مقاومة chapter (1)

Introduction

Concept of stress:-

:-Review

الحمل الخارجي

← earth load   dead load   live load

القوة الداخلية ← axis force يعني عمودي
(normal force)

shear force ، moment bending

مطلوب مني ① تحليل + تصميم ② قطاع مراد.

Stress ؛ ([illegible]) [illegible] → F/ΔA ←

الاجهادات
-:Concept of Stress:-

*The main objective of the study of machines of material is to provide the future engineer with the means of analyzing and designing various machine and load bearing structure

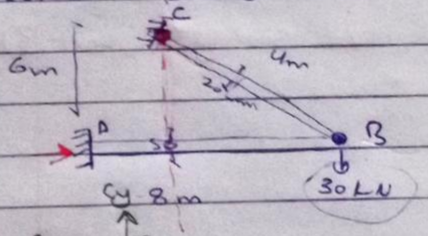
تحليل مبنى قائم — تصميم مبنى آمن

هو يحلل المنشآت / stress و deformations [illegible]

الحمل.

11

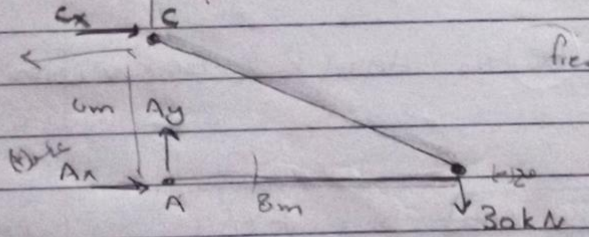
Review of statics



4m x 20mm
8m x 50mm } [illegible]

30 km [illegible]

-: internal force لتعريف :-



free Body Diagram

الاتزان الاستاتيكي

$\Sigma M_C = 0 = Ax(6) - (30 \times 8)$

$\boxed{Ax = 40\,kN}$

$\Sigma F_x = 0 = A_x + C_x$

(x-) [illegible] ← $\boxed{Cx = -40\,kN}$

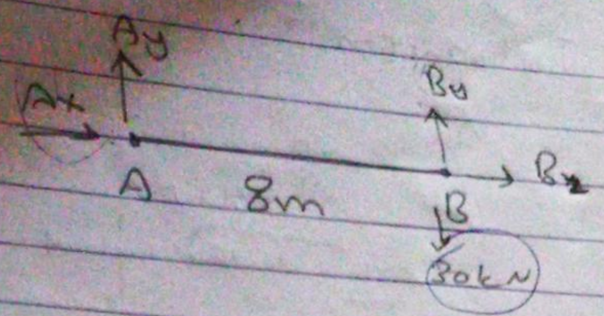
$\Sigma F_y = 0 = C_y + A_y - 30 = 0$

$A_y + C_y = 30\,kN$ ——①

$\Sigma M_a = (-30 \times 8) + (-6 \times C_x) = 0$

$-240 = 6C_x$

$Cx = -40\,kN$



$\Sigma M_B = 0 = -Ay \times 8$

$\boxed{Ay = 0}$

$Ay + Cy = 30$

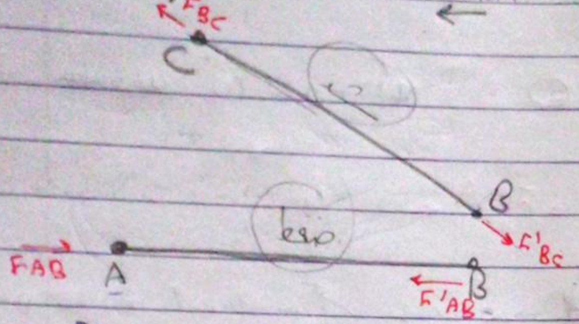
$0 + Cy = 30$

$\boxed{Cy = 30km}$

A = 40kN

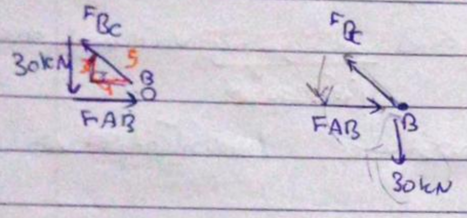
Cx = 40 km ←

Cy = 30km ↑



١. حسب مركبات ردود الأفعال

2. احسب القوة الداخلية المؤثرة



$\Sigma F_B = 0$

$$\boxed{\frac{F_{AB}}{4} = \frac{F_{BC}}{5} = \frac{30}{3}}$$

compression

tension

$3x = 150$

$F_{AB} = 40$ $F_{BC} = 50$

1. السؤال هل هاد ال structre save or not :.

-: Analysis:

can the structure safely support 30kN load ??

From static analysis

$F_{AB} = 40kN$ (compression)

$F_{BC} = 50kN$ (tension)

At any section through member BC, the internal force 50kN with a force intensity or stress of

normal stress (axial)

لازم $\sigma_{BC} = \frac{P \text{ load}}{A \text{ area}} = \frac{50 \times 10^3 N}{314 \times 10^{-6} m^2} = \boxed{159 \text{ MPa}}$

F / DA

$\sigma = \frac{F_{BC}}{A}$

$d_{BC} = 20mm$

30mm قطر

قطر السيخ

∴ Save :- adequate

* From the material proprerties for steel the allowed stress is

$\sigma_{all} = 165 \text{ MPa}$

المصنع

Design of new structures requires selection of appropriate تصميم materials and component dimensions to meet performance requirements

- For reasons based on cost weight, availability, etc. the chance is made to constructe the rod ~~diameter~~?? from aluminum ($\sigma_{all} = 100$ MPa). What's an approriate choice for the rod diameter??

*** FBC = 50 kN

$$\sigma_a = \frac{P}{A} \Rightarrow A = \frac{P}{\sigma_{all}} = \frac{50 \times 10^3}{100 \times 10^6\ Pa} = 500 \times 10^{-6}\ m^2$$

$$\boxed{A = \pi \frac{d^2}{4}} \Rightarrow d = \sqrt{\frac{4A}{\pi}} = \sqrt{\frac{4(500 \times 10^{-6}\ m^2}{\pi}} = 2.52\ mm\ \boxed{25.2}$$

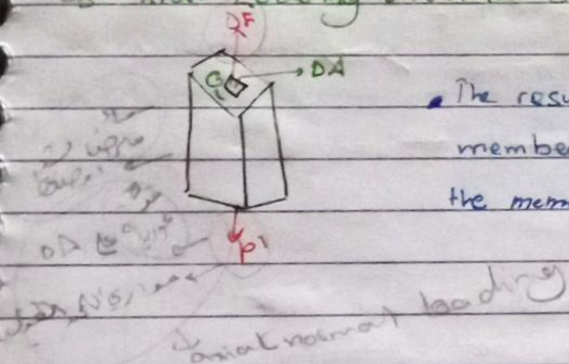
- An aluminum rod 26mm or more in diameter is adequate.

** القطر المناسب = 26 تقريبا (باخذ مقاس أكبر من ما تم حسابه)

يجوا عامة التكاملة احمد طبعي اشير تحريك.

A xial Loading & Normal Stress

axil — moment



- The resultant of internal forces for an axially loaded member is normal to a section cut perpendicular to the member axis

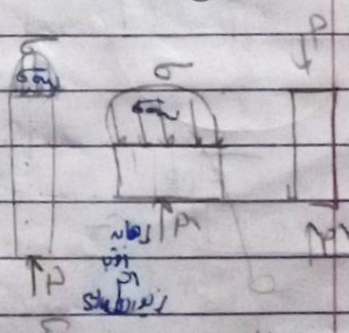
- The force intensity on that section is defind as the normal stress.

$$\sigma = \lim_{\Delta A \to 0} \frac{\Delta F}{\Delta A} \qquad \sigma_{ave} = \frac{P}{A}$$

- The normal stress at a ~~premp~~ particular point may not be equal to the average stress but the resultant the stress distribution must satisfy

$$P = \sigma_{ave} A = \int dF = \int_A \sigma\, dA$$

- The detailed distribution of stress is statically Indeterminate, i.e. can not be found from statics alone

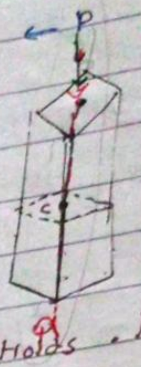


ال stress شكله مقوس نتيجة الضغط

bearing stress → normal stress, توزيع ضغط الواقع ال

Centric & Eccentric loading

load طبق في center ال area (centroid)



قسم خصائص normal stress

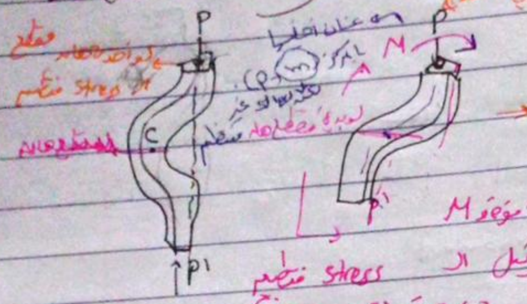
* اذا اطبقت القوة على centroid تتوزع بتساوي **axil force**

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

- A uniform distribution of stress is only possible if the concentrated loads on the end sections of two-force members are applied at the section centroids. This is referred to as centric loading

القوة اثرت على مركز المساحة يكون stress منتظم (منتظمة على ال a) (توزيع متساوي)

(حل محوري (عندي اما حركة



M صارعتبة موجودة → مسبب ال stress منتظم (في جهة اكبر من جهة).

حكم: axial fore / moment ⟹ shear force

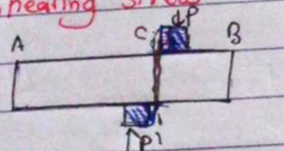
moment + ~~axil~~ axial load = normal force

قص shear — التواء torsion → طبيعي

axid load ⇒ normal stress
moment → normal stress

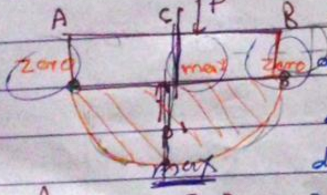
* اذا load axil موجود في المركز يكون stress uniform
* اذا moment ∴ stress non uniform

IV- Shearing stress → اتجاه عمودي

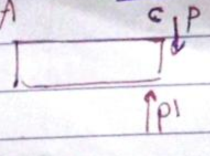


- Forces P and P' are applied transversely to the member AB,

القوى متساوية و متعاكسة



- Corresponding internal forces act in the plane of section C and are called shearing forces
- The resultant of the internal shear force distribution is defined as the shear of the section and is to the load P

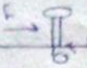


- The corresponding average shear is

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

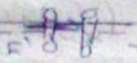
** صيغة τav غير دقيقة

- Shear stress distribution varies from zero at the member surfaces to maximum values that may be much larger than the average value [illegible] force → single shear



Shear stress ~~تصنيف~~ في الرابط [illegible]

[illegible] $\frac{F}{A} = \frac{P}{A} = \tau_{ave}$ → إذا زادت allowed الأعلى Shear stress لو

[illegible]  double stress

أكبر الشكل

أو بسمك

(قطر الرابط)

$\tau_{ave} = \frac{P}{A} = \frac{F}{\boxed{2A}}$

shear force ، bending moment ★ عليه تأثير العضو على ما أو معا.

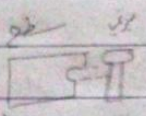
يمكن كل intent force كم كانا موجودة

[illegible] ← [illegible] الجسم الثقيل

(كل فعل ، رد فعل)

Bearing stress in Connections:

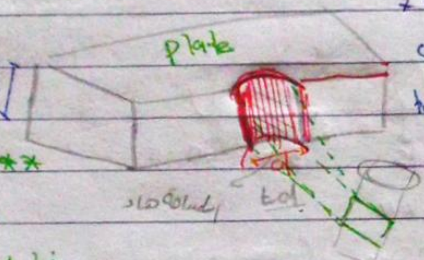
★ ~~Bolts~~ Bolts rivets, and ~~pine~~ pins create stresses on the points of contact or bearing surfaces of the members they connect



[illegible]

★ The resultant of the force distribution on the surface is equal and opposite to the force exerted on the pin

★ crossesponding average force intensity is called the bearing Stress



★ [illegible] القوة [illegible] على السطح

[illegible]

normal force [illegible]

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

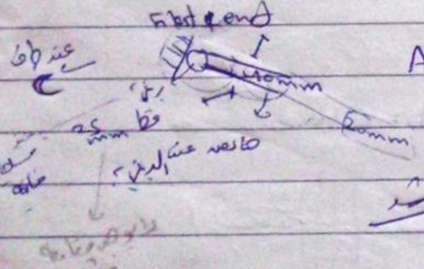
(plate سمك × (قطر الرابط)

example → [illegible]

FAB = 40 kN (C)

FBC = 50 kN (T) $20^2 \times \frac{\pi}{4}$

← member BC $A = 314 \times 10^{-6}\ m^2$ is $\sigma_{BC} = 159\ MPa$ → [illegible]



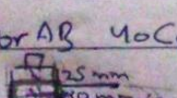
$A = (20\ mm)(40mm - 25mm) = 300 \times 10^{-6}\ m^2$

$\sigma_{BC,end} = \frac{P}{A} = \frac{50 \times 10^3\ N}{300 \times 10^{-6}\ m^2} = \boxed{167}\ MPa$

stress [illegible]

$\boxed{تضعفها}$ plate (area) [illegible]

member AB 40 (C)



$\sigma_{ave} = \frac{P}{A} = \frac{40 \times 10^3}{(30 \times 50) 10^{-6}}$ normal stress of $\boxed{-}$26.7 MPa

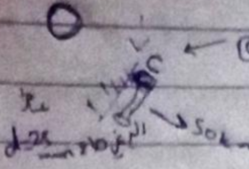
(-) min compression | positive tension

[illegible]

[illegible] shear [illegible] ايجاد القص عن [illegible]

Shear force $\times 10^{-6}$

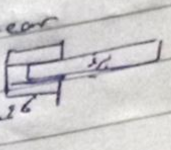
The cross sectional area for pins at A, B and C



$A = \pi r^2 = \pi (25/2\ mm)^2 = 491 \times 10^{-6}\ m^2$ single shear

$\tau_{ave} = \frac{P}{A} = \frac{50 \times 10^3 N}{491 \times 10^{-6} m^2} = 102\ MPa$

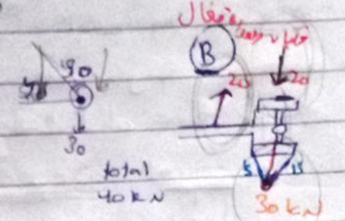
double shear

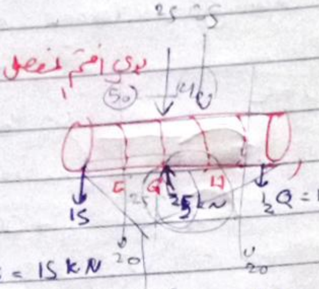


Ⓐ → 25 البين

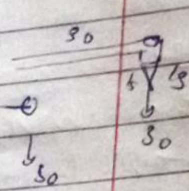
$\frac{40 \times 10^3}{2(491 \times 10^{-6})} = 40.7\ MPa$ $\tau = \frac{F}{2A} = \frac{\frac{1}{2}F}{A} = \frac{20 \times 10^3}{491 \times 10^{-6}}$

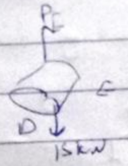
10^{-6}





Shear stress $G_{ave} = \frac{P}{A}$



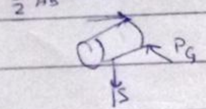


$P_E = 15\ kN$

$P_G = 25\ kN$ (largest)

$\tau_{B_{ave}} = P_G = \frac{25\ kN}{491 \times 10^{-6}} = 50.9\ MPa$

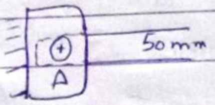
$\frac{1}{2}F_{AB} = 20\ kN$



Bearing stress

$\sigma_b = \frac{P}{td}$ $\frac{40}{(30)(25)}$ 53.3 MPa

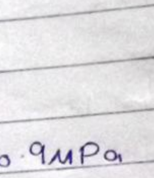
plate



To determine bearing stress at A in the bracket, we have

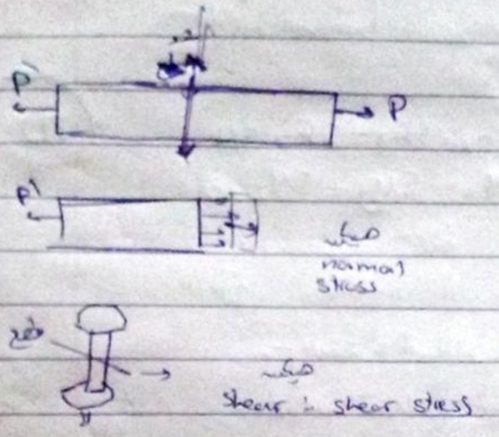
$t = 2(25) = 50\ mm$ $d = 25\ mm$

$\sigma_b = \frac{P}{td} = \frac{40}{50 \times 25} = 32.0\ MPa$



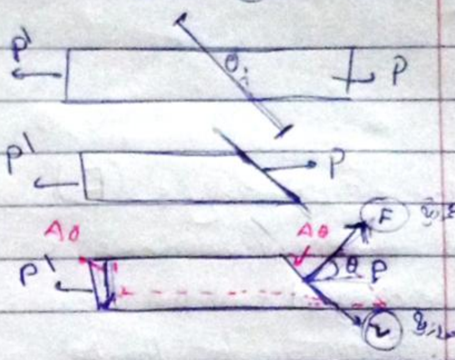
$\frac{40}{(\ )(25)}$

Stress in Two Force Members:



(حالة القطع عمودي ع السطح)

(حالة القطع مائل)



∴ عنه normal stress

و shear stress

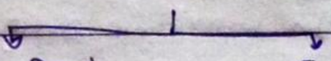
* مش حسب ال stress القوة بتكون عمودي او موازي للسطح إللي بيقع P عليه

يعني (عند القطع مائل) ماتنفع ~~$\sigma = \frac{P}{A}$~~ : غلط

shear normal

موازي، عمودي

تحليل القوة (normal stress)


$V = P\sin\theta$ $F = P\cos\theta$

∴ لحساب normal stress

$$* \quad \sigma = \frac{F}{A_\theta} = \frac{P\cos\theta}{A_0/\cos\theta} = \frac{P}{A_0}\underline{\cos^2\theta}$$

و لحساب Shear stress

shear force هي مطلقا

$$* \quad \tau = \frac{V}{A_\theta} = \frac{P\sin\theta}{A_0/\cos\theta} = \frac{P}{A_0}\underline{\sin\theta\cos\theta}$$

The max normal stress when the refrence plane perpendicular ~~the~~ to the member axis $\sigma_m = \frac{P}{A_0}$, $\tau' = 0$

لما $\theta = \pm 45$ $\tau_m = \frac{P}{A_0}\sin 45 \cos 45 = \frac{P}{2A_0} = \sigma'$

normal stress > shear stress [illegible]

2D × أحيانا يكون عندي

normal ← العمودي   y و x   ~~بيتجه~~ باتجاهين   stress   عامة normal

.shear ← الموازي   2 shear ←

3D

$$\Sigma F_x = \Sigma F_y = \Sigma F_z = 0$$
$$\Sigma M_x = \Sigma M_y = \Sigma M_z = 0$$

:Factor of Safety:- (Fs)

الأهمية:-

1- عدم الثقة بحسابات المادة ، التحليل

2- تعويض التشوهات والعيوب ، عامل أمان

structral members or machines must be designed such that the working stresses are less than the ultimate strength of the material

FS = Factor of safety → [illegible]

$$F_S = \frac{\sigma_u}{\sigma_{all}} = \frac{\text{ultimate stress}}{\text{allowable stress}}$$

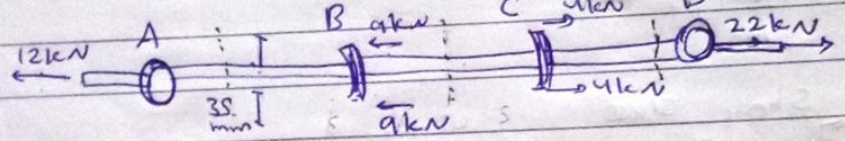
أعلى إجهاد يتحمل

$\frac{B\ 250\ kg/cm^2}{t}$

σ العمود ultimate

(1.5)

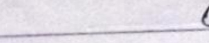
Example:- The bar in Fig-1.8 constant with width 35mm and thikness of 10mm. determin the maximum averge normal stress in the bar when it is subjected to the loading shown



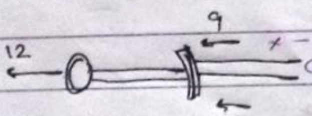
1. شروط الاتزان stability :

$$0 = 12 - 9 - 9 - 4 + 4 + 22$$

2. حساب internal force : نعمل قطع

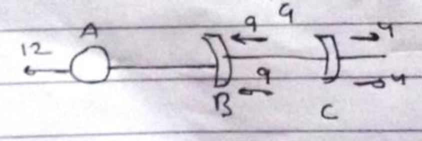
Ⓐ 

$\Sigma F_x = -12 + N = 0$ Normal force$|_A$ = $\boxed{12}$ kN

Ⓑ 

$0 = -9 - 9 - 12 = \boxed{30}$ kN = normal force$|_B$

$0 = 9 + 9 + 12 = 30$

Ⓒ 

$\boxed{4 + 4 - 9 - 9 - 12} = \boxed{-22\ kN}$

$8 - 18 - 12$

normal
يطلع x^- ينزل x^+ ضغط

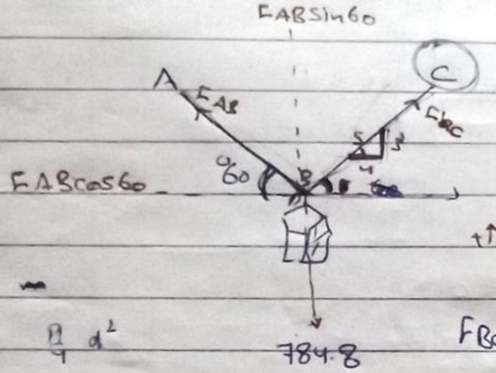
$35\times10^{-6} = 350$ F/ Area normal stress ضغط .2

ⓑⓐ = F/Area $\frac{30(10^3)}{35\times10^{-6}}$ = 85.71 MPa مهم

max ال

1.6) Example(2): The 80 kg lamp in supported by two road AB and BC as shown in Fig. It AB has a diameter of 10mm and BC has a diameter of 8mm. determine the averge internel stress in each road rod

normal



$\overset{+}{\rightarrow}\Sigma F_x = 0 = F_{BC}\frac{4}{5} - F_{BA}\cos\overset{60°}{\theta} = 0$

