{-0.157} & 0.115 d \leq 2 \text{ in} \\ 0.91 d^{-0.157} & 2 < d \leq 10 \text{ in} \\ 1.24 d^{-0.107} & 2.79 < d \leq 51 \text{ mm} \\ 1.51 d^{-0.157} & 51 < d \leq 254 \text{ mm} \end{cases}$

SUT $\rightarrow$ UTS

from table 6-2

شاذ

1- Circular

2- Rotating

$d = d_{actual}$

إذا واصل

$d \neq d_{actual}$

مافة

$d = d_{effective}$

table (6-3)

if $d = 20$ mm $k_b = 1.34 (20)^{-0.107}$

S T A R S N O T E

table 6-2

$k_b = \{$

$$d_e = 0.37 d \Rightarrow 0.37 \times 20 \Rightarrow 7.4$$

$$k_b = 1.24 (7.4)^{-0.107}$$

* Note :- For axial load $k_b = 1$

$$k_c \rightarrow \begin{cases} 1 & \text{bending} \\ 0.85 & \text{axial} \\ 0.59 & \text{torsion} \end{cases}$$

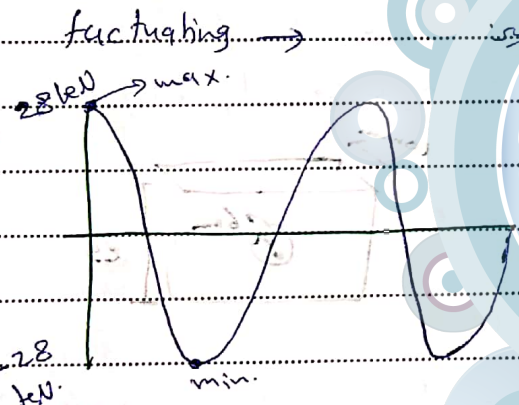
$$k_e \rightarrow = 1 \quad (\text{reliability: } 1 \text{ مئة في المئة})$$

$$k_f \rightarrow = 1 \quad (\text{surface finish: } 1 \text{ مثالي})$$

معاداة التكرار بغير القواسم لها واحد كما ذكرنا

6-10 :- Stress Concentration and Notch

Ex. P(6-25):



* Steps to solve problems

1- UTS

2- S_e'