$+\uparrow\Sigma F_y = 0 = F_{BC}\frac{3}{5} + F_{BA}\sin60 - 784.8$

$\frac{\pi}{4}d^2$

$F_{BC} = 395.2\text{ Ⓝ}$ $F_{AB} = 632.4$

averge normal stress

$\sigma_{BC} = \frac{F_{BC}}{A_{BC}} = \frac{395.2\,N}{0.004\,mm^2} = 7.86\text{ MPa}$

$\sigma_{AB} = \frac{F_{BA}}{A_{BA}} = \frac{632.4\,N}{0.005\,m^2} = 8.05\text{ MPa}$

$\frac{4}{5}F_{BC} - \frac{1}{2}F_{BA} = 0$

$\frac{3}{5}F_{BC} + \frac{\sqrt3}{2}F_{BA} = 800$

$F_{BA} = \frac{8}{5}F_{BC}$

$\frac{3}{5}F_{BC} + \frac{\sqrt3}{2}\left(\frac{8}{5}F_{BC}\right) = 8$

$\frac{3}{5}F_{BC} + \frac{4\sqrt3}{5}F_{BC} = 8$

$\frac{3+4\sqrt3}{5}F_{BC} = 800$

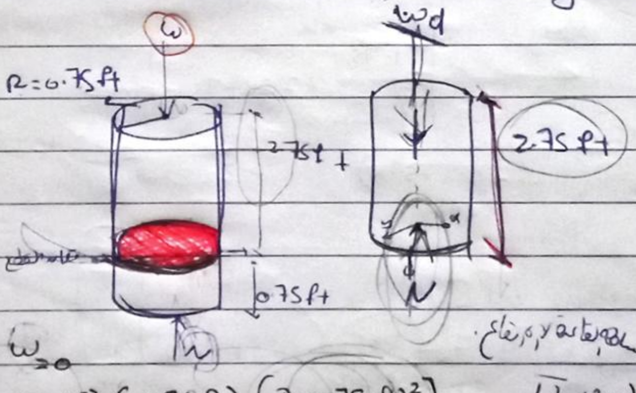
$F_{BC} = \frac{4000}{3+4\sqrt3} \Rightarrow$

$\boxed{\simeq 448.6}$

$\boxed{F_{BA} = 717.8}$

(1.7)

Example (3): The cylinder shown mad of the steel having a spesific weight of $\gamma = 490\ lb/ft^2$. Determine the averge compressive stress acting at Point A and B



الكثافة = الوزن / الحجم

الحجم × الكثافة

$+\uparrow\Sigma F_y = 0 = N - W = 0$

مساحة مقطع دائري (πr^2)

$N = (490\ lb/ft^2)(2.75\ ft)(\pi\times0.75\ ft)^2]$

حجم الاسطوانة $\pi r^2 h$

$= \boxed{2381\ lb}$

averge compression stress

$\sigma = \frac{N}{A} = \frac{⊖2381\ lb}{\pi(0.75)^2} = 1347.5\ \boxed{lb/ft^2}$ /144 = 9.36 psi

من الكتاب

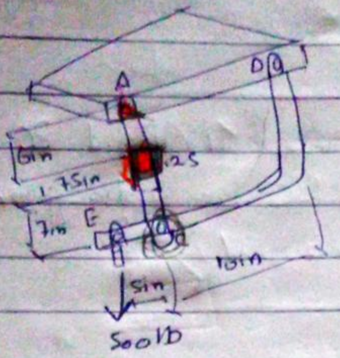
Semple Proplem 1.1

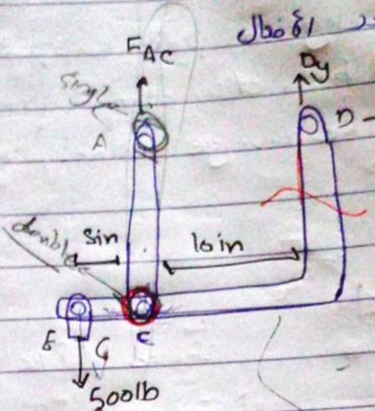
السؤال يطلع 4/1

ABC $\frac{3}{8}$ in سمك

1. حد shear stress

1. ايجاد ردود الأفعال





① Shear stress A, C

$\circlearrowleft + \; M_D = 0 = \quad (500 \times 15) - F_{AC}(10) = 0$

$F_{AC} = +750$ lb tension

single $\bar{\tau} = \frac{F_{AC}}{A} = \frac{750}{\frac{1}{4}\pi(0.375)^2} = \boxed{6790 \text{ psi}}$

من $\frac{3}{8}$ in لـ قطر البرغي

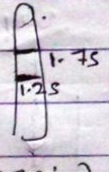
C عن double shear البرغي محسوب من جانبين

[illegible]

$\bar{\tau} = \frac{\frac{1}{2}F_{AC}}{A} = \frac{375}{\frac{1}{4}(\pi)(0.25\text{ in})^2} = 7640$ psi

③ Largest normal stress

القطع



$1.25 \times 1.75 = \text{area}$

$\sigma_A = \frac{750}{(\frac{3}{8}\text{ in})(1.25 - 0.375\text{ in})} = \frac{750}{0.328\text{ in}^2} = 2290$

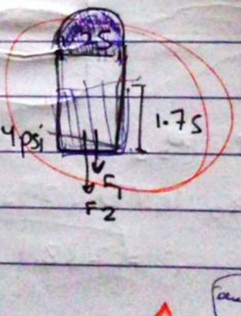
نطرح قطر البرغي

[illegible] area [illegible] قطر البرغي [illegible]

④ Averge shear stress of B

$\tau = \frac{F}{A} = \frac{\cancel{750}\;375}{1.25(1.75)} = 171.4$ psi

$= \frac{750}{2(1.25)(1.75)}$



⑤ Bearing stress $\sigma_b = \frac{375}{0.0625\text{ in}^2}$

[illegible] FAC × قطر البرغي

مساحة $\frac{\pi}{4}$

1.3

43

SAmplG proplem (1.2)

The steel tie bar shown is to be designed to carry a tension force of magnitude $\boxed{P = 120\ kN}$ whe bolled between double brackets at A and B. The bar will be fabricated from 20 mm thick plate stock. For the grade of steel to be used the maximum allowable stress are $\sigma = 175\ MPa$, $\tau = 100\ MPa$, $\sigma_b = 350\ MPa$.

shear compressive max max bearing

Design the tie bar by determining the required values of

(a) the dimater d of the blot

(b) the dimension b at each end of the bar

(c) the dimension h with of the bar عرض

$$\tau = \frac{F}{A} = \frac{60 \times 10^3}{(\frac{1}{4}\pi (d^2)) \times 10^{-6}} = 100$$

double shear لما

باخذ نص القوة او مقسومة

$$\overset{0.25}{(\frac{1}{4}\pi d^2)} \times \frac{100}{100} = \frac{60}{100}$$

$$4 \times \frac{1}{4}\pi d^2 = \frac{6}{10} \times 4$$

$$\pi d^2 = 2.4$$

$d = 27.6\ mm \approx \boxed{28\ mm}$

$60\ kN = 60{,}000\ N$ $\boxed{\times 1000}$

$100\ MPa = 100\ N/mm^2$

$$A = \frac{F}{\tau} = \frac{60\,000\ N}{100\ N}\ mm^2$$

$A = 600\ mm^2$

$$A = \pi d^2 \frac{1}{4}$$

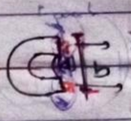
$$600 = 3.14 \times 0.25\ d^2$$

$d = 27.6 \approx \boxed{28}$

at this point → Bearing stress عند النقطة هاد نعمل فحص ال

$$\tau_b = \frac{P}{td} = \frac{120\ kN}{0.02\ m \times 0.028\ m} = 214 < 350 \therefore \text{save. ok}$$

dimision (b) $\frac{P}{120}$



نلاحظ وجود ثقب البرغي (فرغة)

$$\cancel{\frac{120\ 60}{2(b-d)(20)}} = 100$$

$\cancel{20 b - 20 d}$ $\frac{100}{100}$ $= \frac{60}{100} \times \frac{1}{2a}$

$$\sigma = \frac{\frac{1}{2}P}{2a} = 175 = \frac{60 \times 10^3}{0.2a} \quad a = 17.14\ mm$$

$\cancel{20(b-d)}$

$\cancel{b - d = 0.3}$

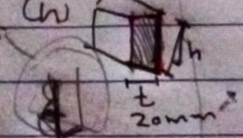
$$b = 2a + d = 62.3 \approx \boxed{63}$$

$$175 = \frac{\overset{60}{\cancel{120}}}{2(b-d)(20)}$$

$$175 = \frac{60}{(b-d)(20}$$

$(b-d)(20)(175)$

(c)



$$175 = \frac{120 \times 10^3\ N}{t\ h}$$

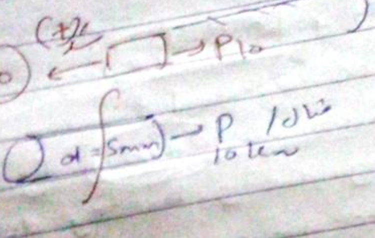
$0.02\ m$

$h = 34.3\ mm$

$\boxed{use = 35}$

Revive chapte (1)

normal stress :- $\sigma = \frac{P_{internal}\ (N)}{A\ of\ section\ (mm^2)}$



$\sigma = \frac{10kN}{\frac{\pi}{4} \times 5^2} = $ (+) MPa

مثال

مصمت

Two solid cylindrical rods AB and BC are

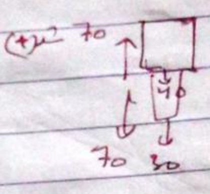
$d_1 = 50mm$ $d_2 = 30mm$

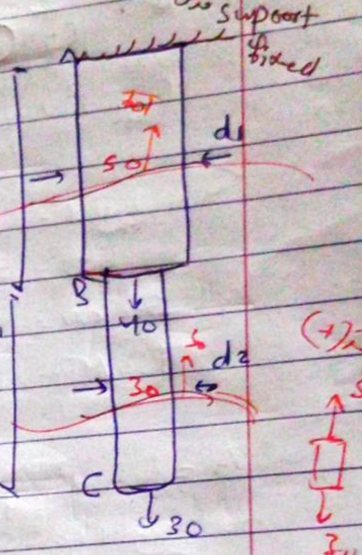
المطلوب Find average normal stess at the midsection of (a) rod AB , BC

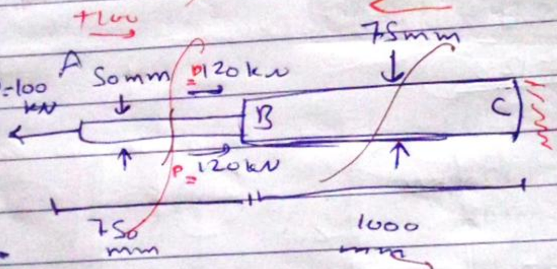
$\rightarrow \sigma_{BC} = \frac{+30 \times 10^3\ N}{\frac{\pi}{4} \times 30^2}$

$- \sigma_{AB} = \frac{70 \times 10^3}{\frac{\pi}{4} \times 50^2} = MPa$

[illegible]



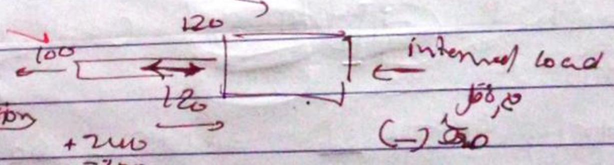




مثال

normal stress AB section
BC "

$\rightarrow \sigma_{AB} = \frac{+100 \times 10^3}{\frac{\pi}{4} \times 50^2}$

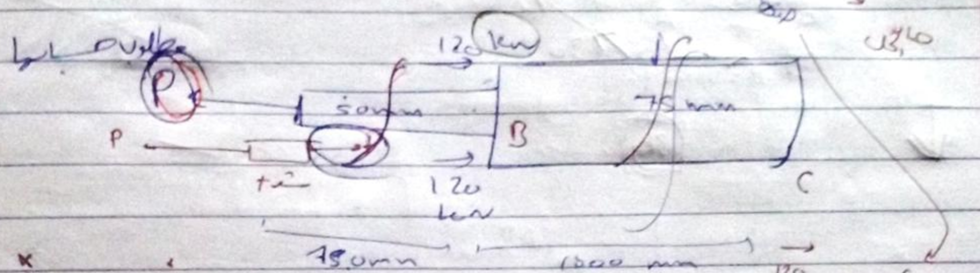


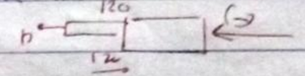
compression

$\rightarrow \sigma_{BC} = \frac{-140 \times 10^3}{\frac{\pi}{4} \times 75^2} = -MPa$

+240
−100
140

Two solid cylindrical road AB & BC are wheald together/weld at B and --> shown. determine the magitude of the force P for when tensile ~~strength~~ stress in rod AB = stress BC compression





$$\sigma_{AB} = \frac{+P}{\frac{\pi}{4} \times 50^2}$$

σ_{BC} compression (-)

internal force (240 - P)

$$\frac{P}{\frac{\pi}{4} 50^2} = \frac{-(240 - P)}{\frac{\pi}{4} \times 75^2}$$

[illegible] →
$$\frac{P}{\cancel{\frac{\pi}{4}} 50^2} = \frac{-240 + P}{\cancel{\frac{\pi}{4}} \times 75^2}$$

section [illegible] do

din [illegible] A = do din

A hollow circular post ABC P1 = 1700N acting at the top, P2 is uniformly distributed around the cap plate at B. The diameters and thicknesses of the upper ~~part of the post~~ and lower parts the post ~~and~~ d_{AB} = 32mm, t_{AB} = 4mm
[illegible] d_{BC} = 56mm, t_{BC} = 8mm respectively

① Calculate normal stress σ_{AB} in the part upper of the post

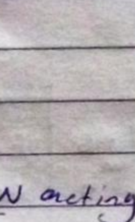
② if it is desired that the lower part of the post have the same compressive stress at the upper part, what should be the magtitude of the load P2?

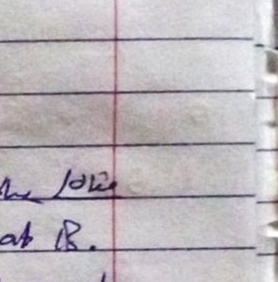
Area $\frac{\pi}{4}(do^2 - di^2)$

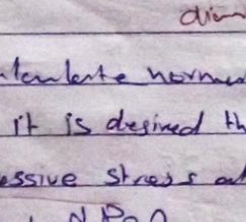
$AB \rightarrow \sigma$ upper

① $= \frac{-1700 \text{ N}}{\frac{\pi}{4}(32^2 - 24^2)}$ = MPa

(-) compression

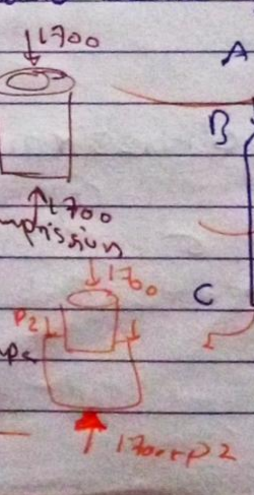




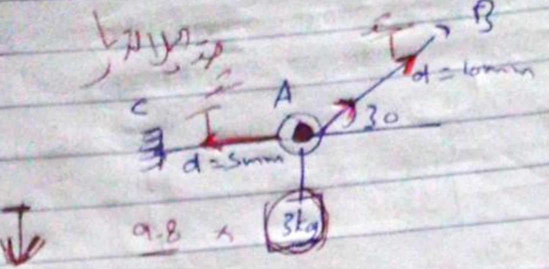


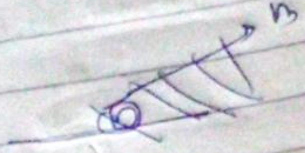
[illegible] 32 - (4+4)

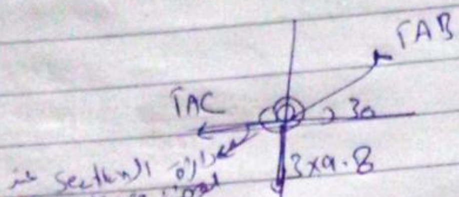
② $\frac{-(1700 + P2)}{\frac{\pi}{4}(56^2 - 40^2)}$ = MPa



مسائل ع [illegible] ع normal stress.







$\Sigma F_x = 0 \Rightarrow$

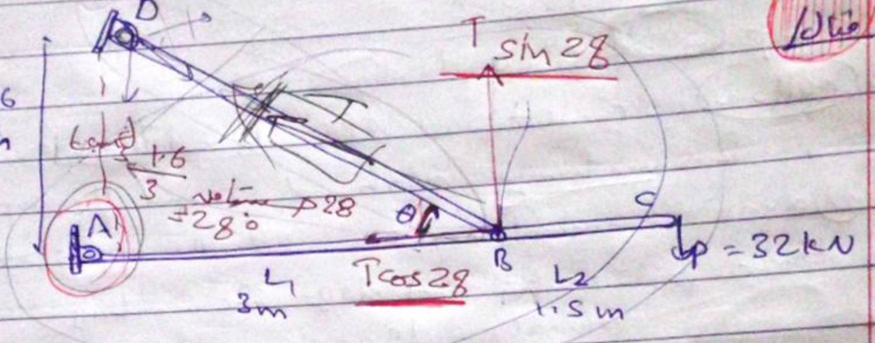
$\Sigma F_y = 0 =$

$$\sigma_{AB} = \frac{T_{AB}}{\frac{\pi}{4} \times 10^2} = \_\_\_$$

$$\sigma_{BC} = \pm \frac{T_{AC}}{\frac{\pi}{4} \times 5^2} = \_\_\_$$

مثال

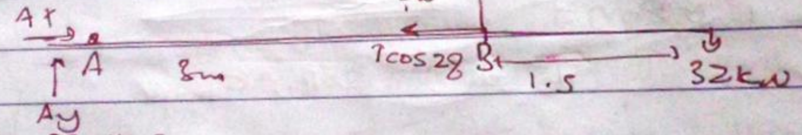
$\tan\theta = \frac{1.6}{3}$



المطلوب [illegible] normal stress في كل عضو مطلوب T or C [illegible] في الحل

نوجد normal stress BD

$\sigma = \Sigma$ T sin 28



$\Sigma M_A = 0$: $T\sin 28 (3) - 32 \times 4.5$

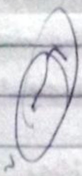
$T = \boxed{+} \approx 62$

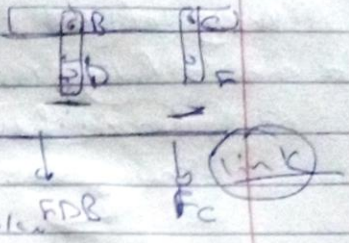
$\sigma = \frac{T}{\_\_\_}$

Area 481mm² [illegible]

+ Tension
− compression

طول
section تبا
Area link.





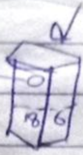
$\sigma = \frac{-15 \times 10^3}{18 \times 6}$

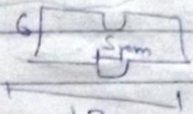
$\sigma_{BC} = \frac{20 \times 10}{(18 - \boxed{5}) \times 6}$

$F_{BC} = 20 \text{ kN}$

$F_{CE} = -15 \text{ kN}$

بريئ الا مقبض

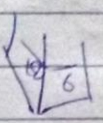




Area
critical Area
(C) aied

عند الـ Tension $(18-5) \times 6$

أما هاد بكون الأصغر بالنص مش حالة compression

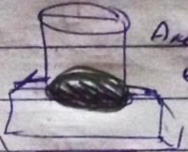


-: Review Bearing stress ع (σ_b)

contact

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

Area of contact



$\ell =$

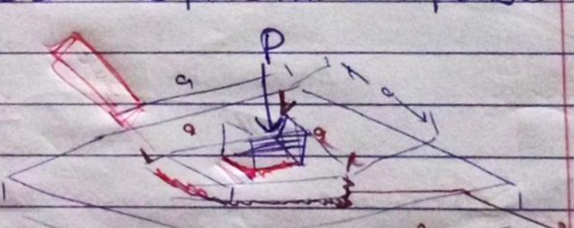
عمود على
قاعدة

An axil load P is supported by a short W8x40 coloumn ~~[illegible]~~ of cross-sectional area $A = 7650 \text{ mm}^2$ and is distribute to concrete foundation by a squar plate. knowing the average normal stress on the ~~concrete~~ coloumn must not concrete 200 MPa and that the bearing stress on the concrete foundation must not exeed 20 MPa. determine the side a of the plate that will provide the most economical and safe

σ_{b} bearing $= \frac{P}{a \times a} = 20$

normal stress

$\frac{200}{1} = \frac{P}{7650}$



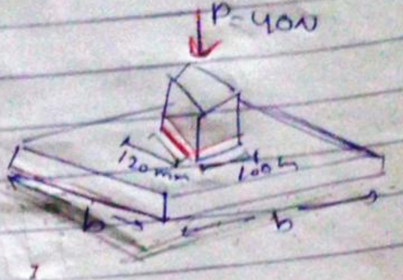
σ_n on the coulomn $\sigma = \frac{P}{A} = 200 = \frac{P}{7650} = 153 \times 10^4 \text{ kN}$

σ_b on Concret footing : $\sigma_b = \frac{P}{A} = 20 = \frac{153 \times 10^4}{a^2}$

[illegible] bearing [illegible]

stress [illegible] ، bearing stress [illegible]

A 40 kN axil load is applied to short wooden post that is supported by a concrete footing resting on undisturd soil. determine (a) the max bearing stress on the concrete footing, (b) the size of the footing for which the average bearing stress in the soil is 145 kPa.



σ_b on the concrete footing

$= \frac{40 \times 10^3}{120 \times 100} = 3.33$ MPa

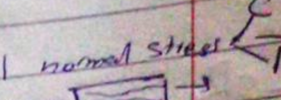
Area contact

(b×b) [illegible] = 145 kPa [illegible] bearing stress

$145 \text{ kP} \times 10^{-3} = \frac{40 \times 10^3}{b \times b}$

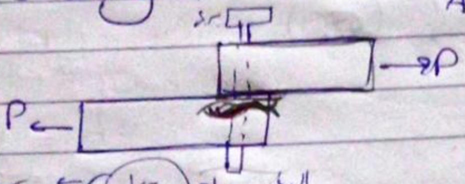
= MPa

axil normal stress



Review Shearing Stress : $(\tau) = \frac{P}{A}$ → internal shear force

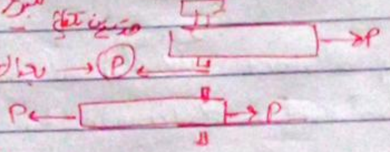
A → Area of shear



Shear Stress ← (يتقطع) راح البين

shear ÷ القطع بالعرض

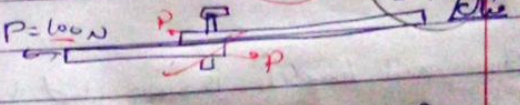
البرغي [illegible]



[illegible] ← (P)

$\tau = \frac{P \text{ (N)}}{\frac{\pi}{4} \times d^2 \text{ (mm}^2)}$

[illegible]

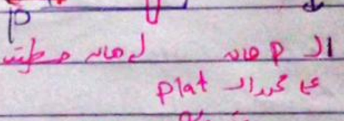


$\tau = \frac{P}{A} = \frac{100 \text{(N)}}{\frac{\pi}{4} \times 5^2 \text{(mm}^2)} = 5.1$ MPa

أنواع ال Shear stress

$= \frac{P}{A}$

single She



①

ال P هنا [illegible] shear [illegible] القطع [illegible] (1 م)

ع جدار ال plat

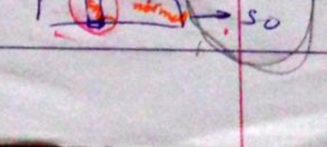
[illegible] normal stress

2 plates [illegible] Shear

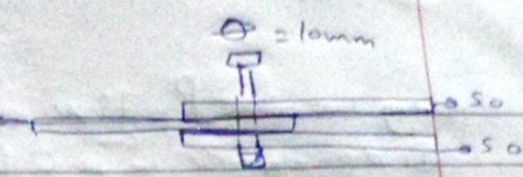
$\tau = \frac{P}{②A} = 100 \rightarrow$ [illegible] 100

← [illegible]

Shear



$\bar{\tau} = \frac{P}{2A} = \frac{100}{2(\frac{\pi}{4} \times 10)^2} = 0.63$ Mpa $\}$ 100 ←

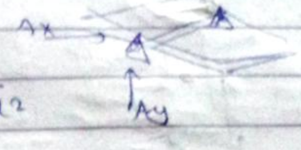


resultand

$A = \sqrt{Ax^2 + Ay^2}$ $\quad \bar{\tau} = \frac{Ay}{\frac{\pi}{4} \times d^2}$

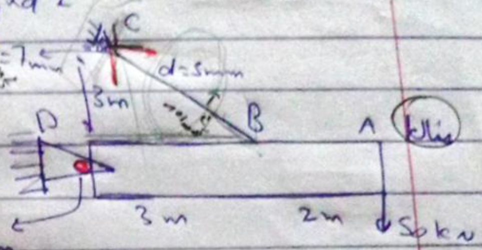
$\bar{\tau} = \frac{R}{A}$ $\quad \bar{\tau} = \frac{Ax}{\pi/4 \times d^2}$

double single



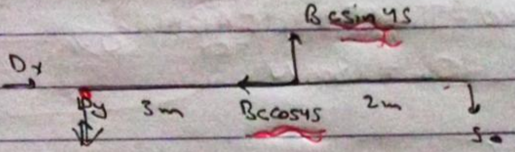
shear قطر d = 7mm

1. determine the normal stress on cable BC?



shear قطر d = 10 mm

Free body diagram عمل ← D A بس لل



$\Sigma M_D = 0 = +Bc\sin 45 (\times 3) - 50 \times 5$

$= 97.9$ kN (T) +

$\sigma = \frac{97.9 \times 10^3}{\frac{\pi}{4} \times 5^2} = 4\ldots$

$\Sigma F_y = 0 = Dy + 97.9\sin45 - 50$

$Dy = -33.3$

$\therefore Dy \downarrow$

2) shear stress on the BD

$\Sigma F_x = 0, Dx - B\cos45$

$Dx = 26$

resultat عمل Dy و Dx من Shear ملاحظة عند D محل ال

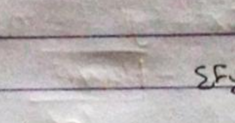
$D = \sqrt{Dx^2 + Dy^2} = \sqrt{-33.3^2 + 26^2} = 45$ تقر kN

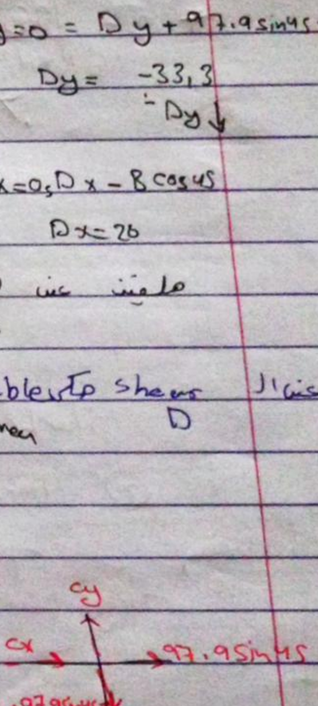
$\tau_{BD} = \frac{45 \times 10^3}{2(\frac{\pi}{4} \times 10)^2} = \checkmark$ → double لأن shears D في ال

2×Area في ال shear ال bolt نفسه

10mm ده

3) shear stress on the pin C





dauble C [illegible]

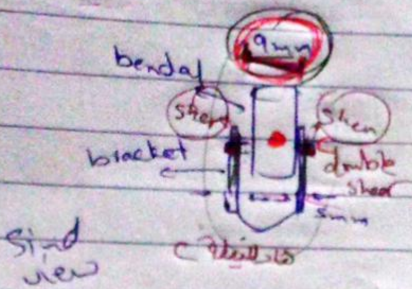
$- \Sigma F_x = 0 = Cx + 97.9\sin45$

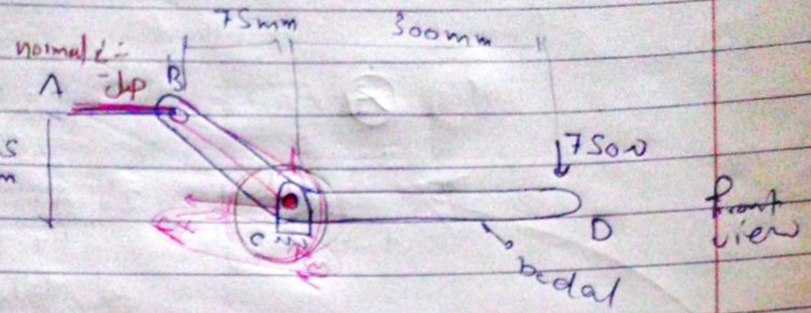
$- \Sigma F_y = Cy - 97.9\cos45$

$\bar{\tau} = \frac{C_{resultant} \times 10^3}{2 \times (\frac{\pi}{4} \times 7^2)}$ $\quad C_{resultant} = \sqrt{C_x^2 + C_y^2}$

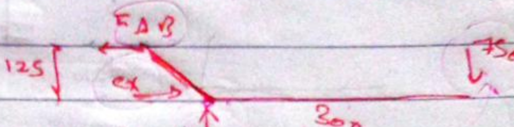
knowing that a force P = 750N applied to the pedal. دواسة مثال

① diameter for the pin C دبوس for which the averge shearing stress in the pin is 40MPa? (b) the cross bending bearing stress in each support bracket at C.





$\bar{\tau}$ = 40 MPa في c ال d. مطلوب :



ΣMc = 0 = 750 * 300 + FAB * 125 (= Cx)

① ∴ Cx = 1800 N

~~مجهول~~

FAB 1800 N

~~ΣFx = 0 = cy −~~

ΣFx = Cx − FAB = 0

ΣFy = cy − 750 = 0

FAB = Cx

cy = 750

C resultat = $\sqrt{Cx^2 + Cy^2}$ = 1950

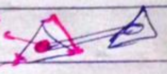
* $\tau = \frac{1950\,N}{(\frac{\pi}{4} * d^2)2}$ − $\boxed{40MP}$

d = ?

②

(البرج) contact

. C ال bracket م



ال bearing نتيجة أقل من shear و normal

shear عشان يكون عمودي bearing $\sigma_b = \frac{C_{resultant}}{d * t}$

d قطر البن

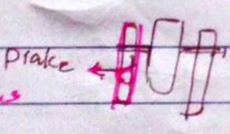
t سمك ال pedal

$\frac{1980}{d * 9mm}$

d ناتج من (1)

Short في الاخط للـ bering

③ مطلوب σ_b عن ال Darket



$= \frac{1950}{2(d * t)}$

d مطلوب

t 5mm

[illegible]

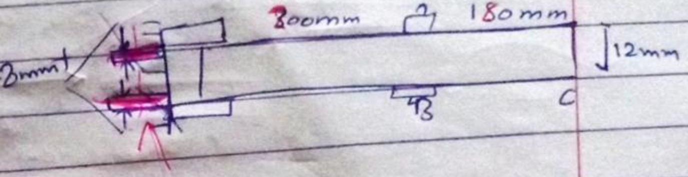
In the structure shown, an 8mm diameter pin is used at A, and 12mm diameter pins are used at B and D. if the load P=120kN and the ultimate shear stress at each pin is 1800 MPa

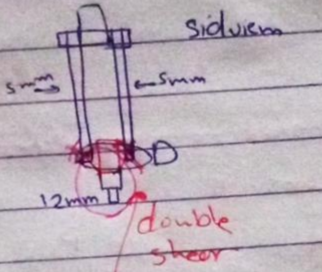
allow [illegible]

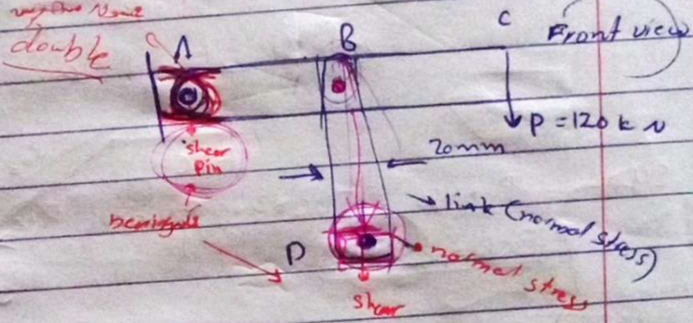
a) Reactions at A and D

b) shear stress at pin A and pin D

c) Suitable Factor of safty



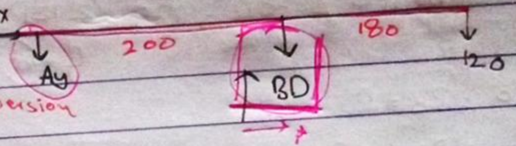




A is $\Sigma M_A = 0 = -BD * 200 - 120 * 380$

$\Sigma BD = -228\ kN$ → compersion

∴ ↑

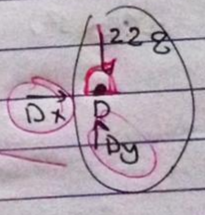


$\Sigma F_y = -A_y + \overset{228}{BD} - 120 = 0$

$A_y = 108 kN$ ↓

$\Sigma F_x = 0 = A_x$

D is reaction



228 = Dy

Shear stress A , D

$$\frac{A_{resultant} \sqrt{Ax^2 + Ay^2}}{2\left(\frac{\pi}{4} * d^2\right)} = \boxed{\tau_A}$$

double

8mm

→ allow double

A resultant = 108

$$\frac{\sqrt{Dx^2 + Dy^2}}{\text{single}\left(\frac{\pi}{4} * 12mm^2\right) 2} = \boxed{\tau_D}$$ → allow

③ F.s → shear [illegible] $= \frac{\tau_{ult}}{\tau_{allow}} = \frac{1800}{\tau_A} = F.S$

[illegible] F.s [illegible]

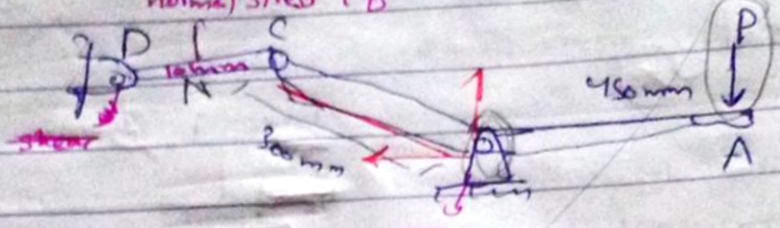
[illegible]

$\frac{1800}{\tau_D} = F.S$

[illegible]

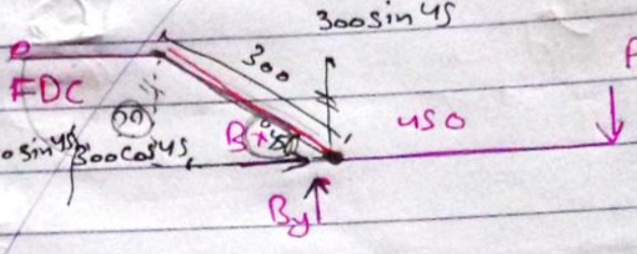
determine the max vertical force P that can be applied to the bell crank so the average normal stress developed in the 10mm diameter rod CD, and the average shear stress in the 6mm diameter double shear pin B not exceed 175 MPa and 75 MPa respectively

قضيب
normal stress 175



shear stress
75 MPa
مسمار
6mm

نطلع P في shear و normal stress ، ناخذ الأقل.



$\Sigma M_B = 0 = -P * 450 + FDC * 300\sin 45$

$\boxed{FCD = 2.12P}$

normal stress منه ↓

normal stress $\sigma = \frac{FCD}{Area} = 175 = \frac{2.12P}{\frac{\pi}{4} * 10^2}$ ∴ P_1 | normal

$\Sigma F_y = 0 ;\ B_y = P$

$\Sigma F_x = 0 = B_x = FDC = 2.12P$

$B = \sqrt{(P)^2 + (2.12P)^2} = 2.34P$

$\sqrt{(2.12^2 + 1^2)P^2} = 2.34P$

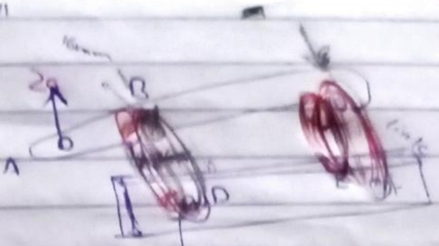
$\tau = 75 = \frac{2.34P}{2(\frac{\pi}{4} * 6^2)} = P_2$ | shear

$\boxed{\text{نختار } P \text{ الأقل}}$

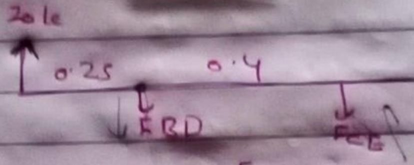
$\sqrt{P^2 C}$

link [illegible] = 8x36 mm و [illegible]
16mm

BD و CE [illegible] normal stress [illegible]



link [illegible] link [illegible]



$\Sigma M_B = 0 = -20 * .25 - F_{CE} * 0.4$

$F_{CE} \rightarrow = \ominus 12.5$ kN (C)

F~~BD = 0~~ = $\Sigma M_E = F_{BD} * 0.4 - 20 * (0.25 + 0.4) = 0$

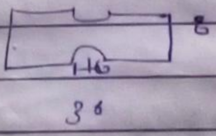
$F_{BD} = \oplus 32.5$ (T)

(C) $\sigma_{CE} = \dfrac{\ominus 12.5 \text{ kN} * 10^3}{(2)(8 * 36)} = \text{MPa}$

2 link [illegible] CE

$\sigma_{BD} = \dfrac{\oplus 32.5 * 10^3}{(2)\,\cancel{36}\,(36-16) * 8} = \text{MPa}$ → link [illegible]

[illegible]



- A.M (1) :-

[illegible] 1.7 [illegible] 1.1

[illegible] 1.70

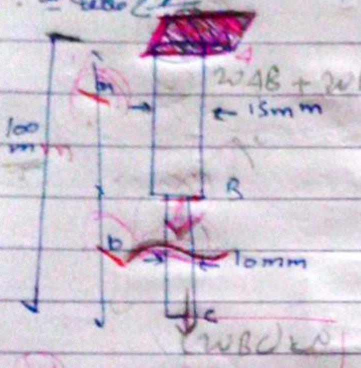
[illegible] 1.20 [illegible]

1.55 1.29 [illegible]

- 1.6 - Two brass rods AB and BC, each of uniform diameter, will be brazed together at B to form a nonuniform rod of total length 100m which will be suspended from support at A as shown. knowing that the density of brass 8470 kg/m³,

(a) the length of rod AB for which the maximum normal stress and minimum [illegible] AB [illegible]

(b) the corresponding value of the max normal stress.



$w_{BC} + w_{AB}$ AB (A)

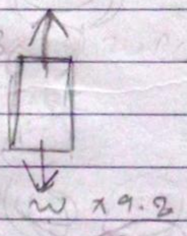
$\sigma = \frac{\text{Total } w}{A(15)}$

$\sigma = \frac{w_{BC}}{A(b)}$ w_{BC} (B)

$\sigma_B = \sigma_A$

$A_1 = \frac{\pi}{4} d_1^2 = \pi/4 (0.015)^2 = 1.767 \times 10^{-4} m^2$

$A_2 = \frac{\pi}{4} (0.01)^2 = 0.785 \times 10^{-4}$



A

$BC = \frac{w_{BC}}{\frac{\pi}{4}(10)^2}$

الكثافة = الكتلة / الحجم

$\sigma_B = \frac{w_{BC}}{A_2} = \frac{\rho g \cancel{A_2} b}{\cancel{A_2}} = \boxed{\rho g b}$

الكثافة = الكتلة / الحجم

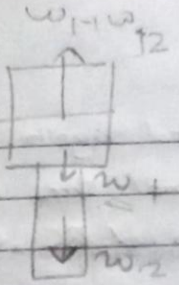
الكتلة = كثافة x حجم

$\Sigma F_y = 0 \quad N = w$

$N = w \, 9.8$

$$\boxed{= \rho (A_2) b \; 9.8}$$

$a+b=100$



A_{ws}

$$\sigma_A = \frac{\rho g A_2 b + \rho g A_1 a}{A_1}$$

$$= \frac{\rho g (A_2 b + A_1 a)}{A_1} = \rho g\left(\frac{A_2}{A_1} b + a\right)$$

$N = w_1 + w_2$

$N = \rho g (A_2) b) + g \rho A_1 a$

$\rho g (A_1 a + A_2 b)$

$w_B + w_A$

$\downarrow$

$\rho g b\, A_2 + A_1 a\, \rho g$

$$\frac{\rho g (A_2 b + A_1 b)}{A_1}$$

$\sigma_A = \sigma_B$

$$\rho g b = \rho g\left(\frac{A_2}{A_1} b + a\right)$$

$$b = \frac{A_2}{A_1} b + a$$

$$a = b - \frac{A_2}{A_1} b \Rightarrow a = b\left(1 - \frac{A_2}{A_1}\right)$$

$b = 100 - a$

$$a = (100-a)\left(1 - \frac{0.785}{1.767}\right)$$

$(100-a)(0.555) = a$

$55.57 - 0.555a = a$

$55.57 = 1.555a$

$a = 35.7\ m$

$a+b=100$

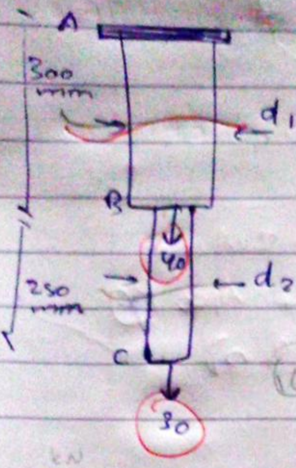
$b = 100 - 35.7$

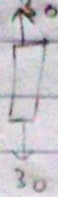
$= 64.2\ m$

2.- $\sigma_{max} = \rho g b = (8470 \times 9.8 \times 64.2) \times 10^{-6}$

$= 5.34\ MPa$

-1.4 Two solid cylindrical rods AB and BC are welded together and loaded as shown. knowing that the averge normal stres must exceed 175MPa in rod AB and 150MPa in 150MPa in rod BC, determ the smallest allowable values of d_1 and d_2





BC

$$\frac{30 \times 10^3}{A} \leq 150 \times 10^6$$

$$30 \times 10^3 \leq 150 \times 10^6 A$$

$$2 \times 10^{-4} \leq A \ (0.25 \pi d^2)$$

$$0.0159 \leq d$$

$$15.9 \text{ mm} \leq d_2$$

(16)

$$\frac{30 \times 10^3}{A} \leq 150$$

$d = 15.9$ mm

kN/m

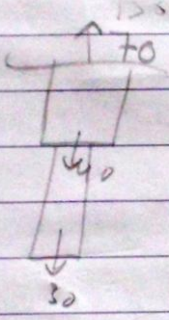
= GPa

$P = N/m^2$

$\boxed{N/mm^2 = MP}$

→ $P = N$ ... m N/m^2 (UK...)