3- $S_e = k_a k_b k_c \dots S_e'$

4- If failure occur

5- $f = 1 + q (k_t + 1)$

6- $a f_s = 1 + \frac{q}{S_s} (k_{ts} + 1)$

7- $\sigma_a = \frac{\sigma_{max} - \sigma_{min}}{2}$

8- $\sigma_m = \frac{\sigma_{max} + \sigma_{min}}{2}$

9- $\sigma_{max} = k_f \sigma_{nominal}$

10- $T_{max} = k_{fs} T_{nominal}$

$$1- UTS = 590 \text{ MPa} ; S_y = 490 \text{ MPa}$$

$$2- S_e' = (0.5) (590) = 295 \text{ MPa}$$

$$3- S_e = k_a k_b k_c k_d k_e k_f S_e'$$

machine surface hole & ax

$$k_a = 2.7 \left(\frac{UTS}{590} \right)^{-0.265}$$

$$* \text{axial load} \rightarrow k_b = 1$$

$$k_c \text{ (from table)} = 0.85$$

$$k_d = 1 \rightarrow \text{temp. و } \sigma_{max}$$

$$k_e = 1 \rightarrow \text{surface finish}$$

$$k_f = 1$$

$$7- \sigma_a = \frac{\sigma_{max} - \sigma_{min}}{2}$$

$$\sigma_m = \frac{\sigma_{max} + \sigma_{min}}{2}$$

$$\sigma_{max} = k_f \sigma_{nominal}$$

$$T_{max} = k_{fs} T_{nominal}$$

$$\sigma_a = \frac{\sigma_{max} - \sigma_{min}}{2}$$

$$\sigma_m = \frac{\sigma_{max} + \sigma_{min}}{2}$$

$$\sigma_{max} = k_f \sigma_{nominal}$$

$$T_{max} = k_{fs} T_{nominal}$$

$$\sigma_a = \frac{\sigma_{max} - \sigma_{min}}{2}$$

$$\sigma_m = \frac{\sigma_{max} + \sigma_{min}}{2}$$

$$\sigma_{max} = k_f \sigma_{nominal}$$

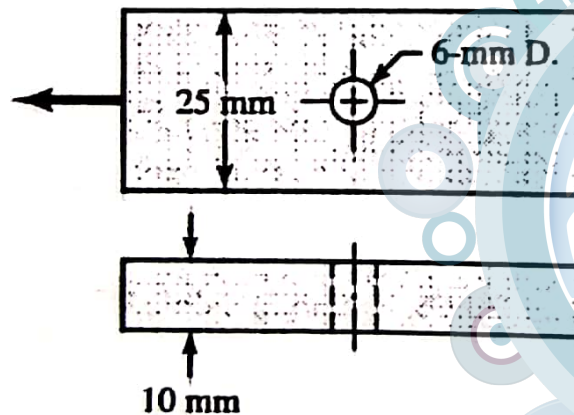
$$T_{max} = k_{fs} T_{nominal}$$

$$\sigma_a = \frac{\sigma_{max} - \sigma_{min}}{2}$$

$$\sigma_m = \frac{\sigma_{max} + \sigma_{min}}{2}$$

6-25

The cold-drawn AISI 1040 steel bar shown in the figure is subjected to a completely reversed axial load fluctuating between 28 kN in compression to 28 kN in tension. Estimate the fatigue factor of safety based on achieving infinite life and the yielding factor of safety. If infinite life is not predicted, estimate the number of cycles to failure.



Problem 6-25

Subject:

$$S_e = 2.7 (390)^{-0.265} \times 1 \times 0.85 \times 1 \times 1 \times 1 \times 295 = 208.6 \text{ MPa}$$

actual

4- → failure allowable stress below
life of wp &
fatigue.

$$5- k_f = 1 + q (k_t - 1)$$

Fig 6-20.

$$k_t : \frac{d}{w} = \frac{6}{25} = 0.24 \rightarrow k_t = 2.44$$

من الرسم.

→ Notch = 3

590 MPa

→ 0.59 GPa.

0.6

بين 0.4 و 0.7 ويمكن ان يكون 0.7

q ≈ 0.8

$$k_f = 1 + 0.8 (2.44 - 1)$$

$$k_f = 2.2$$

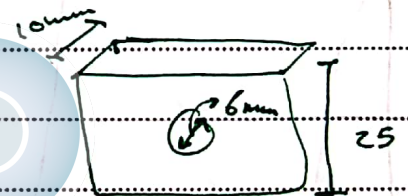
كل واحد من k_t و k_f و k_f في k_t و k_f في k_f

$$6- \sigma_a = \frac{\sigma_{max} - \sigma_{min}}{2}$$

amplitude

$$= 2.2 \left[\frac{28 \times 10^3}{(25-6) \times 10} - \frac{-28 \times 10^3}{(25-6) \times 10} \right]$$

$$k = \frac{F}{A} = \frac{F}{(w-d)t}$$



$$\sigma_{max} = k_f \sigma_{max (F)}$$

$$= 324.2 \text{ MPa}$$

$$= 2.2 \times \frac{28 \times 10^3}{(25-6) \times 10} = () \text{ MPa} = 324.4 \text{ MPa}$$

$$\sigma_{min} = k_f \sigma_{min}$$

$$= 2.2 \times \frac{-28 \times 10^3}{(25-6) \times 10} = -324.4 \text{ MPa}$$

$$\sigma_m = \text{zero}$$

mean

7- Check for yielding.

$$\sigma_a + \sigma_m < S_y$$

$$324.2 + 0 < 390$$

✓ not yield.

بما ان $\sigma_a + \sigma_m \geq S_y$ لا يمكن

Subject :

24 / 5 / Tues.