AB



$$\frac{70 \times 10^3}{A} \leq 175$$

$$70 \times 10^3 \leq 175 A$$

$$400 \leq A \ (0.25 \pi d_1^2)$$

$$(24) = (22.5) \leq d$$

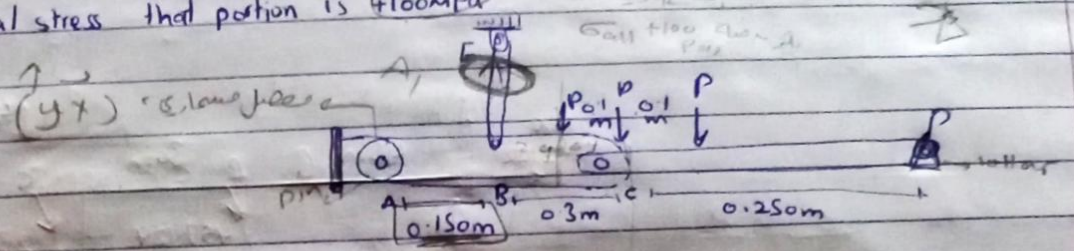
<

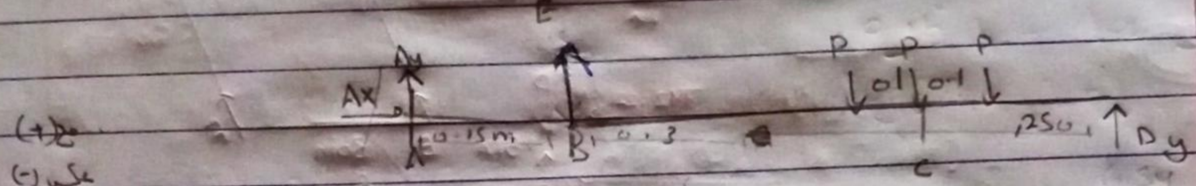
MPa 175 5 $\frac{P}{A}$

0599458204

1.10

Three forces each of magnitude P=4KN, are applied to the mechanism shown, Determine the cross-sectional area of the uniform portion of rod BE for wich the normal stress that portion is +100MPa





$\bigstar$ ~~ΣFy=0~~ $= Ay + E + Dy - 3P = Ay + E + Dy = 12$

$\bigstar$ $\Sigma M_A = 0 = -E(0.15) + P(\underset{1.4}{0.35} + \underset{1.8}{0.45} + \underset{2.2}{0.55}) - Dy(0.7)$

$0.15E = 5.4 - 0.7Dy$

③ Fixed

$\bigstar$ $\Sigma M_B = 0 = Ay(0.15) + P(0.2 + 0.3 + 0.4) - Dy(0.55)$

rollar Ay

$0.55Dy = 0.15Ay + 3.6$

$\boxed{Dy = 0.27Ay + 6.54}$

$Ay + 5.4 - 0.7Dy + Dy = 12$

$Ay = 6.6 - 0.3Dy$

$Dy = 0.27(6.6 - 0.3Dy) + 6.54$

$Dy = 1.782 - 0.081Dy + 6.54$

$E = 12 - Ay - Dy$

$1.081Dy = 8.322$

1.10 : 285 mm^2

$Dy = 7.698$

$Ay = 4.29$

$E \doteq 0.012\ kN$

$$Area = \frac{0.012 \times 10^3}{100}$$

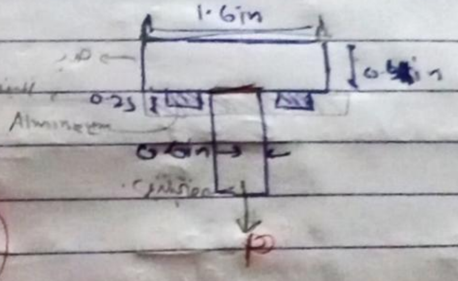
$\Sigma M_D =$

$Area = 0.12\ mm^2$

⑰ aload (P) is applied to a steel rod supported as shown by an alminum plate which a 0.6 in - dimater hole been drilled. knowing that the shearing stress must not exceed 18 ksi in the steel rod and 10 ksi in alminum plate, determine the larges load P that can applied to rod

- Single stress shear :

$\tau = \frac{P}{A}$ المساحة المعرضة للقص



Alminume — Steell

$10 \text{ ksi} = \frac{P}{\cancel{0.25}A}$

① القضيب المعدني قطره (0,6in)

سماكة الـ plate (t) = 0.4in

اسأل ما المساحة ؟ بتنقطع [illegible] = A = $\boxed{\pi * d * t}$

$= \pi * 0.6 * 0.4 = 0.754 \text{ in}^2$

$P_{steel} = \tau_{steel} * A_{steel}$

$= 18 * 0.754 = 13.57$ kips

② بالنسبة للألمنيوم نقطة سطح التماس 1.6in (أساس القوة ذي ضد الرد، سيخف الألمنيوم)

سماكة 0.25 = A alun

$A = \pi * d * T = \pi * 1.6 * 0.25 = 1.257 \text{ in}^2$

$P_{alume} = \tau * A_{alu}$

$= 10 * 1.257 = 12.57$ kip

القوة ينكسر اذا تجاوز 13.57 kips

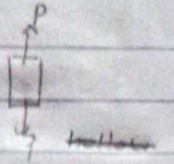
الألمنيوم " " " 12.57 kips

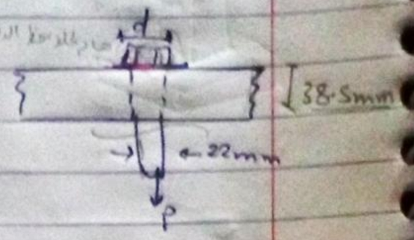
لضمان عدم الانكسار أي جزء من النظام نختار القيمة الأصغر

P = 12.57

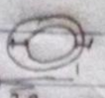
$\boxed{1.19}$ the load P apllied a steel dimater for rod 22mm and inner dimater $\boxed{\sigma 25mm}$ which is slightly larger than the diamder of hole, determine the smallest allowable outer dimeter d of washer, knowing the axial normal stress in steel = 35 MPa and the averge bearing stress beltween the washer and timber 5 MPa

d أكبر من 25 [illegible]





normal stress: $\sigma = \frac{P}{A}$



$$\sigma = \frac{+P}{\frac{\pi}{4}(d^2)}$$

$$\text{Area} = \frac{\pi}{4} d^2 = \frac{\pi}{4}(22)^2 = 380.1$$

$$\frac{\pi}{4}(22mm)^2 * 35 = P$$

$\boxed{~~P = 4.235~~}$ $P = 13304.6$ N

bearing $5MPa = \frac{P}{dt\ A}$

سمك الخشب ← t

قطر البرغي ←

مساحة [illegible] الخشب

[illegible]

$$5 * 22 * t = P * 10^3$$

$$t = \frac{4.235 * 10^3}{5 * 22}$$

$t = 38.5$mm

$$5MP = \frac{P}{A_{contact}}$$

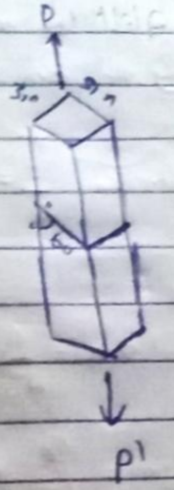
$$A: \frac{P}{5} = \frac{13304.6}{5} = \boxed{2660.9mm^2}$$

$$\text{Area} = \frac{\pi}{4}(d^2 - d_i^2)$$ 25 القطر الداخلي

$$2660.9 = \frac{\pi}{4}(d^2 - 25^2)$$

$\boxed{d = 63.35mm}$ ≃ 65 mm

[1.29] The 1.4 kip load P is supported by two wooden member of uniform cross section that ar joind by the simply glued scarf splice shown. determine noramul and shear stress



normal stress $= \frac{P}{A^0} \cos^2\theta =$

$= \frac{1.4}{5*3} \cos^2 60 = 0.093$ kips

shear stress $= \frac{P}{A^0} \sin\theta \cos\theta =$

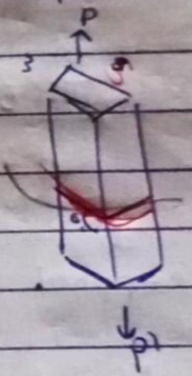
1.29 [illegible] نقص

$= \frac{1.4}{5*3} \sin 60 \cos 60 = 0.040$

[1.30] max allowble tansile stress in the glued splice is 75 psi

(a) the largest load P

(b) shear stress



normal stress $= \frac{P}{A^0} \cos^2\Theta$

$75 = \frac{P}{15} \cos^2 60$

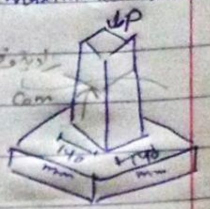
$\frac{15 * 75}{\cos^2 60} = P \qquad P = 4500 \text{ lb}$

shear stress $= \frac{P}{15} \sin 60 \cos 60 = 129.9$ kps

[illegible]

135) A 1060 kN load P $\frac{-1060\times10^3}{140\times140} =$ MPa

determine the resulting max valuim (a) normal stress (b) shear stress. Specify the orientation of the plane on which each of these maximum value occurs



normal stress $= \frac{P}{A} = \frac{-1060\times10^3}{140\times140} = -54.08$ MPa

shear stress

normal stress $= \frac{P}{A_0}\cos^2\theta = \sigma = \frac{+1060\times10^3}{140\times140}\cos^2\theta$

shear stress $= \frac{P}{A_0}\cos\theta\sin\theta = \frac{+1060\times10^3}{140\times140}\cos\theta\sin\theta = \tau$

Bear $= \frac{P}{\text{Area contact}}$

(max) shear , normal أكبر ص *

$\tau = 0$ 54.08 MPa = normal stress max $\theta = 0$ عند .

$\theta = 45°$ max أكبر τ ص .

الحل

135) ج

$\frac{1060\times10^3}{140\times140}\cos45\sin45 = 27.04$

$\sigma = \tau$ هذه الحالة في

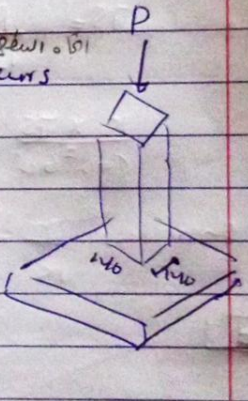
136) A centrical P is applied , shear stress (18 MPa), determine
↳ max value
أنا السطح الذي يحدث عليه أقصى إجهاد قص

→ (a) P

(b) orintation of a surface on which max shear stress occurs

(c) normal stress exerted on that surface → 45° الزاوية

(d) max valine normal stress in block → الإجهاد أكبر $\theta = 0$



1- stress shear $= \cancel{18} = \frac{P}{140\times140}$

$6_\tau = \theta = 45°$

$18 = \frac{P}{140\times140}\cos45\sin45$

$P = \frac{18\times140\times140}{\cos45\sin45} = 705600 = 705.6\times10^3\ N = 705.6$ kN

$\frac{\sqrt{2}}{2}\ \frac{\sqrt{2}}{2}$

(b) $\theta = 45°$

(c) Stress $= \frac{705.6\times10^3}{140\times140}\cos^2\theta$ $\boxed{= 18\ MPa}$

$d = \frac{P}{A_0} = \frac{705.6\times10^3}{140\times140} = 36$ MPa

C.H.P (2) stress and strain : Axial Loading

١- أي load سببت stress هو عبارة عن قوة نتيجة load

*** مهم يكون أقل ← allow stress × أقل actual stress (applied)

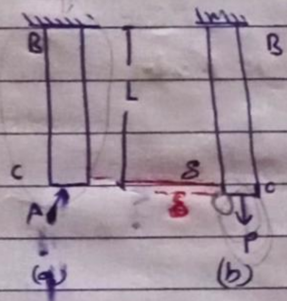
مستبعد 88 ينفع لا، حال).

$$\boxed{\text{allow} \ \text{أكبر} \ \text{actula stress}}$$

• القوة بعد ينتج من مادة ستاتيكيا غير أيضاً indetaminate.

• الأعضاء axil loading فقط سيتم الرسم

① normal strain معدل التغير نسبة للشكل رأسيا



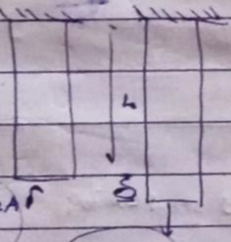
$\sigma = \frac{P}{A}$ = stress

$\varepsilon = \frac{\overset{\text{التغير}}{\delta}}{\underset{\text{الطول}}{L}}$ = normal strain

[illegible]

normal stress

هنا لو ضعفنا المساحة P



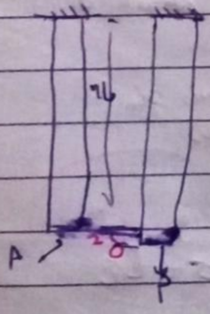
2A المساحة مضاعفة

2P الحمل مضاعف

$\sigma = \frac{2P}{2A} = \frac{P}{A}$

$\varepsilon = \frac{\delta}{L}$ ← حل نفس الشيء

هنا لو زدنا L
مع بقاء A, P



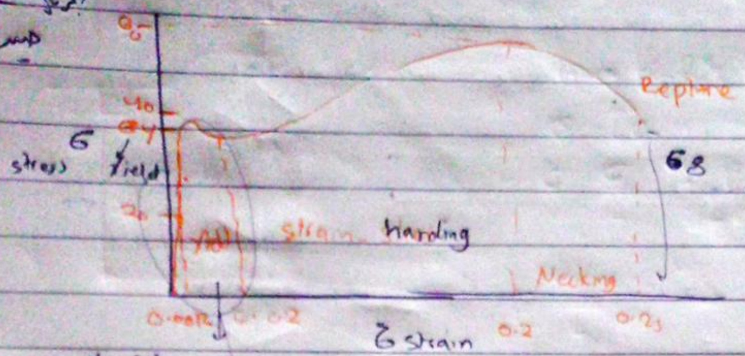
$\sigma = \frac{P}{A}$

$\varepsilon = \frac{2\delta}{2L} = \frac{\delta}{L}$ نفس الشيء.

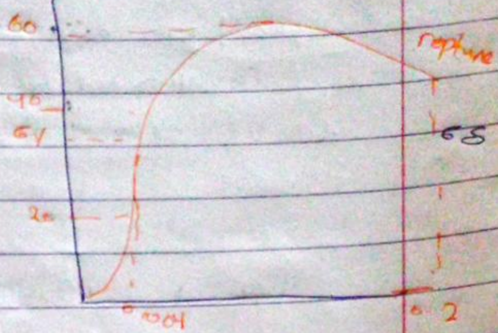
المعادلة ثابتة ما الحال في طول الـ member أو A -

Stress - strain : Ductile Materials ①

تجريبي
حسبر



Low - carbon steel



Aluminum steel

كل ما زاد σ زاد ε

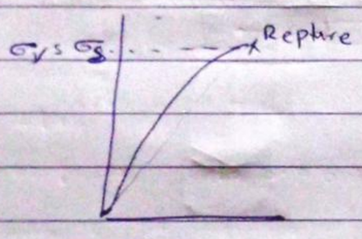
هاد بشلت الحمل يرجع طبيعي

بعد الـ Yield point مزيد بيطل

بطل شوي .

أنا بستعمل عنوع

allow stress لحد ما يس = σy (yeild point) . → material فايدتك للـ

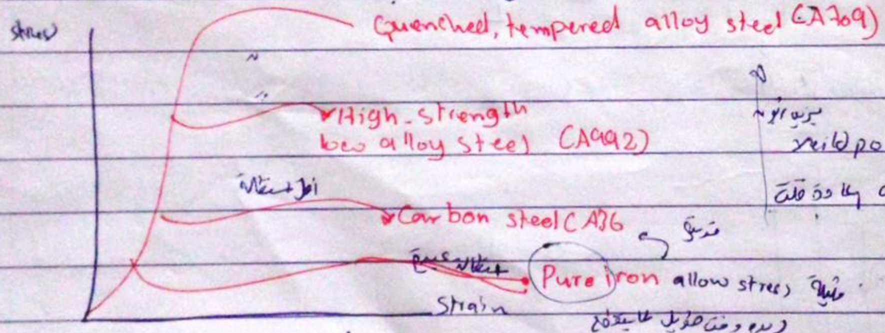


ما بصير استطالة ←

قطع مباشرة ..

brittle material

Hook's Law : Modulus of Elasticity ②



تدريجي

Pure iron allow stress قليلة

دبده وقت طويل لا يتقطع

بيزيد ↑

زادة yeild point

بس ductility الماده قلت

أنواع كثيرة من steel

بستخدم حسب المطلوب .

stress strain

$$\sigma = E\varepsilon$$

E = Young Modulus or

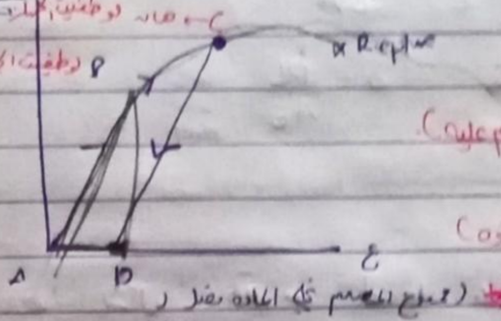
Modulus of elasticity

modulus of elasticity [illegible]

③ elastic Vs plastic Behavior

C ← هاد لو طبقت الكسر عند قوة بيزيد ع وما برجع [illegible]

لو طبقت الكسر عند B ع رح ترجع [illegible] zero



من A لـ B شغل elastic limit (A-B)

بعد B لو طبقت عليه ع رح (ترجع)

elastic zone : (مادة مرنة)

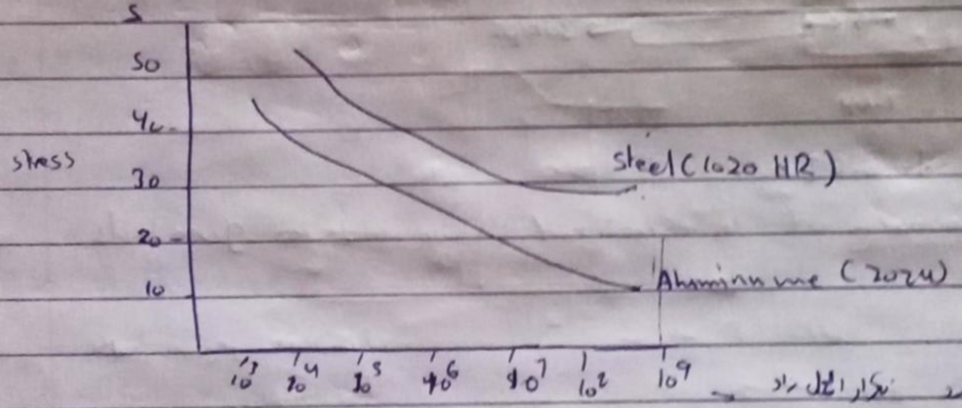
بعد C لو طبقت عليه ع رح (تتشوه)

plastic zone : ~~[illegible]~~ (تشوه المعدن في المادة هنا plastic zone)

هاد من , اصنع

④ Fatigue

→ علاقة Failure بتصير بكثرة التحمل

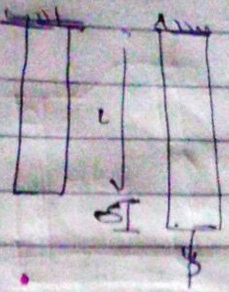


عدد تكرار الحمل زاد →

الاجهاد

stress قلت قدرة تحمله

Deformation Under Axial Loading



From Hooke's Laws

$\sigma = E\varepsilon$,

$\varepsilon = \frac{\sigma}{E} = \frac{P}{EA}$

$\varepsilon = \frac{\delta}{L}$ $\delta = \frac{PL}{AE}$ — دائما لنفس العنصر

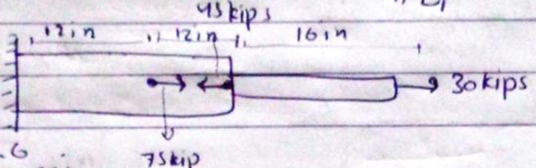
Force ∗ stiffness ∗

لنفرض الشكل أكثر من load على الشكل ← نجيب أجزاء كل جزء فيه حمل لوحده

ونجيب δ ثم Σ

$$\delta = \sum_i \frac{P_i L_i}{A_i E_i}$$

مثال:



$E = 29 \times 10^{-6}$ psi

D = 1.07 in d = 0.618 in

Determine the deformation of the steel rod shown under the given loads

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

الحل: نقسم وفقاً للأحمال — عندي 3 أجزاء

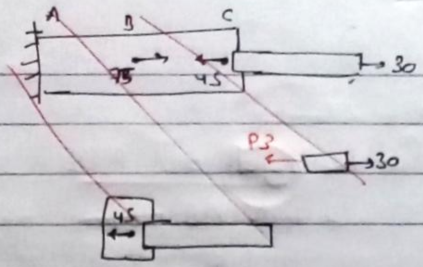
2- Free body

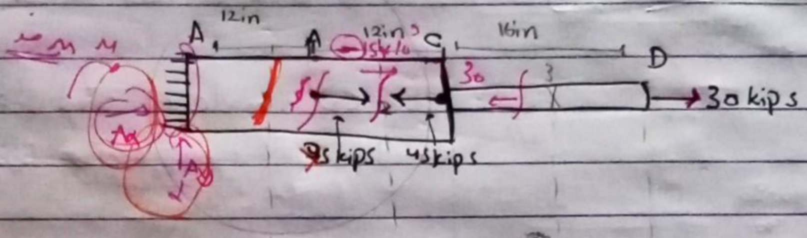
مقطع كبير d^{11} مقطع صغير D^{2}

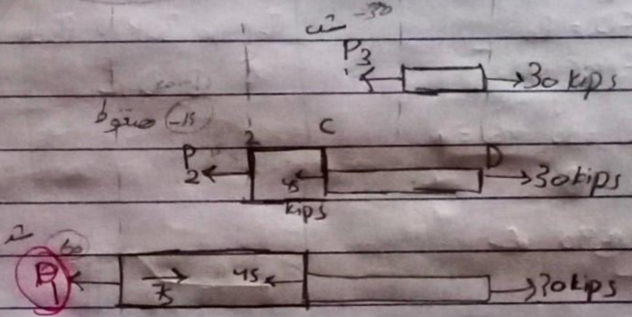
من أول ① أكثر من قوى عند المقاطع (2)

② عند نقطة حمل (3) المجموع

∴ نحتاج $\boxed{3 \text{ مقاطع}}$







$P_3 = 30 * 10^3$ lb

$P_2 = \textcircled{-}15 * 10^3$ lb

$P_1 = 60 * 10^3$ lb

$30 - 45 + P_2 = 0$

$L_1 = L_2 = 12in \qquad L_3 = 16in$

$\rightarrow A_1 = A2 = 0.9 in^2 \qquad A_3 = \frac{\pi}{4}(0.618)^2 = 0.3 in^3$

$\frac{\pi}{4} d^2 = \frac{\pi}{4}(1.07^2)$

$E = 29 * 10^{-6}$ psi

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

[illegible]

$$\therefore \delta = \sum \frac{P_i L_i}{A E_i} = \frac{1}{E}\left[\frac{P_1 L_1}{A_1} + \frac{P_2 L_2}{A_2} + \frac{P_3 L_3}{A_3}\right]$$

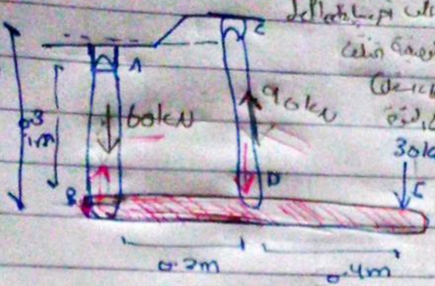
$$= \frac{1}{29 * 10^6}\left[\frac{(60 * 10^3) * 12}{0.9} + \frac{-15 * 10^3 * 12}{0.9} + \frac{30 * 10^3 * 16}{0.3}\right]$$

$$= \boxed{75.9 * 10^{-3} in}$$

$\times 10^3$ ميغا ← GPa تحويل

Sample pooplem 2.1

Part (2)



(نقطة ثابتة) no deformation

deflection [illegible]

30kN AB, CD

The rigid bar BDE is supported by to link AB ~~is mar~~ and CD

Link AB is mad of alminum E = 70 GPa and area of cross section 500 mm^2

Link CD is made of steel E = 200 GPa and area of cross section 600 mm^2

For the 30kN force shown, determint the deflection of B, D, E

(+) شد

(−) ضغط

AB, 90 − 30

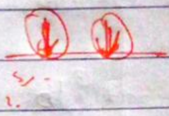
$\Sigma F_y = 0 = AB + CD = 30$

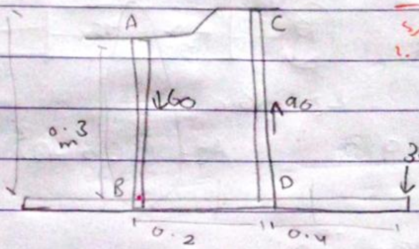
AB = (−)60 comp

$\Sigma M_B = CD(0.2) + 30(0.6) = 0$

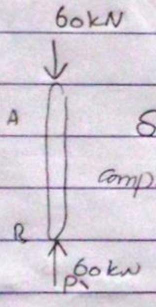
$0.2\,DC = -18$

DC = (+)90 C





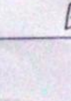
$$\delta = \frac{PL}{AE}$$



kN → N

comp (−)

$$\delta_B = \frac{PL}{AE} = \frac{(-60 \times 10^3 N)\,0.3}{(500 \times 10^{-6} m^2)(70 \times 10^9 pa)} = (-)514 \times 10^{-6} m = \boxed{0.514\ mm \uparrow} \rightarrow comp$$



$P = 90 \times 10^3 N$ (Tension)

$L = 0.4\ m$

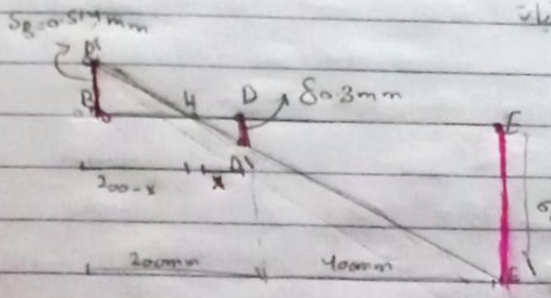
$A = 600 \times 10^{-6} m^2$

$E = 200 \times 10^9 pa$

$$\frac{(90 \times 10^3 N)(0.4)m}{(600 \times 10^{-6} m^2)(200 \times 10^9 pa)} = 3 \times 10^{-4} = 0.3\ mm \downarrow$$

DC ، AB ع deflection lines

[illegible] E [illegible]



$$\frac{BB'}{DD'} = \frac{BH}{HB}$$

$$\frac{0.514}{0.3} = \frac{200-x}{x}$$

$$x = 73.7\text{mm}$$

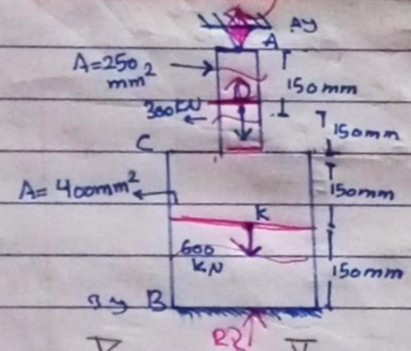
$$\frac{EE'}{DD'} = \frac{HE}{HD}$$

$$= \frac{EE'}{0.3} = \frac{(400+73.7)\text{ mm}}{73.7}$$

$$\boxed{\delta_E = 1.928\text{mm} \downarrow}$$

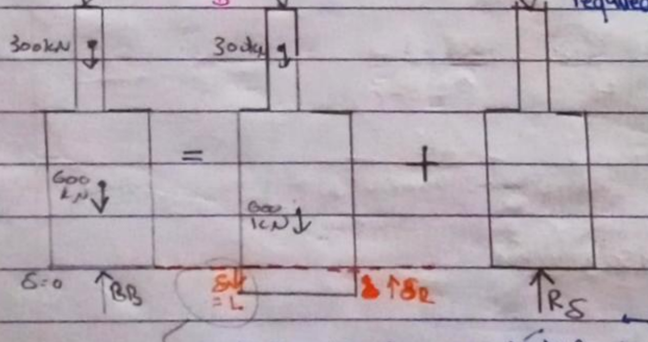
[illegible]

Static Indeterminacy :-



* structures for which internal forces and reactions cannot be determined from ~~steel~~ statics alone are said to be statically indeterminate.

* A structure will be statically indetermine whenever it is held by more supports than are required to maintain it's equilibrium.



كيف حلها:

[illegible] D [illegible]

support [illegible] deformation

A [illegible]

$$\delta = \delta_L + \delta_R = 0$$

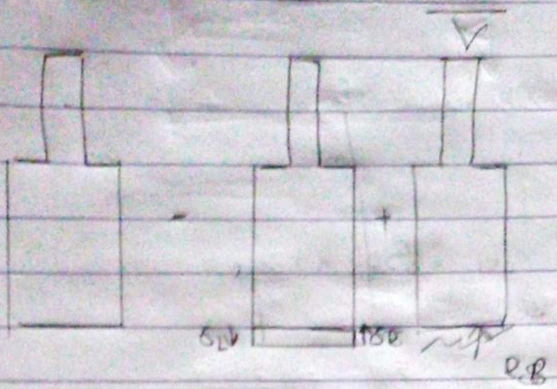
[illegible] B (RS) Reaction [illegible]

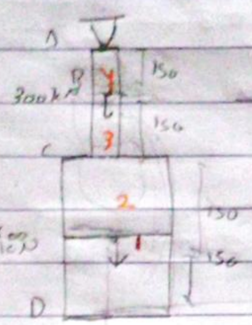
deformation

RS [illegible]

[illegible]

حل سؤال الواجب





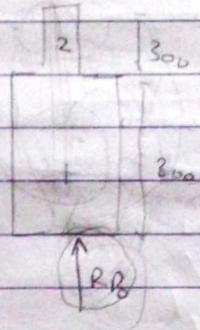
$\rightarrow P_1 = 0 \quad P_2 = P_3 = 600 * 10^3 \quad P_4 = 900 * 10^3 N$

$A_1 = A_2 = 400 * 10^{-6} m^2 \qquad A_3 = A_4 = 250 * 10^{-6} m^2$

$L_1 = L_2 = L_3 = L_4$

$\delta_L = \underline{\sum \frac{PL}{AE}} = \boxed{\frac{1.125 * 10^9}{E}}$

[illegible]
member 1, 2
[illegible]



$P_1 = P_2 = -RB * 10^3 \ N$

$A_1 = 400 * 10^{-6} m^2 \qquad A_2 = 250 * 10^{-6} m^2$

$L_1 = L_2 = 0.3$

$\delta_R = \sum \frac{PL}{AE} = \ominus \frac{RB(1.95)}{E}$

$\frac{\pi}{4}(d)^2$

$\frac{\pi}{4}($

$\frac{-0.3\,RB}{400*10^{-6}E} + \frac{-RB(0.3)}{250*10^{-6}E} =$

$-750\,RB \qquad 1200$

-1950

$\frac{1}{E}\left[\frac{-RB(0.3)}{A_1 L_1} + \frac{-RB\,0.3}{A_2 L_2}\right]$

$\frac{1}{E}\left[-RB\left(\frac{0.3}{400*10^{-6}*0.3} + \frac{0.3}{250*10^{-3}*0.3}\right)\right]$

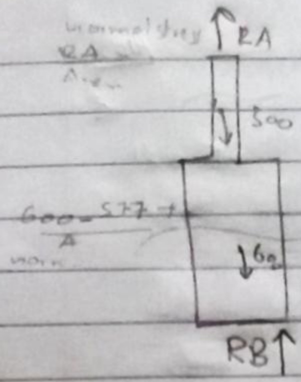
$\frac{-RB}{E}(1950)(10^3)$

انتبه للاشارة

$\delta = \delta_L + \delta_R = 0$

$\frac{1}{E}\left[\frac{1.125*10^9}{E} + \frac{-RB(1.95)}{E}\right] = 0 \qquad \frac{1.125*10^9}{\cancel{E}} = \frac{RB(1.95)}{\cancel{E}}$

$\boxed{RB = 577 * 10^3 N = 577 kN}$



$$\Sigma F_y = RA + 577\times10^3 - 300\times10^3 - 600\times10^3 = 0$$

$$RA = 323\times10^3\ N$$

* [illegible] normal stress [illegible] internal force :- [illegible]

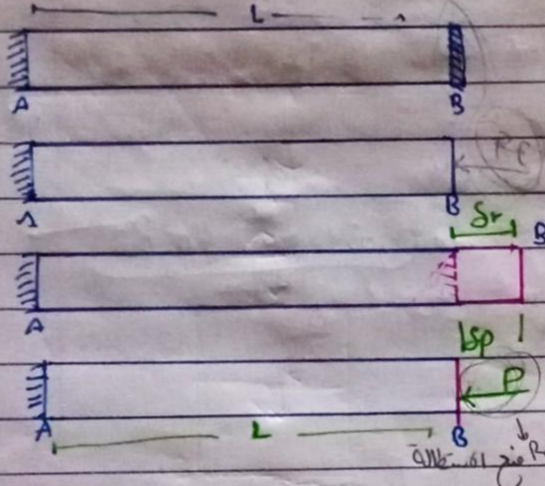
normal stress [illegible]

Thermal Stresses..

support ⟨ rigid fixed, roller

bar [illegible]

* [illegible] (support).



* [illegible] cross section [illegible]

[illegible] member straight [illegible] bolt

stress

$R_P = R_A$

Reaction

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

coffient [illegible] material [illegible]

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

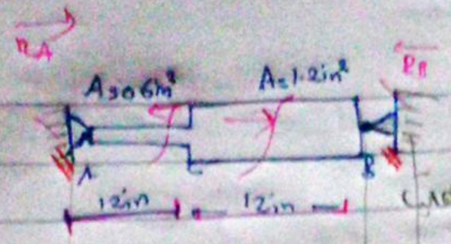
α = Thermal expansion coef

$$\delta = \delta_p + \delta_T = 0$$

① $\therefore P = (-)AE\alpha(\Delta T)$

② $\sigma = \frac{P}{A} = (-)E\alpha(\Delta T)$

Part.C

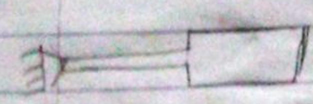


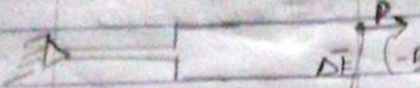
[2.66]

الحراة كانت -50 [illegible] +75 [illegible]

$E = 29 \times 10^{6}$ psi

$\alpha = 6.5 \times 10^{-6}$ F

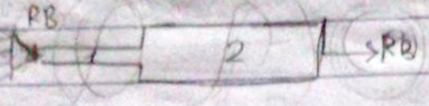




$\Delta T = (-50) - 75 = -125°F$

[illegible]

$\delta_T = \alpha(\Delta T)L = (6.5 \times 10^{-6})(-125)(24) = (-)19.5 \times 10^{-3}$ in



$L_1 = L_2 = 12$ in

$A_1 = 0.6 in^2 \quad A_2 = 1.2 in^2$

reaction in part CB, AC = RB

deformation $\delta_P = \frac{P_1 L_1}{A_1 E_1} + \frac{P_2 L_2}{A_2 E}$

$$\frac{RB}{29 \times 10^{6}\ psi}\left(\frac{12 in}{0.6 in^2} + \frac{12}{12 in^2}\right) \Rightarrow \boxed{1.0345 \times 10^{-6}\ in/lb\ R_B}$$

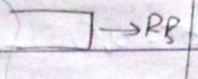
$\delta_P + \delta_T = 0$

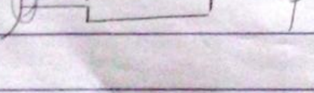
$-19.5 \times 10^{-3} + 1.0345 \times 10^{-6}\ RB = 0$

$\therefore RB = 18.85 \times 10^{3}$ lb $= 18.85$ kips

$\Sigma F_x = 0 \quad RB = RA$

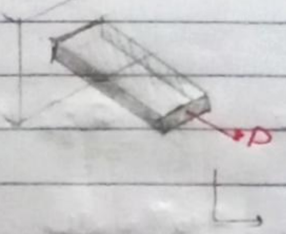
normal stress $= \frac{RB}{Area\ 1.2 in^2}$





$stress_{AC} = \frac{RB}{Area\ 0.6}$

Poission's Ration:



$\varepsilon_x = \frac{\sigma_x}{E}$ $\sigma_y = \sigma_z = 0$

bolt عند الشد

زاد طوله وعرضه قل وارتفاعه قل

poissons ratio is defined as

$$\boxed{\nu = \left|\frac{\text{lateral strain}}{\text{axil strain}}\right|} = \frac{-\varepsilon_y}{\varepsilon_x} = \frac{\varepsilon_z}{\varepsilon_x}$$

Generalized Hook's Law

لو عرضنا strain

لازم نقيس stress كل الاتجاهات

$\varepsilon = \frac{\delta}{L_1}$ $\delta = \varepsilon + 1$

x of stress تأثير

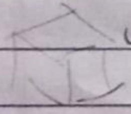
Poisson's ration

مقدار القوة

$$\begin{cases} \varepsilon_x = \frac{+\sigma_x}{E} - \frac{\nu\sigma_y}{E} - \frac{\nu\sigma_z}{E} \\ \varepsilon_y = \frac{-\nu\sigma_x}{E} + \frac{\sigma_y}{E} - \frac{\nu\sigma_z}{E} \\ \varepsilon_z = \frac{-\nu\sigma_x}{E} - \frac{\nu\sigma_y}{E} + \frac{\sigma_z}{E} \end{cases}$$

لو ال member معرض لقوى من كل الاتجاهات

Dilatation. Bulk Modulus



التغير الحجمي $e = 1 - \left[(1+\varepsilon_x)(1+\varepsilon_y)(1+\varepsilon_z)\right] = 1 - \left[1+\varepsilon_x+\varepsilon_y+\varepsilon_z\right]$

$= \varepsilon_x + \varepsilon_y + \varepsilon_z \quad = \frac{1-2\nu}{E}(\sigma_x + \sigma_y + \sigma_z)$

$$\boxed{e = -p\frac{3(1-2\nu)}{E} = \frac{-P}{K} \qquad K = \frac{E}{3(1-2\nu)} = \text{bulk modulus}}$$

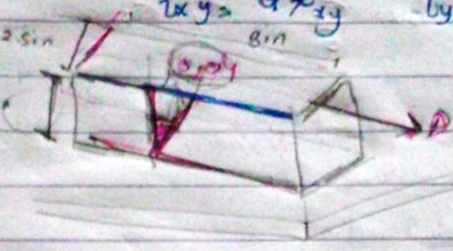
$0 < \nu < \frac{1}{2}$

→ Shear strain: جاما = مقدار التغير في الزاوية

$\tau_{xy} = f(\gamma_{xy})$ ← قوة أثرت بها على أعلى المكعب (يعتبر رفيع).

modulus of rigidity ثابت G

$\tau_{xy} = G\gamma_{xy}$ $\quad \tau_{yz} = G\gamma_{yz}$ $\quad \tau_{zx} = G\gamma_{zx}$



مثال 2.10

2in ← المسافة اللي فيها التشوه

$G = 90\,ksi$

ازاحة اللي فوق تحركت 0.04 الشق

$\gamma_{xy} = \tan\gamma_{xy} = \frac{0.04\,in}{2in}$ $\qquad \gamma_{xy} = 0.02\,rad$

حساب shear stress

$\tau_{xy} = G\gamma_{xy} = (90 \times 10^3\,psi)(0.002\,rad) = 1800\,psi$

(علاقة بسيطة)

حساب P $\qquad \tau = \frac{P}{Area}$

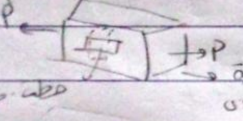
$P = \tau \times \boxed{Area}$

$= (1800)(8)(25) = 36 \times 10^3\,psi$

36 kpsi

relation among E, v, G

$$* \quad \frac{E}{2G} = (1 + v)$$

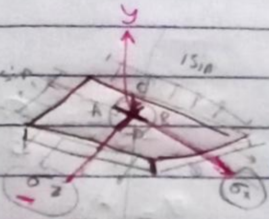


طول بالاتجاه مع القوة
قصر بالاتجاه العمودي
شد قوة شد

لو طلعنا مكعب ← زوايا متغيرة
حسب الأبعاد

تغير الزوايا (shear stress)

Sample proplem 2S



d = 9in

t = 3/4 السماكة وأبعاد 15in مثال:

ستريس — stress — اذا كان stress σ

strain اكبر : stress σ ← σx = 12 ksi σz = 20 σy = 0 اكبر strain

E = 10 * 10^6 ادي y و z راح يكون نسبة strain نسبة الانكماش

Possion ratio

ν = 1/3

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

$\varepsilon_z = \left(\frac{\sigma_z}{E} - \frac{\nu\sigma_x}{E}\right) - \frac{\nu\sigma_y}{E}$

*DC

$\boxed{\varepsilon_y} = \frac{\sigma_y}{E}\left(-\nu\frac{\sigma_z}{E} - \nu\frac{\sigma_x}{E}\right)$

length of diameter AB الطول

" " " CD

plate ال السماكة

plate حجم ال

$$\varepsilon_x = +\frac{\sigma_x}{E} - \frac{\nu\sigma_y}{E} - \frac{\nu\sigma_z}{E}$$ [illegible]

$$= \frac{1}{10 * 10^6\ \text{psi}}\left[12\ \text{ksi} - 0 - \frac{1}{3}(20\text{ksi})\right] = +0.533 * 10^{-3}\ \text{in/in}$$

$$\varepsilon_y = \frac{-\nu\sigma_x}{E} + \frac{\sigma_y}{E} - \frac{\nu\sigma_z}{E} = -1.067 * 10^{-3}\ \text{in/in}$$

$$\varepsilon_z = \frac{-\nu\sigma_x}{E} - \frac{\nu\sigma_y}{E} + \frac{\sigma_z}{E} = +1.600 * 10^{-3}\ \text{in/in}$$

$\delta_{B/A} = \varepsilon_x d = (+0.533 * 10^{-3})(9\text{in}) = +4.8(10^{-3})$ in

$\delta_{C/D} = \varepsilon_z d = (+1.6 * 10^{-3})(9\text{in}) = +14.4 * 10^{-3}$ in

سماكة $\delta_t = \varepsilon_y t = (-1.067 * 10^{-3})(0.75) = -0.8 * 10^{-3}$ in

نقص بالسماكة

$e = \varepsilon_x + \varepsilon_y + \varepsilon_z = \boxed{1.067 * 10^{-3}}$

$\Delta V = eV = 1.067 * 10^{-3}(15 * 15 * 0.75)$ $\boxed{= +0.187\ \text{in}^3}$

صح

$\Delta V = e V_0$

$\frac{1-2\nu}{E}(\sigma_x + \sigma_y + \sigma_z)$

$\varepsilon_x = \frac{P L}{A E}$ $\varepsilon = \frac{\delta}{L}$

$\varepsilon_x = \delta E$

part 2/

Composite Material [illegible]

$E = \frac{\sigma_x}{\varepsilon}$ y z

$E_x = \frac{\sigma_x}{\varepsilon_x}$ $E_y = \frac{\sigma_y}{\varepsilon_y}$ $E_z = \frac{\sigma_z}{\varepsilon_z}$ $\frac{P_c L}{E_c A_c}$

$\nu_{xy} = \frac{\varepsilon_y}{\varepsilon_x}$ ~~$\nu_{xz} = \frac{\sigma_z}{\sigma_x}$~~ $\nu_{12} = \frac{\varepsilon_2}{\varepsilon_x}$ $\nu_{xz} = \frac{\varepsilon_z}{\varepsilon_x}$

غالبا ν_{xy} لا تساوي ν_{xz} ← anisotropic

* كيف نحسب ال stress و strain

و load = $\frac{\text{مجموع الاحمال}}{\text{المادة الاولى}} + \frac{\text{مجموع الاحمال}}{\text{المادة الثانية}}$

*** ملاحظة كلا المادتين يتم الاستطالة بنفس المقدار

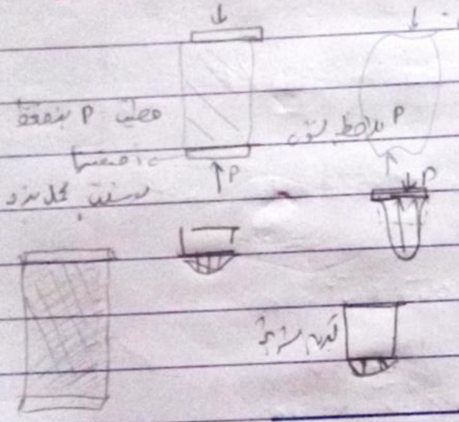
Saint-Venant's Principle:

يعني (يعني) rigid plate يكون strain منتظم

لو عندي حد واحد رفيعة

لو ضغطت مع الحجر المنطقة التالية بشكل منتظم stress uniform

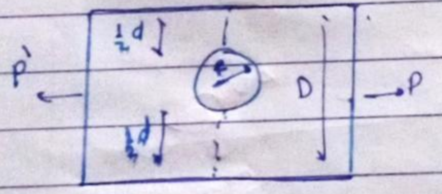
بعد لو بس الطاقة [illegible] عالية (8)

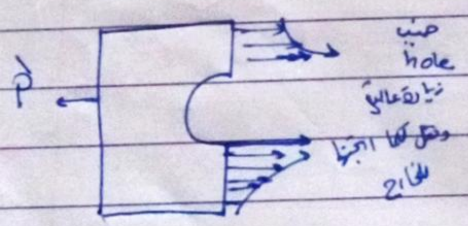


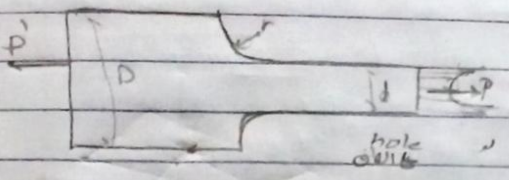
Stress Concentration: Hole (او save [illegible]) Factor و allow stress مسموح