→ Table A-20

$$n_y = \frac{S_y}{\sigma_{max}} = \frac{490}{F} = \frac{490}{\frac{2.8 \times 10^3}{10(25.6) \times 10^{-3} \times 10^{-3}}} = \frac{490}{147.4} = 3.32 \quad \underline{\underline{\text{Ans}}}$$

→ yielding factor of safety.

$$n_f \text{ (Fatigue factor of safety)} = \frac{S_e}{\sigma_a} = \frac{208.6}{324.2} \approx 0.64 \quad \underline{\underline{\text{Ans}}}$$

⇒ * of cycles to failure N_f ?!

$$N = \left(\frac{\sigma}{a} \right)^{1/b}$$

$$a = (f S_{ut})^2 \Rightarrow f \text{ at } 590 \text{ MPa} = 85 \text{ ksi} \rightarrow f = 0.87$$
$$= \frac{(0.87 \times 590)^2}{208.6}$$
$$= 1263$$

$$b = -\frac{1}{3} \log \left(\frac{f S_{ut}}{S_e} \right) = -\frac{1}{3} \log \left(\frac{0.87 \times 590}{208.6} \right) = -0.1304$$

$$\text{So } N_f = \left(\frac{324.2}{1263} \right)^{\frac{1}{-0.1304}} = 3381.2 \text{ cycles} \approx 34000 \text{ cycles.}$$

Ans

Subject:

24 / 5 / Tues.

→ Table A-20

$$n_y = \frac{S_y}{\sigma_{max}} = \frac{490}{\frac{F}{A}} = \frac{490}{\frac{28 \times 10^3}{10(25-6) \times 10^{-3} \times 10^{-3}}} = \frac{490}{147.4} = 3.32 \quad \underline{\underline{\text{Ans}}}$$

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$$\text{So } N_f = \left(\frac{324.2}{1263} \right)^{\frac{1}{-0.1304}} = 33812 \text{ cycles} \approx 34000 \text{ cycles.} \quad \underline{\underline{\text{Ans}}}$$

[G-14]

* Combinations of loading Modes:

$$\sigma_a' = \left\{ \left[(k_f)_{\text{bending}} (\sigma_a)_{\text{bending}} + (k_f)_{\text{axial}} \frac{(\sigma_a)_{\text{axial}}}{0.85} \right]^2 + 3 \left[(k_f)_{\text{torsion}} (\tau_a)_{\text{torsion}} \right]^2 \right\}^{1/2}$$

$$\sigma_m' = \left\{ \left[(k_f)_{\text{bending}} (\sigma_m)_{\text{bending}} + (k_f)_{\text{axial}} (\sigma_m)_{\text{axial}} \right]^2 + 3 \left[(k_f)_{\text{torsion}} (\tau_m)_{\text{torsion}} \right]^2 \right\}^{1/2}$$

if shaft → delete axial

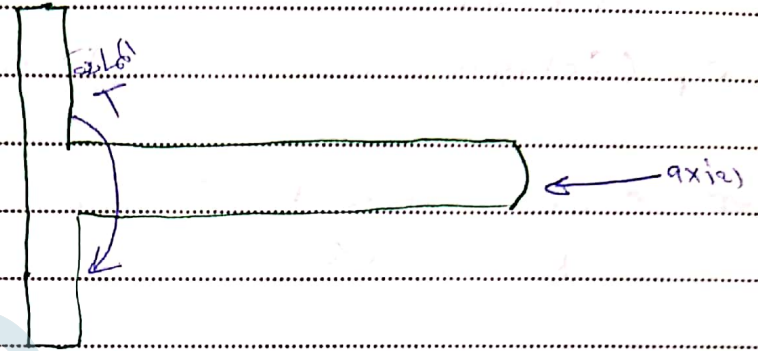
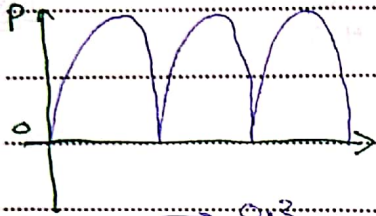
$$\sigma_a' + \sigma_m' = \frac{S_y}{n}$$