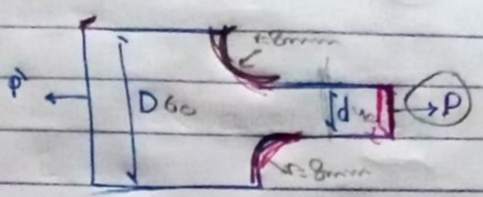
اذا صمم ع max → $K = \frac{\sigma_{max}}{\sigma_{ave}}$

total area $\frac{P}{A_t}$ ←









2.12 مثال

Determine the largest axial load P that can be safely supported by a flat steel bar consisting of two portions, both $\overset{\text{سمك}}{10\text{mm thick}}$, and respectively $\overset{d}{40}$ and $\overset{D}{60}$mm wide connected by fillets of radius r=8mm. Assume an allowable normal stress of 165MPa

$$\frac{D}{d} = \frac{60\text{mm}}{40\text{mm}} = 1.50$$ (k) لإيجاد (1) : حل

$$\frac{r}{d} = \frac{8\text{mm}}{40\text{mm}} = 0.2$$

منحنى ثابت

$$k = 1.82$$

$$\boxed{\sigma_{ave}} \quad \frac{\sigma_{max}}{(k)} = \frac{165\text{MPa}}{1.82} = 90.7\text{MPa}$$

safety [illegible]

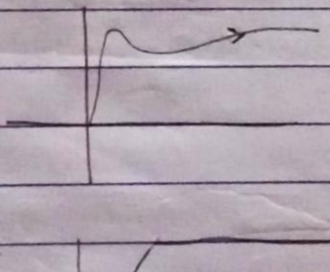
$$\boxed{\sigma_{ave}} = \frac{P}{dt} \qquad P = \sigma_{ave} \times d \times t$$

$$(90.7)(40\text{mm})(10\text{mm}) = 36.3\text{kN}$$

(P)

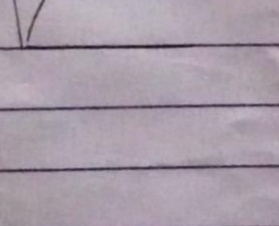
Elastoplastic Materials تمثل لمواد معينة

يعني عند الحد للقوة



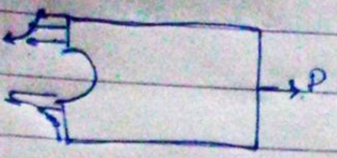
ا ص elastic مرجع

plastic



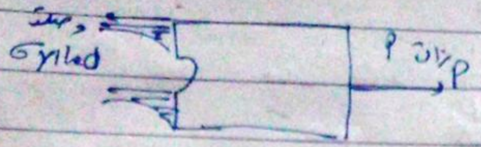
plastic Deformation

مراحل وصول plastic

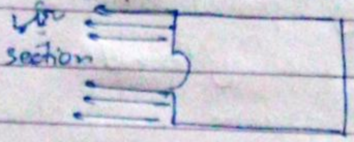


$P = \sigma_{ave} A = \frac{\sigma_{max}}{k} A$

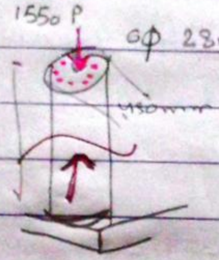
لسا elastic



فضل أزود حمل لحد ما السيكشن كله



لو → 1.30



① مساحة الحديد ← $6 \left(\frac{\pi}{4} 28^2 mm\right)$

$E_{steel} = 200$ → $E_{concrete}$ ↘

مساحة الخرسانة قطاع ⇐ $\frac{\pi}{4} * 450^2$ + حديد

[illegible] - حديد

Pconcrete

① $\overset{1550}{P} = P_s + P_{concrete}$

② deformation $\delta_{concr} (1.5) = \delta_{steel}$

$\frac{load \times L}{E_s A} = \frac{load \times L (1.5)}{E_c A}$

load [illegible]

① $P_s + P_c = P$

② $\varepsilon_s = \varepsilon_c \rightarrow \delta_c = \delta_s$

load L

2.1:- An 80m long wire of 5-mm diameter is made of steel with Es = 200GPa and ultimate strength of 400MPa. If a factor safty of 3.2 is ~~desird~~ desired. (a) the largest allow able tension in the wire

(b) the crossepanding elongation of the wire

$L = 80m$ $d = 5mm = 0.005m$ $A = \frac{\pi d^2}{4} = \frac{\pi (0.005m)^2}{4} = 1.96 * 10^{-5} m^2$

$E = 200 * 10^9$ Pa

$\sigma_{ult} = 400$ MPa $= 400 * 10^6$ Pa

$F_s = 3.2$

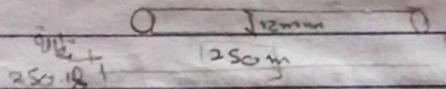
① $\sigma_{all} = \frac{\sigma_u}{F_s} = \frac{400 * 10^6}{3.2} = 125 * 10^6$ Pa

(a) $P = \sigma_{allow} A = 125 * 10^6 (1.96 * 10^{-5}) = 2454.37$ N

(b) $\delta = \frac{\sigma_{all} L}{E} \overset{or}{=} \frac{PL}{AE} = \frac{(125 * 10^6 \text{ Pa})\ 80m}{200 * 10^9 \text{ Pa}} = 0.05$ m $= 50$ mm

2.7:- Two gage marks are placed exactly 250mm apart on a 12mm diameter aluminum rod, knowing that with an axial load of 6000N acting on the rod. the distance between gage marks is 250.18mm. determine the modulus of Elasticity of the aluminum use in the rod

6000N : P شد



E

الطول الاصلي .25m $D = 0.012m$ $P = 6000$ N

الطول النهائي = 250.18 mm

مقدار التشوه = 250.18 − 250 = 0.18 mm = $1.8 * 10^{-4}$ m

$A = \frac{\pi}{4} (0.012)^2 = 1.131 * 10^{-4} m^2$

$\delta = \frac{PL}{AE} = 1.8 * 10^{-4} = \frac{6000 N * 250mm}{1.8 * 10^{-4} * E}$ $E = 73.68 * 10^9$ Pa

$\frac{\pi}{4} d^2$

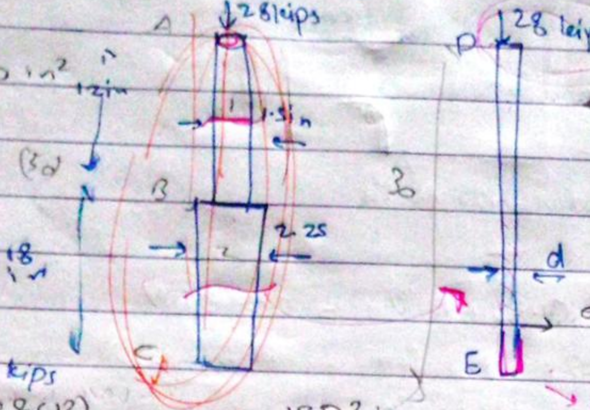
$\boxed{73.68 \text{GPa}}$

δ 0.1 C

-. 2.44 :- The aluminum ABC ($E = 10.1 \times 10^6$ psi), which consists of two cylinder Portions AB and BC, is to replaced with cylinder rod DE ($E = 2.9 \times 10^6$ psi) of the same overall length. Determine the minumim required diameter d of the steel rod if its vertical deformation is not exceed the deformation of the aluminume rod under the same load and if the allowble stres in the steel rod is not to exceed 24 ksi

$A_1 = \frac{\pi}{4}(1.5^2) = 1.76\ in^2$

$A_2 = \frac{\pi}{4}(2.25^2)$



← [illegible]

$\delta_{[illegible]} \geq \delta_{[illegible]}$

$\frac{P}{A}$ $\frac{\pi}{4}d$

$\delta_{AB} = \frac{P L_{AB}}{A_{AB} E_{al}} = \frac{28(12)}{1.76(10,000)} = 0.01883\ in$ kips

$\delta_{BC} = \frac{P L_{AC}}{A_{BC} E_{al}} = \frac{28(18)}{3.97(10,100)} = 0.01255$

$\delta_{al\ AC} = 0.01883 + 0.01255 = \boxed{0.03138\ in}$

$\delta \leq 0.03138$

$\frac{28(36)}{(\frac{\pi}{4})d^2(29,000)} \leq 0.03138$

$d \geq 1.084\ in$

$\sigma_{st\ allow} \leq 24\ ksi$

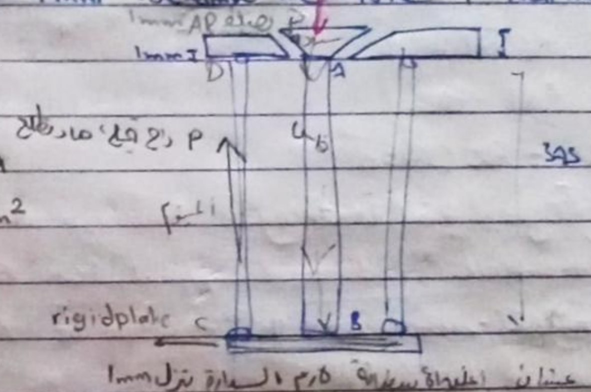
$\frac{P}{A_{st}} \leq 24$

$\frac{28}{\frac{\pi}{4}d^2} \leq 24$ $\boxed{d \geq 1.219\ in}$ →

$\boxed{d_{min} = 1.219\ in}$ $\simeq 1.3$

-12.16. ~~The longe bars~~ brass

The brass tube AB (E= 105 GPa) has a cross sectional are of 140mm² and fitted with a plug at A. The tube is attached at B to a rigid plate that is itself attached at C to the bottom of an aluminum cylinder (E =72GPa) with a cross sectional area of 250mm². The cylinder is then hung from a supported D In order to close the cylinder is then hung from a supported at D. In order to close the cylinder, the plug must move down through 1mm Determine the force P that must be applied to the cylinder

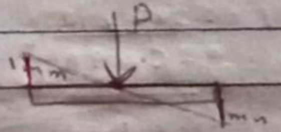


نحاس AB $E= 105*10^9$ Pa

$a=140*10^{-6}\ m^2$

ألمنيوم $A=250*10^{-6}\ m^2$

عشان الغطاء يسكر لازم السدادة تنزل 1mm



∴ التشوه في النحاس والالمنيوم الي لازم يكون 1mm

$\delta_{total}=\delta_{br}+\delta_{al}=1mm$

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

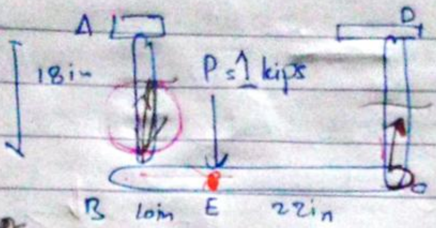
عند النحاس $\longrightarrow \frac{PL}{AE}=\frac{P*375}{140*105*10^3}=(2.551*10^{-5})P$

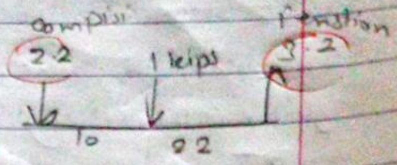
عند الالمنيوم $\frac{P*375}{250(72*10^3)}=2.083*10^{-5}P$

$2.551*10^{-5}P+2.083*10^{-5}P=1mm$

$\boxed{P=21.58kN}$

2.25:- each of the links AB on CD is aluminum $E(10.9*10^6 psi)$ and has a crossectional are of $0.2 in^2$, knowing the they support the rigid member BC, determine the deflection of point E





$\Sigma F_y = 0 = -1 + F_{AB} + F_{DC}$

$F_{AB} + F_{DC} = 1$

$+\Sigma$ $-$ $\Sigma M_B = 1(10) - F_{DC}(32) = 0$

$-10 = -32 F_{DC}$ $\quad$ $F_{DC} = 3.2 (+)$ Tenstion

$\frac{\cancel{32}}{\cancel{32}} F_{DC} = \frac{10}{32}$ $\quad$ $F_{AB} + 3.2 = 1$

$F_{AB} = 2.2 (-)$ compirision

A–B: $\delta = \frac{PL}{AE} = \frac{-2.2*10^3 * 18 \text{ in}}{0.2(10.9*10^6) \text{ psi}} = -0.018$ in $= 0.018 \uparrow$ compn

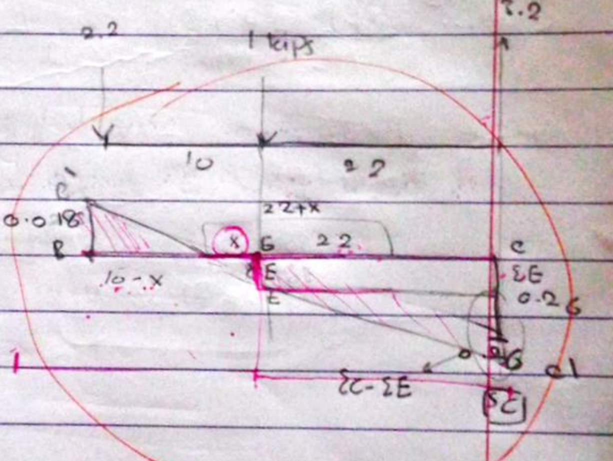
D–C: $\delta = \frac{+3.2*10^3 * 18}{0.2(10.9*10^6)} = +0.026$ in ↓

$\delta_E = \delta_B + \frac{BE}{BC} \cdot (\delta_C - \delta_B)$ [illegible]

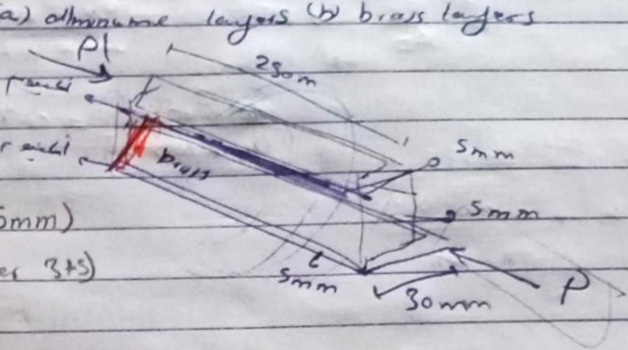
$= 0.018 + \frac{10}{32} \cdot (0.026 - -0.018)$

$\oplus = 0.0119$

↓ هنزل



2.36:- A 250 mm bar of 250 * 30mm rectangle crose section of to aluminum layers ,5mm thick ,brazed a center brass layer of the same thikness , if AS subjected to centaric force P= 30kN , and knowing that Ea= 70 GPa and Eb = 105 GPa determine the normal stress in (a) alluminume layers (b) brass layers



width b = 30mm

Thekness of each layer t=(5mm)

Total haight = 15mm (3layer 3*5)

P=30,000N

$E_{al} = 70{,}000$ MPa

$E_b = 105{,}000$ MPa

$A_{aL} = 30mm * 5 = 150mm^2 * 2 = 300mm^2$

$A_{brass} = 30 * 5 = 150mm^2$

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

$P = \sigma A$

$P = P_a + P_b$ → composite member

$P = \sigma_a A_a + \sigma_b A_B$

$\sigma = \varepsilon * E$ وفقاً لقانون هوك

$P = E_a A_a \varepsilon + \varepsilon A_b E_b = 30 * 10^3$

$\varepsilon [E_a A_a + E_b A_b] = 30 * 10^3$

$\varepsilon_{all} = \varepsilon_{br}$

$$\varepsilon = \frac{30 * 10^3}{(70 * 10^3 * 300) + (105 * 10^3)(150)}$$

$\varepsilon = 0.0008163$

$\sigma_{all} = 0.008163 * 70 * 10^3 = 57.14 MPa$

ط ما تقدر أشرح عليهم $\sigma_b = 0.008163 * 105 * 10^3 = 85.71 MPa$

$\sigma = E \varepsilon \quad \frac{\delta}{L}$

36

تابع السؤال

2.37 :- determine the deformation of the composite bar of Prob. 2.36 if it is subjected to centric force of P 45 kN.

$P = 45 * 10^3$ $L = 250$ mm

$\delta = \frac{PL}{AE}$ → 2 ألمنيوم $\frac{45*10^3 * 250}{300 * 70*10^3} = 0.535$

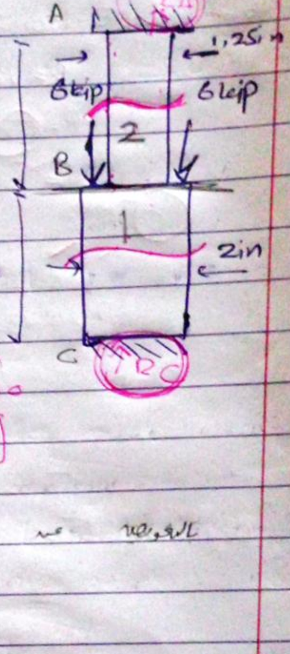
→ 1 brass

$\frac{45*10^3 * 250}{150 * 105*10^3} = 0.714$

$\varepsilon = \frac{\delta}{L}$ $\xrightarrow{\text{ألمنيوم}}$ $\frac{0.535}{250} = 0.00214$

→ نحاس 0.00285

2.40 :- A polystyrene rod consisting of two cylinder portions AB and BC is restained at both ends and support two 6kips loads as shown, E = 0.45 * 10^6 psi, determine the reaction as A and C , (b) normal stress in each portion of the rod



$Area = \frac{\pi}{4}(2)^2 = 3.14 in^2$ $L =$

$P_1 = P_2 = 6kips$

أيضاً نفتح الركائز C

الحل يتوزع ع AB و BC

ونضغط

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

$= \frac{12 * 10^3 \times 25in}{3.14in^2 * E} = \boxed{\frac{95.54}{E}}$

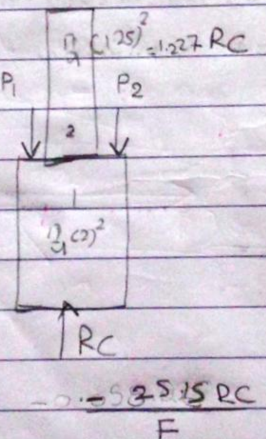
$RA + RC - 12 = 0$

$\boxed{RA + RC = 12}$

$P_1 = P_2 = -RC * 10^3$

$L_2 = 25in$

$L_1 = 15in$



$\frac{\pi}{4}(1.25)^2 = 1.227$ RC C

$\frac{\pi}{4}(2)^2$

$\delta_{RC} = \frac{PL}{AE}$

$\frac{1}{E}\left[-RB\left(\frac{L1}{A_1} + \frac{L2}{A}\right)\right]$

$\frac{1}{E}\left[-RB\left(\frac{15}{3.14} + \frac{25}{1.227}\right)\right]$ $\frac{-25.15 RC}{E}$

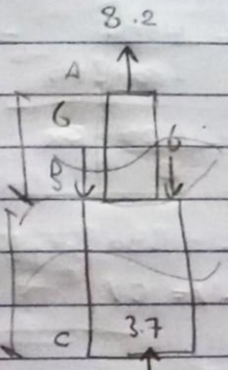
$\delta = \delta_P + \delta_{RC} = 0$

$\frac{95 \cdot 54''}{\cancel{E}} = \frac{25 \cdot 15 P_C}{\cancel{E}}$

$R_C = (+) 3.79$ kips ↑ compression

$F_y = 0 = R_A - 12 + 3.79 = 0$

$R_A = (+) 8.2$ ↑ tension



$\sigma_{BC} = \frac{-3.7 \text{ kips}}{3.14 \text{ in}^2} = (-) 1.178 \text{ kips/in}^2$

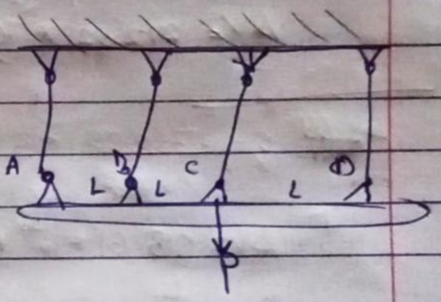
$\sigma_{AC} = \frac{8.2 \text{ kips}}{1.227 \text{ in}^2} = (+) 6.68 \text{ kips/in}^2$

2.43 The rigid bar ABCD is suspended from four identical wires. Determine the tension in each wire caused by the load P shown.

$\boxed{T_A + T_B + T_C + T_D = P}$ ①

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

$\Sigma M_A = \frac{(T_B \cdot 2) + (T_C \cdot 2L) + (T_D \cdot 3L) - (P \cdot 2L)}{L} = 0$



$T_B + 2T_C + 3T_D = 2P \rightarrow$ ②

علان الجسم rigid فـ الاستطالة سلوك اعتبار $\delta_A, \delta_C\ \delta_D, \delta_B$

خاد الاستطالة تقع على خط مستقيم واحد.

تناسبية $\delta_B - \delta_A = \delta_C - \delta_B = \delta_D - \delta_C$

$T_B - T_A = T_C - T_B$ $\quad \delta = \frac{TL}{AE}$ $\quad$ كل الأسلاك ليها نفس الطول

$T_C = 2T_B - T_A$

$$\boxed{\begin{aligned} T_B &= T_A + \Delta T \\ T_C &= T_A + 2\Delta T \\ T_D &= T_A + 3\Delta T \end{aligned}} \rightarrow$$

نعوض في (1)

$4T_A + 6\Delta T = P$

بالتعويض في (2)

$T_A = 0.1P$

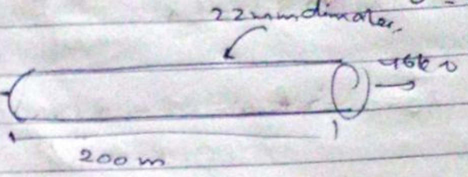
$T_B = 0.2P$

$T_C = 0.3P$

$T_D = 0.4P$

~~[illegible] 61 = 68~~
~~[illegible] 95 = 100~~

2.83. - Determine the dilation (e) and the chang in volume of the 20 mm length of the rod (a) the rod is made of steel E = 200 GPa $\nu = 0.3$ (b) the rod is made of aluminum with E = 70 GPa $\nu = 0.35$



① $A = \frac{\pi}{4} d^2 = \frac{\pi}{4}(22^2) = 380.13\,mm^2 = 380.13 \times 10^{-6}\,m^2$

$\sigma_x = \frac{P}{A} = \frac{46 \times 10^3}{380.13 \times 10^{-6}} = 121.01\,MPa$

$$\boxed{e = \frac{1-2\nu}{E}\sigma_x}$$

$\Delta V = e\,V$
$\varepsilon_x + \varepsilon_y + \varepsilon_z$
$e = \frac{1-2\nu}{E}\sigma_x$

الحجم V $= AL = 380.13 \times 200 = 76{,}026\,mm^3$

التغير في الحجم $\Delta V = e.V$

الحديد $e = \frac{1-2(0.3)}{200 \times 10^3} \times 121.01 = 242.02 \times 10^{-6}$

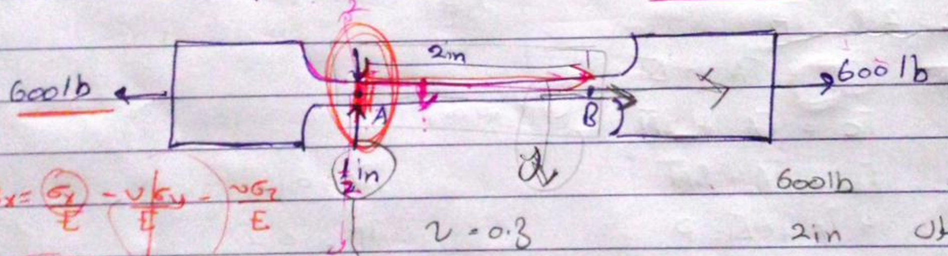
$e = \varepsilon_x + \varepsilon_y + \varepsilon_z$
$e = \left(\frac{1-2\nu}{E}\right)\sigma$

$\Delta V = 242.02 \times 76{,}026 = 18.40\,mm^2$

(b) الالمنيوم $e = \frac{1-2(0.35)}{70 \times 10^3} \times 121.01 = 518 \times 10^{-6}$

$\Delta V = 518.61 \times 10^{-6} \times 76026 = 39.43\,mm^2$

2.61/ A 600-lb tensile load is applied to a test coupon made from $\frac{1}{16}$ in flat steel plate. ($E = 29 \times 10^6$ psi, $\nu = 0.3$). Determine the resulting change (a) in the 2-in. gage length, (b) in width of portion AB of the test coupon, (c) in the thickness of portion AB, (d) in the cross sectional area of protion AB



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

$\nu = 0.3$

$\sigma_x = \varepsilon_x E$
$\frac{P}{A}$

$\nu = -\frac{\varepsilon_y}{\varepsilon_x} \quad \frac{\varepsilon_z}{\varepsilon_x}$

$\Delta V = eV$

الحمل	600lb
الطول	2in
العرض	0.5
السمك	1/16in t
E	29×10^6 psi

t ▯ $\frac{1}{2}$ in

$A = w*t = 0.5 * \frac{1}{16}$ A مساحة المقطع العرضي

$= 0.03125 \text{ in}$

$\sigma_x = \frac{P}{A} = \frac{600}{0.03125} = 19200 \text{ psi}$

$\varepsilon_x = \frac{\sigma_x}{E} = \frac{19200}{29*10^6} = 6.6207*10^{-4}$

$\Delta L = \varepsilon_x l$ ε هو نسبة التغير في الطول الى الطول الاصلي $\varepsilon = \frac{\Delta L}{L}$

$= (6.6207*10^{-4}) * 2$

$= \oplus \boxed{0.0013}$ ← زيادة

$1.324*10^{-3}$ زاد الطول

التغير ثاني

$\nu_{xy} = \frac{-\varepsilon_y}{\varepsilon_x}$ $\varepsilon_y = -\nu \cdot \varepsilon_x = -0.3(6.6207*10^{-4}) = (-)1.986*10^{-4}$

نقص

$\Delta w = \varepsilon_y \cdot w = (-1.986*10^{-4})(0.5) = (-)0.0000\ 9931 \text{ in}$

$9.93*10^{-5}$ in نقص

$\cancel{\varepsilon_z} \ \nu_{xz} = \frac{-\varepsilon_z}{\varepsilon_y}$

$\Delta t = \varepsilon_z \cdot t = \varepsilon_y \cdot t$

$\Delta t = (-1.986*10^{-4})(0.0625) = -0.00001241 \text{ in}$

$\cancel{\varepsilon_z = \nu} \varepsilon_y$

0.3

نقص في السمك مقدار $1.241*10^{-5}$ in

$\boxed{\varepsilon_z = -\nu \varepsilon_x}$

التغير في (A) من حاصل ضرب العرض الجديد في السمك الجديد

$w' = w + \Delta w$ $t' = t + \Delta t$

او $\frac{\Delta A}{A} = \varepsilon_y + \varepsilon_z = 2\varepsilon_y$

$\Delta A = A \cdot 2\varepsilon_y = 0.03125(2*-1.9862*10^{-4}) = -0.00001241$

نقص $1.241*10^{-5} \text{ in}^2$

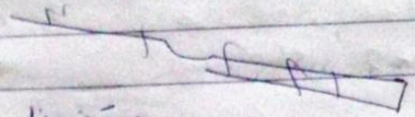
$\nu = \frac{-\varepsilon_y}{\varepsilon_x} = \frac{-\varepsilon_z}{\varepsilon_x}$ $e = \boxed{\varepsilon_x + \varepsilon_y + \varepsilon}$

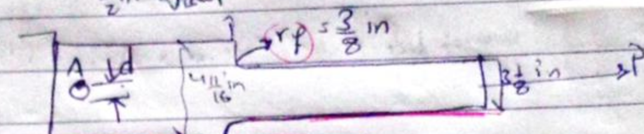
ν_e =

$\frac{1}{16}$ $\frac{1}{4}$

0.5 1.in

2.99: A hole is to be drilled in the plate at A. The diameter of the bits available to drill the hole range from 1/2 to in, in 1/4 in increments. if the allowable stress in the plate is 21 ksi, determine (a) the diameter d of the largest bit that can be used if the allowable load P at the hole is to exceed that at the fillets (b) the corresponding allowable load P





3.125in العرض الصغير   4.6875in العرض الكبير

نصف قطر f. 0.375

سمك 0.5in

- أقطار الثقوب المتوفرة $\frac{1}{2} \rightarrow 1\frac{1}{2}$ (بمقدار $\frac{1}{4}$) (0.5, 0.75, 1, 1.25, 1.5)

① حساب القوة المسموح بها عند منطقة الانحناء

قبل ان نختار قطر الثقب نحدد قيمة P الي بتحملها العرض الصغير (شرط السؤال P عند الثقب أكبر من عند الانحناء)

$$\frac{D}{w} = \frac{4.6875}{3.125} = 1.5$$

$$\frac{r}{w} = \frac{0.375}{3.125} = 0.12$$

$$\boxed{K \approx 1.9}$$

$$\sigma_{max} = K_f \frac{P}{w \cdot t}$$ القوة من fillet

$$= 21 = 1.9 * \frac{P}{3.125 * 0.5}$$

$$P_{fillet} = \frac{21 * 3.125 * 0.5}{1.9} \approx 17.27 \text{ kips}$$

② اختيار قطر الثقب

المطلوب هو أكبر قطر ثقب (d) حيث تكون القوة المسموح بها عند الثقب Phole

الفرض: 17.27

عرض منطقة الثقب 4.6875 ، المقطع حسب المعادلة w-d

$\sigma_{max} = k_n \frac{P}{(w-d)t}$

$P_{hole} = \frac{21(4.6875 - d)\,0.5}{k_n}$

$k_n = 2.3$ $\frac{d}{w} = \frac{1.5}{4.6875} = 0.32$ $d = 1.5in$ اذا اعتبرنا

X $P_{hole} = 14.54$ kips → ~~15.16~~ اصغر من 17.27 ~~T~~

X $P_{hole} = 15.16$ اصغر 17.27 $k = 2.38$ 1.25in اذا اعتبرنا

X $P_{hole} = 16.28$ $k_n = 2.7$ 0.5

اذا كل الافتراضات اعطت قوة اقل نختار الاكبر

نختار 0.5in لان P = 16.8

الحل 99

2-100 / for P = 13 kips $d = \frac{1}{2}in$, determine stress in the plate shown

(b) solve part a, assuming that the hole at A is not drilled

3.125 w 4.6875in W 0.5 = d 13 القوة

0.5 t 0.375 t

$\sigma = \frac{P}{A}$ 131

$k_s \sigma_{max}$

D

D /

A

$\frac{d}{w} = \frac{0.5}{4.6875} = 0.107$

$k = 2.7$

$A_{net} = (w-d)t = (4.6875 - 0.5) * 0.5 = 2.09375 in^2$

$\sigma_{max} = \frac{kP}{A_{net}} = 2.7 * \frac{13}{2.09375} = 16.75 ksi$

$\frac{r}{w} = \frac{0.375}{3.125} = 0.12$, $\frac{W}{w} = 1.5$ اعتبار Fillet او عند

$k = 1.9$

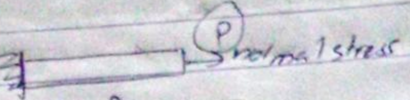
$A_{min-net} = 3.125 \times 0.5 = 1.56 in^2$ المساحة الصغرى

$\hookrightarrow \sigma_{max} = k\frac{P}{A_{min}} = 1.9 * \frac{13}{1.5625} = 15.8$

16.76 ∴ أعظم اجهاد في اللوح من المنطقة 16.76

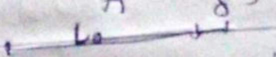
(b) اذا وضعنا الثقب عند A يصبح تركيز الاجهاد عند A $\sigma_{max} = 15.8$

Review chapter -2.



نقدر

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



الطول الأصلي قبل ما نحط الحمل

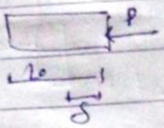
(ابدأ)

التغير في الطول بيسمى strain ε بسبب تأثير الـ (axial load)

التغير في الطول .

strain قانون $\varepsilon = \frac{\delta}{l_0}$ = unit less بدون وحدة

comp $\frac{-\delta}{l_0}$ الضغط قلل الطول



σ stress $\frac{P}{A}$ $\qquad \varepsilon = \frac{\delta}{L}$

$\sigma = E\ \varepsilon$ العلاقة بينهم

$\times 10^3 L$ modulus of elasticing

ملاحظة E تقاس بوحدة GPa
لما نعوض نضرب بـ 10^3
كل شيء بال stress M(Pa)

$\frac{P}{A} = E \times \frac{\delta}{L}$

$\therefore \delta = \frac{PL}{EA}$ internal force, الطول الأصلي, Area of cross section

مهم
حساب
دلتا
يعني strain

$\frac{N \cdot mm}{\left(\frac{N}{mm^2}\right) MPa\ mm^2}$

$\therefore$ تقاس δ بالـ mm

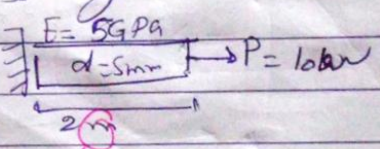
internal force

$\delta = \frac{PL}{EA} = \frac{10 \times 10^3 \times 2m \times 10^3}{5 \times 10^3 \times \frac{\pi}{4}(5)^2 mm}$ elnogatin احسب

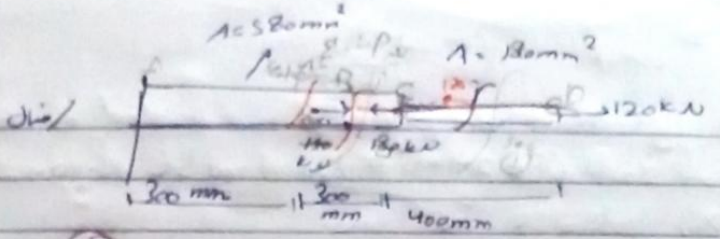
MPa

$= (\ \ ) mm$

احسب مقدار elongation بعد



مع ملاحظة احسب الدلتا δ ما يتغير غير الـ P , L , E , A .



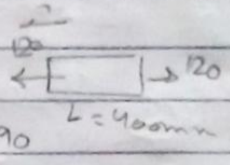
Ⓔ 200 GPa

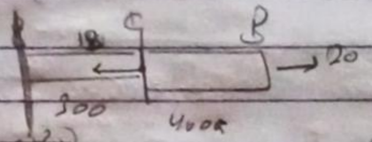
([illegible]) total deformation

∴ AB , BC , CD

① CD $\delta = \frac{PL}{AE} = \frac{20*10^3 * 400}{200*10^3 * \cancel{580}\ 190}$

MPa ① 1.26 mm + incre





BC

+120 - 180 = -60 comp

~~180 - 150~~ = -30

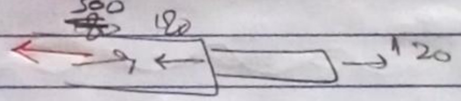
comp

$\frac{\cancel{-60*10^3 * (400+300)}}{200*10^3}$

∴ BC [illegible] BC elongation [illegible]

BC $\frac{-60*10^3 * 300}{200*10^3 * 580} = -0.155$ (dec)

[illegible]



AB $\frac{\cancel{+120*10^3} * 300}{200*10^3 * 580} =$

~~120 + 180 - 180~~ = 0

~~(+) 120~~

$\frac{+240*10^3 * 300}{200*10^3 * 580} = +$ mm

120 + 300 - 180 = (+) 240

[illegible]

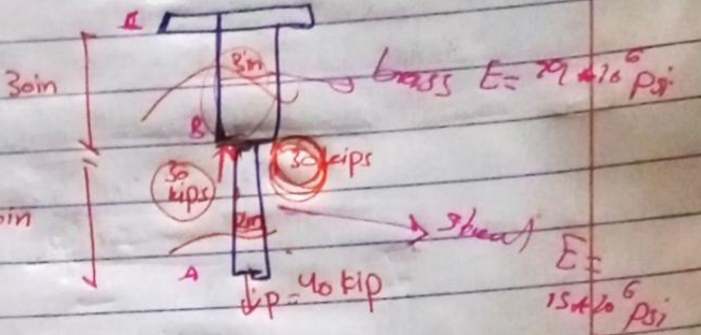
English unit

2.1? Two solid cylindrical are jointed B and loaded as shown. Rod AB is made of steel (E = $29*10^6$ psi), and rod BC of brass (E = $15*10^6$ psi). Determine

(a) the total deformation of the composint rod ABC

(b) the deflection of point B

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



AB → tension

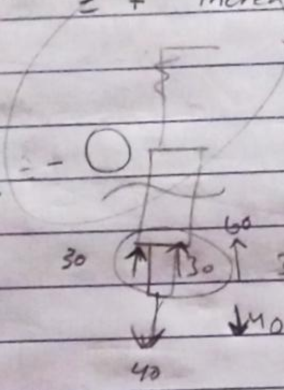
internal cut

$+\frac{40*40}{29*10^6*\frac{\pi}{4}(2)^2}$ ① = + increa

+ total deformation

BC

$\frac{-20*30}{15*10^6*\frac{\pi}{4}(3)^2}$ = − ○



60 ↑ 30+30−40 = +20

↓40 40 − 60 = ⊖20

لو طلب منى الحقيقية نختار نقطة واحدة ثابتة (وجد)
اذا زود مجموع بين التغير بين النقطة الاخرى في نفس اتجاهها

deflection of B

حالة مثبتة من جهة واحدة

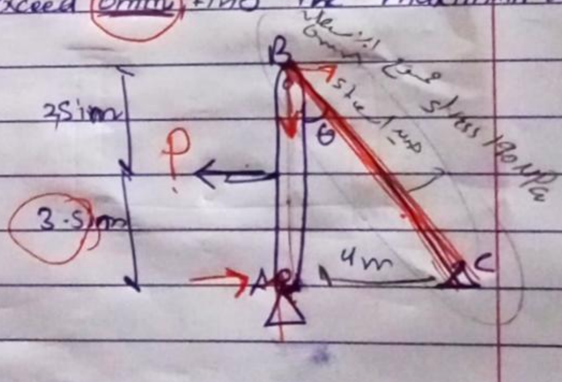
ومن اذا عندي نقطة معينة

راح نأخذ مجموع مقدار التشوه بين النقطة deflection

العلوية والنقطة الثابتة

$\delta_B = \frac{P_{BC} \cdot L_{BC}}{A_{BC} \cdot E_{BC}}$

2.14 The 4mm diameter cable BC is made of a steel with E = 200 GPa. knowing that the maximum stress it the cable not exceed 190 MP and the elongation of the cable must not exceed 6mm, find the maximum load P that can be applied as shown.

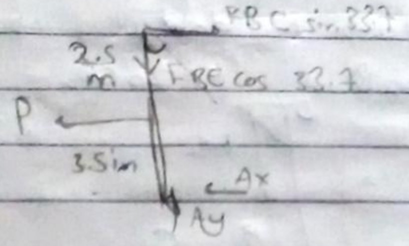


C (T) link normal stress

normal strain normal stress

strain T.C

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



$\Sigma M_A = 0 = +P(3.5) - F_B \sin 33.7 (5) = 0$

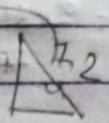
$\text{normal stress} = 190 = \frac{P \quad F_{BC}}{A}$

$F_{BC} = 1.05P \;\; T$

$\text{stress} = 190 = \frac{1.05P}{\frac{\pi}{4}(d)^2} = \_\_\_$ نو

72 ~~×10^3~~

$\delta = \frac{PL}{EA}$ $\frac{1.05P \times (\text{فيثاغورس من الطول الكبير})}{200 \times 10^3 \times \frac{\pi}{4}(d)^2}$



P نجيب

حنا ، P اقل

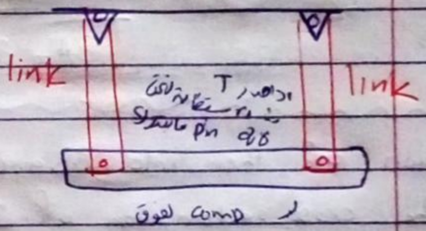
link

link → normal stress $\sigma = \frac{P}{A}$ $\overset{+T}{\underset{-C}{}}$ | normal stress يعرفه
normal ~~strain~~

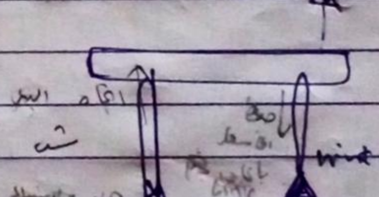
→ $\delta = \frac{PL}{EA}$

→ T ↓

C ↑

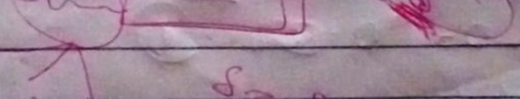


اتجاه السهم صار اعلى بدل اسفل نفسه



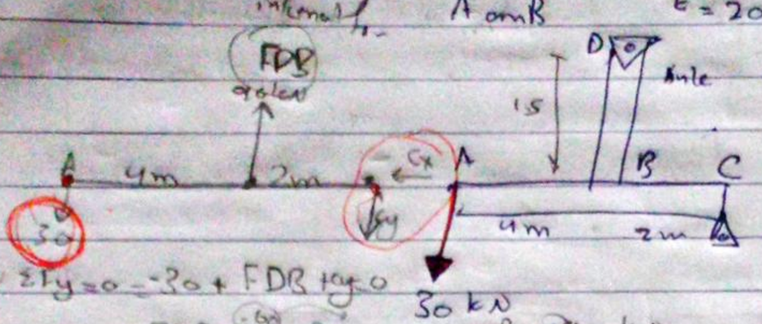
$\delta = \Delta L$

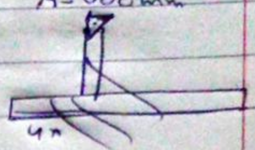
$\delta = \delta + \delta T$



determin the deflection in point A and B / [illegible]

E = 20 GPa $A = 600 mm^2$





$\Sigma F_y = 0 = -30 + FDB + c_y = 0$

$FDB + \overset{-60}{c_y} = 30$ $FDB = (+)90\ kN$

$\Sigma M_B = 0 = + c_y(2) + 30(4)$ (T) شد

$c_y = -60$

$$\delta_B = \frac{PL}{AE} = \frac{90*10^3 * 1.5*10^3}{20*10^3 * 600} = (+)\ \boxed{11.25 mm}\ \downarrow$$

[illegible] D (راح ينزل) B [illegible]

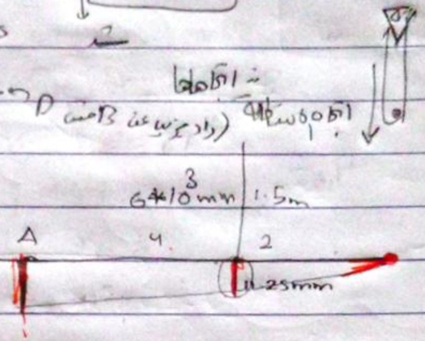
[illegible]

Reaction

y<x [illegible] C [illegible] x

support [illegible] A عند x

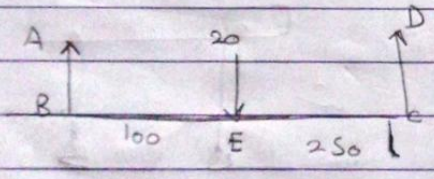
deflection diagram ←

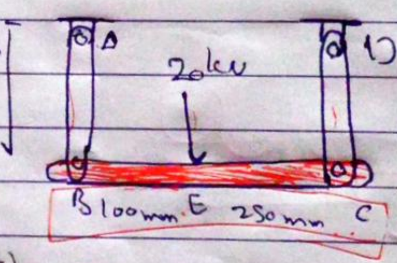


$$\frac{\delta_A}{11.25} = \frac{6*10^3 mm}{2*10^3 mm}$$ [illegible]

$$\boxed{\delta_A = 33.75 mm}$$

each of the link AB and CD is made of aluminume (E = 72 GPa) the cross section area of $360 mm^2$ knowing that they supporte the rigid memeber BC determine the deflection of point E

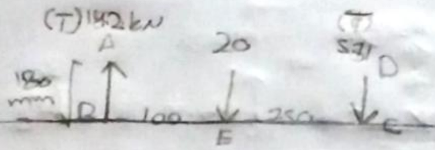




$\Sigma M_D = 0 = 20(250) - AB(350)$

$350\, AB = 20*250$ $AB = (+) 14.2\ kN$ (T)

$\Sigma F_y = 0 = 14.2 \overset{(70)}{-} 20 + D =$ $D = (+) 5.71\ kN$ (T)



[illegible] Rigid [illegible] BC [illegible]

[illegible]

(links [illegible]) T cc [illegible] [illegible] deflection [illegible]

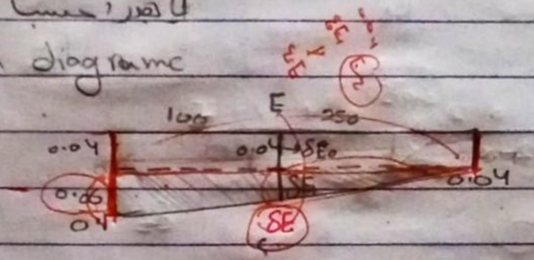
$$\overset{(T)}{\delta_A} = \frac{(+)\,142\times10^3 \times 180}{360\times72\times10^3} = (+)\,0.1\ \text{mm}$$

$$\overset{(T)}{\delta_D} = \frac{(+)\,57\times10^3 \times 180}{72\times10^3 \times 360} = (+)\,0.04\ \text{mm}$$

[illegible] deflection [illegible]

[illegible]

deflection diagramme



$$\frac{350}{250} = \frac{0.06}{\delta E_2}$$

$$\boxed{\square}\ \delta_E = \underset{0.04}{\delta E_0} + \delta E_2$$

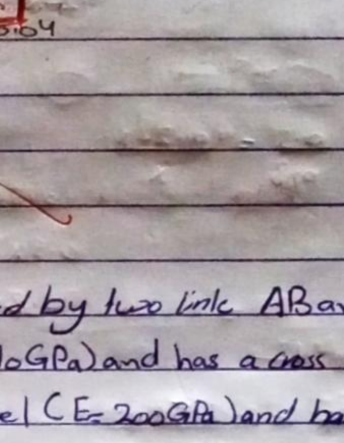
([illegible]) The rigid bar BDE is supported by two link AB and CD. link AB is made of aluminum (E = 70 GPa) and has a cross sectional a of (500 mm²). link CD is made of steel (E = 200 GPa) and has a cross se (600 mm²)

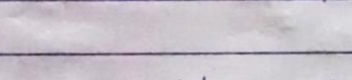
For the 30 kN force shown, determine the deflection (a) of B of (D).