$$\sigma_a' + \sigma_m' = S_y$$

S T A R S N O T E B O O K

$k_c = 1$ if combined

6-57 :-



$$T = \frac{f P (D+d)}{4}$$

$n_f = 3$
 $n_y = ?$
 $P_{max} = ?$

1- $UTS = 145 \text{ kpsi}$

* $S_y = 120 \text{ kpsi}$

2- $S_e' = 0.5(145) = 72.5 \text{ kpsi}$ (Exp) $k_t = 3$; $k_{ts} = 1.8$

$k_a = 2.7(145)^{-0.265} = 0.722$

so $k_b = 0.879(1.2)^{-0.107} = 0.862$

→ Circulation ✓

→ rotation ✓

so $d = d_{actual} = 1.2$

$k_c = 1$

$k_d = 1$

$k_e = 1$

$k_f = 1$

3. $S_e = 0.722 \times 0.862 \times 1 \times 1 \times 1 \times 1 = 45.12 \text{ kpsi}$ (actual)

→ no failure bec he gives us (exp) 11 is for

$n_f = 3$ → 1 is for UTS a failure

* notch radius = 0.1 in $r = 0.9$ $k_t = 3$

$1 - k_f = 1 + 2(k_t - 1) = 1 + 0.9(3 - 1) = 2.8$

$$q_{fs} = 0.92 \quad k_{fs} = 1.8$$

$$k_{fs} = 1 + q(k_{fs} - 1)$$

$$= 1 + 0.92(1.8 - 1)$$

$$= 1.74$$

comp →
ten to →
is compression

$$6- \quad \sigma_{\max} = \frac{P}{A} = \frac{P}{\frac{\pi(1.2)^2}{4}} \times k_f = -2.476 P$$

$$\sigma_{\min} = 0$$

$$\sigma_a = \left(\frac{2.8 P}{\frac{\pi(1.2)^2}{4}} - 0 \right) \div 2 = -1.238 P$$

$$\sigma_m = \sigma_a = -1.238 P$$

$$T \rightarrow \tau \quad \tau_{\max} = \frac{T_r}{J} = \left(\frac{(F P (D+d)/4) + \frac{1.2}{2}}{\frac{\pi}{32} (1.2)^4} \right) \times k_{fs} = 2.769 P$$

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

$$\tau_a = \tau_m = \frac{\tau_{\max}}{2} = \frac{2.769 P}{2} = 1.385 P$$

$$\sigma_a = \sigma_m \quad ; \quad \tau_a = \tau_m \rightarrow \sigma_{\max} = \sigma_a$$

$$\sigma_a' = \left[(\sigma_a / 10.85)^2 + 3 \tau_a^2 \right]^{1/2} =$$

$$= 2.81 P$$

$$\sigma_m' =$$

$$= 2.7 P$$

$$\sigma_a' + \sigma_m' \stackrel{!}{=} \sigma_y \rightarrow 120 \text{ MPa}$$

$$2.81 P + 2.7 P \stackrel{!}{=} 120$$

∴ yielding is not done since $\sigma_a' + \sigma_m' < \sigma_y$

∴ upper, P is not used since $\sigma_a' + \sigma_m' < \sigma_y$ like it

$$\frac{1}{n_f} = \frac{\sigma_a'}{S_e} + \frac{\sigma_m'}{S_{ut}} = \frac{2.81P}{45.12} + \frac{2.70P}{145} = \frac{1}{3}$$

$$\rightarrow P = 4.12 \text{ kpsi}$$

$$n_y = \frac{S_y}{\sigma_a' + \sigma_m'} = \frac{120}{(2.81 \times 4.12) + (2.7 \times 4.12)} \approx 5.3$$

* Final Ques :- ^{is shorter in bearing} bearing is ^{is p of shaft} p of shaft is 12. ^{is 12} ^{is 12} *

shear ^{web}

&
B.M

dia.

analysis ^{del} ^{max} ^{job}

stress ^{max} ^{job}

analysis ^{max} ^{job}

line

改善

TEAM

[axial ^{max} ^{job} Torque + Bending ^{max} ^{job}]
[shear & Bending dia.] ^{max} ^{job}

* eg. (7-7) factor of safety to shaft (few steps) than ch 6

* Any ques in ch 6 ^{ask you find} ^{ask you find} ^{ask you find} XX axis

Fatigue

Bearing

limit