[illegible] deflection [illegible] rigid [illegible] BDE [illegible]

[illegible]

[illegible] deflection [illegible] AB ، DC [illegible]

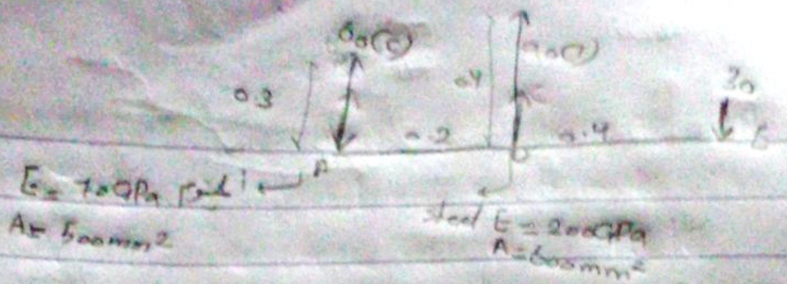




(−) [illegible]
(+) [illegible]

$\Sigma M_B = 0 = 0.2 \times DC - 30\,(0.6)$ $\quad AB = 0.2\,DC \quad DC = (+)\,90\ \text{kN}\ (T)$

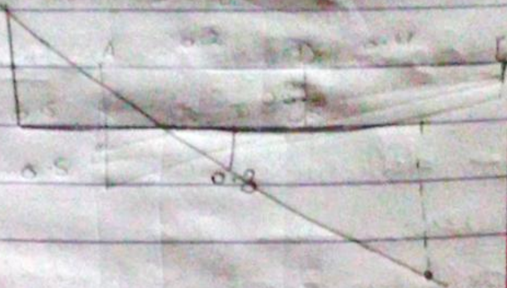
$\Sigma F_y = 0 = AB + 90 - 30 \quad AB = -60\ \text{kN}\ (C)$

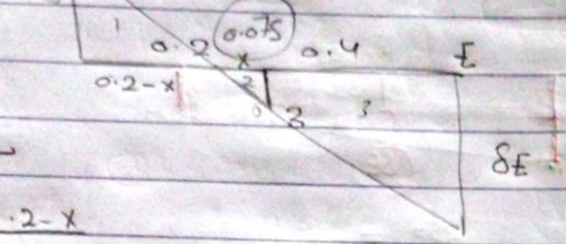


alu $\delta_{AB} = \frac{PL}{AE}$

$= \frac{-60*10^3 * 0.3*10^3}{500*70*10^3}$ $\boxed{(-)\,0.51\text{mm}}$

steel $\delta_{DC} = \frac{PL}{AE} = \frac{90*10^3 * 0.4*10^3}{200*10^3*600}$ $\boxed{(+) = 0.3\text{mm}}$





x من : 1,2 تشابه

$$\frac{0.5}{0.3} = \frac{0.2-x}{x}$$

$0.5x = 0.3(0.2-x)$

$0.5x = 0.06 - 0.3x$

$0.8x = 0.06$ $x = 0.075$

2,3 تشابه

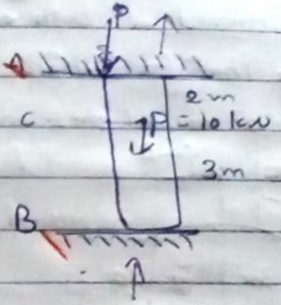
$$\frac{\delta E}{0.3} = \frac{0.075+0.4}{0.075}$$

$0.075\,\delta E = 0.3(0.075+0.4)$

$0.075\,\delta E = 0.0225 + 0.12$

$\boxed{\delta E = 1.9\text{mm}}$

معادلة غير محددة استاتيكيا



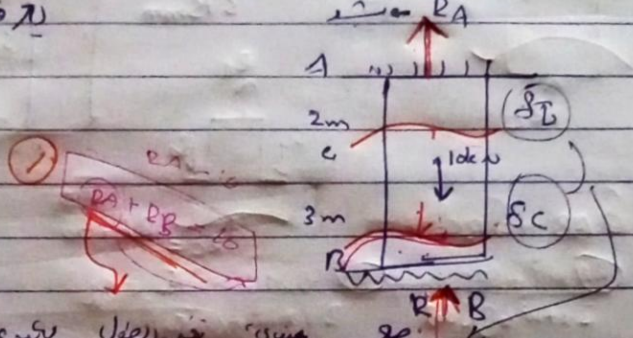
Fixed مثبتة من الجهتين

$\Sigma F_y = 0 = RA + RB - \textcircled{10} = 0$ ①

كيف أحصل على معادلة ثانية حتى أحصل على قيم RB

من الرسم CB تحت ضغط (C) (اتجاهات الـ Reaction اللي بنفرضها ولا طلع الجواب

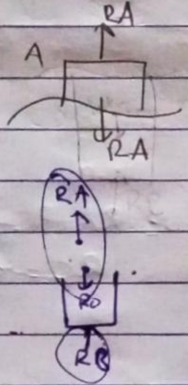
(يعرف اتجاهها صحيحة)



صح مجموع التغير بالطول لكل الجسم مثبت بـ two fixed

$\Sigma F_y = RA + RB = 10$ ∴ مجموع الحركات

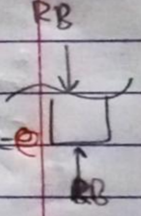
صار عندي معادلتين] $\delta_{AC} + \delta_{BC} = 0$



$\frac{PL}{EA} = \delta_{AC}$

$\delta_{AC} \qquad \delta_{BC}$

$= \frac{RA * 2 * 10^3}{E\ A} + \frac{-RBC * 3 * 10^3}{EA} = 0$



أو نعوض $RBC \rightarrow RA - \textcircled{10}\,P$

$\frac{RA * 2 * 10^3}{\cancel{EA}} = \frac{RBC * 3 * 10^3}{\cancel{EA}}$

② ← $RA = 1.5\, RBC$

$RA = 10 - RB$

$1.5\, RBC = 10 - RB$

$2.5\, RBC = 10$

$RBC = 4 \qquad RA = 6$

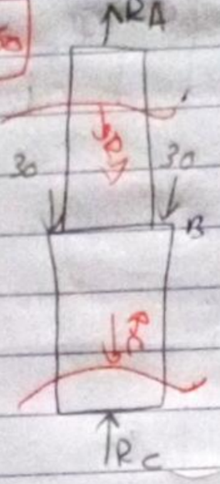
[illegible]

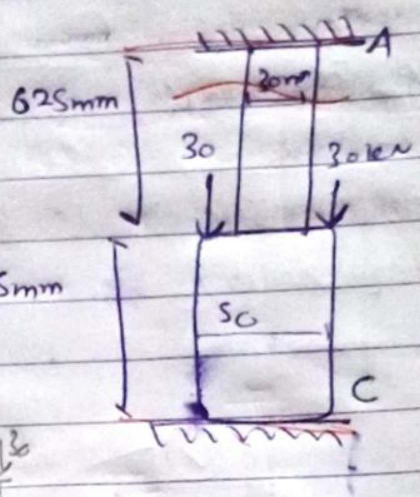
2.39. [A polystyrene consisting of two cylindrical portions AB and BC is restrained at both ends and supported two 30kN loads as shown. knowing that E = 3.1 GPa determine (a) the reactions at A and C

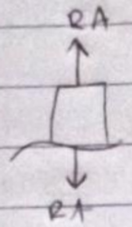
(b) normal stress in each portion of the rod.

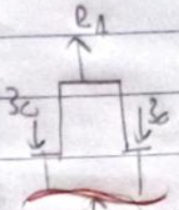
ΣFy: $\boxed{R_A + R_C = 60}$

$R_A + R_C = 60$









$R_C = R_A - 60$

$\delta_{AB} + \delta_{BC} = 0$

$$\frac{R_A \times 10^3 \times 625}{3.1\times10^3 \times \frac{\pi}{4}(30)^2} + \frac{(R_A - 60)\times 10^3 \times 375}{3.1\times10^3 \times \frac{\pi}{4}(50)^2} = 0$$

$$\frac{R_A \times 10^3 \times 625}{\cancel{3.1\times10^3 \times \frac{\pi}{4}}(30)^2} = -\frac{(R_A - 60)\times 10^3 \times 375}{\cancel{3.1\times10^3 \times \frac{\pi}{4}}(50)^2}$$

$$\frac{625\ R_A}{30^2} = \frac{(R_A - 60)\ 375}{50^2}$$

$50^2 \times 625 R_A = -375A + 22500\ (30)^2$

$50^2 \times 625 R_A + 375A = 22500\ (30)^2$

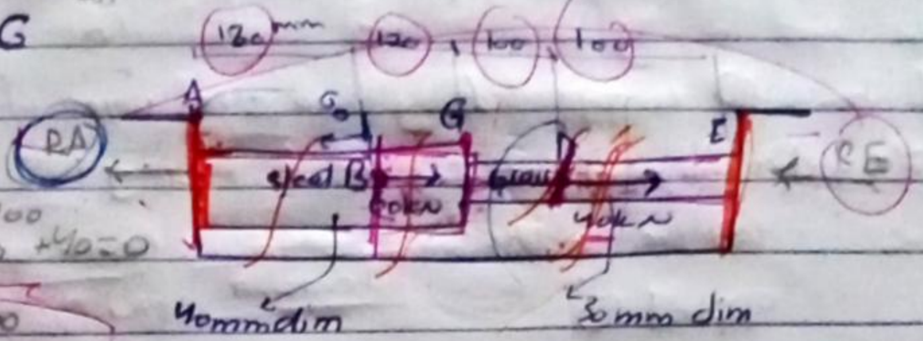
(12.9)

$R_A = 12.9$ kN

$\Sigma F_y = 0 : R_A + R_C - 60 = 0$

$R_C = 47.04$ kN

Two cylindrical rods, one of steel and the other of brass, are jointed at C and restrained by rigid support at A and E for the loading shown and knowing that $E_{steel} = 200$ GPa, $E_{brass} = 105$ GPa, determine (a) the reactions at A and E (b) deflection of point G



X ما نعرف

$$\Sigma F_x = -RA - RE + 60 + 40 = 0$$

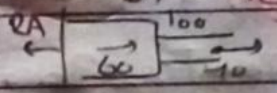
① ← $\boxed{RA + RE = 100}$

سابقاً $\delta = \frac{PL}{AE}$ ذكرنا انه بنعوض P ، L ، A ، E نحل

بس عند النقطة الي صار عندها التغير (داخل جزء) لوحده

مثل كل load وبعد 60 - مثل وبعد load

وبالتالي RA-100



② → $\delta_{AB} + \delta_{BG} + \delta_{GD} + \delta_{DE} = 0$

$$\frac{RA \times 10^3 \times 180}{200\times10^3 \times \frac{\pi}{4}(40)^2} + \frac{(RA-60)\,120}{200\times10^3 \times \frac{\pi}{4}(40)^2} + \frac{(RA-60)\times100}{105\times10^3 \times \frac{\pi}{4}(30)^2} + \frac{(RA-100)\,100}{105\times10^3 \times \frac{\pi}{4}(30^2)} = 0$$

-(-) علاكيا نعوض $\frac{100-RA}{100-RA}$ بالسالب [illegible]

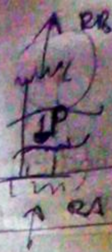
$$7.16\times10^{-7}\,RA + (RA-60)\,4.77\times10^{-7} + (R-60)(1.34\times10^{-6}) + (R-100)\,1.34\times10^{-6} = 0$$

~~$RA = -2.4\times10^{-4}$~~

~~$3x+2$~~ $= 0$

$\frac{4x}{4}$ $+2 = 0$ $\frac{-21}{4}$

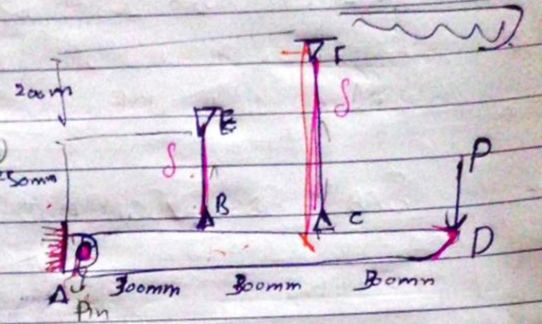
δ — ○□
Φ □



deformation في strain [illegible] normal stress [illegible]

1 The rigid bar AD is supported by two steel (wires) of 1.5mm diameter (E = 200 GPa) and a pin and bracket at A. knowing that the wires were ~~[illegible]~~ determine (a) the additional ~~rection~~ tentsion in each wire when a 1kN load P is applied D 1kN P [illegible]

(b) The crossponding deflection of point D



ΣF_y -

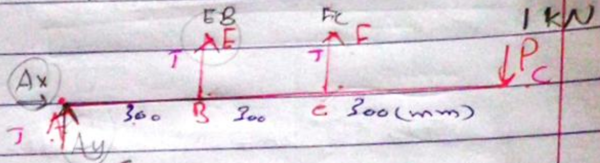
$\Sigma M_A = 0 = EB(300) + FC(600) - 1(900)$

① ← EB + 200 Fc = 300

① ← EB + Fc = 3

δ Reac < Ay, Ax

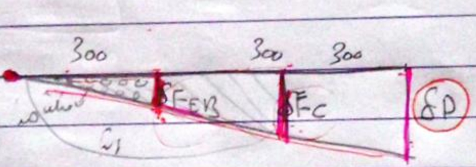
[illegible] مش داعي احسبها



عشان 4 مجاهيل غير محدد استاتيكيا

نرسم deflection diagram عشان [illegible] P بيزل [illegible] Fc [illegible] BE [illegible]
load [illegible] BE يزل [illegible] BE

عشان ال deflection في pin = صفر



اول معادلة بين EB ، Fc من الاستاتيكا

$$\frac{\delta Fc}{\delta EB} = \frac{600}{300}$$

$$300\ \delta Fc = 600\ \delta EB$$

$$\boxed{\delta Fc = 2\delta EB}$$

$$250\ 546\ \frac{\overset{Fc}{PL}}{AE} = 2\frac{\overset{EB}{PL}}{AE}$$

$$\frac{\delta_{900}}{300} = \frac{\delta D}{\delta E}$$

δD

$\frac{PL}{AL}$

$\delta F_C = 2\delta F_B$

[illegible] $\frac{F_C * 450}{200*10^3 * \frac{\pi}{4}(1.5)^2} = \frac{2 * F_B * 250}{200*10^3 * \frac{\pi}{4}(1.5)^2}$

[illegible]

$\boxed{F_B + 2F_C = 3}$

وطلع :

[illegible]

$\delta F_B < \delta F_C$

δD وحل [illegible]

وبعدين [illegible]

$450\, F_C = 500\, F_B$

$F_B = 0.9 F_C$

$0.9 F_C + 2F_C = 3$

$F_C = \oplus 1.03\ (T)$ kN

$F_B = \oplus 0.93\ (T)$ kN

① $450\, F_C = 500\, F_B$

$F_C = 0.9 F_B$

$F_C - 0.9 F_B = 0$

$F_C + F_B = 3$

$1.9 F_B = 3$

$F_B = \boxed{0.67}$

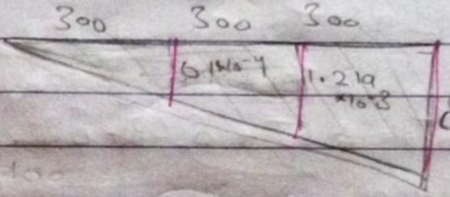
③

$\Sigma F_y = 1 + F_C + F_B + A_y = 0$

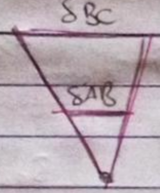
④

$\delta C = 1.219 \times 10^{-3}$

$\delta B = 6.1 \times 10^{-4}$

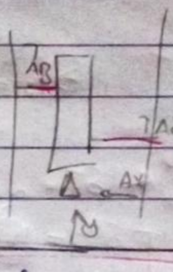


$\frac{900}{600} = \frac{\delta D}{1.219 \times 10^{-3}}$



[illegible]

$\Sigma M_A = 0$



δT

temprature → deformation

$\delta T = \alpha\, \Delta T\, \boxed{L}$

معامل التمدد الحراري ← coff thermal expansion

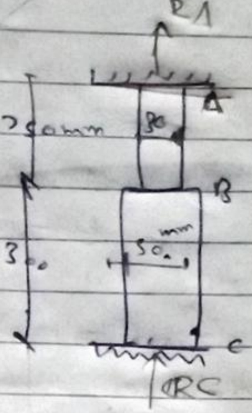
التغير

[illegible]

A rod consisting of two cylindrical portions AB and BC is restrained at both end. Portion AB is made of steel $E_s = 200$ GPa as $\alpha = 17 \times 10^{-6}$ /°C and portion BC is made of brass $E_b = 105$ GPa $\alpha = 20.9 \times 10^{-6}$ /°C, knowing that the road initially unstressed determine the compressive force induced in ABC when there tempreture rise of 50 °C.

dis

50°C [illegible] compressive [illegible]



[illegible] $\delta_T = \alpha \Delta T L$

Reaction

2 support [illegible] $\leftarrow \delta_{total} = 0$

reaction [illegible]

$\delta_{total} = \delta T + \delta AB + \delta BC$

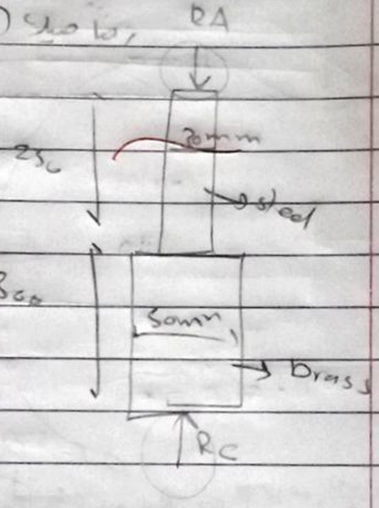
① $\Sigma F_y = 0$

② ← $\delta T \ominus \delta AB + \underset{\text{load}}{\ominus} \delta BC$ compression

([illegible] compression)

[illegible] Reaction [illegible]

$\delta_{total} = 0 = \delta T + \delta$



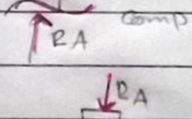
[illegible] $\delta T = \alpha \Delta T * l$

$$\left[\begin{array}{l} \delta T_s = 11.7 \times 10^{-6} * 50 * 250 = \boxed{0.14625} \text{ mm} \\ \delta T_b = 20.9 \times 10^{-6} * 50 * 300 = \boxed{0.3135} \text{ mm} \end{array}\right.$$

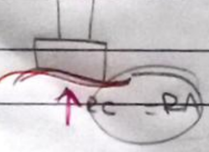
$\delta T = \delta T_s + \delta T_b$ $\boxed{0.4598 \text{ mm}}$

δT

$$\delta_{AB} = \frac{\ominus RA * 250}{200 \times 10^3 * \frac{\pi}{4}(30)^2}$$



$$\delta_{BC} = \frac{\ominus RA * 300}{105 \times 10^3 * \frac{\pi}{4}(50)^2}$$



$$\boxed{\delta_{AB} + \delta_{BC} + \delta T = 0}$$

$-RA\ 6.339 \times 10^{-6} + 0.45950 = 0$

$$\boxed{RA = 1.38 \times 10^{-5} = RC}$$

$\Sigma F_y = RA - RC = 0$

$\boxed{RA = RC}$ → compression force

a rod consisting cylindrical AB and BC is restrained

AB $\alpha_{brass} = 20.9 \times 10^{-6}$ /°C and portion BC mad aluminum $E = 72$ GPa, $\alpha = 23.9 \times 10^{-6}$

$E_{brass} = 209 \times 10^{6}$

knowing that the rod is initially unstressed determine

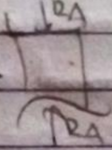
(a) normal stress induced in portion AB, BC by temprature rise 42°C

(b) the corresponding deflection pon B. ?

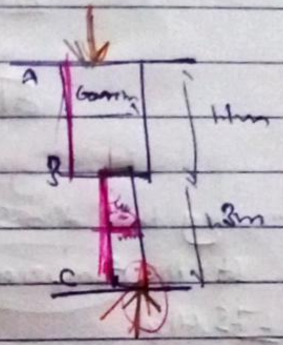
$$\delta_{total} = 0 = \overset{(-)comp}{\delta T} + \overset{(-)com}{\delta_{AB}} + \delta_{BC} = 0$$

brass $\delta T = \alpha \Delta T L =$ نعوض

alumin $\delta T = \alpha \Delta T L =$ نعوض



$$\delta_{AB} = \frac{R_A \times L}{A \times E}$$



δ

$$\alpha T L_{AB} + \alpha T L_{BC} - \overset{com}{\frac{P L_{AB}}{E A_{AB}}} - \overset{comp}{\frac{P L_{BC}}{E A_{BC}}} = 0$$

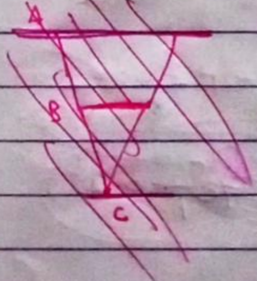
$$(20.9 \times 10^{-6} \times 42 \times 1.1 \times 10^{3}) + (23.9 \times 10^{-6} \times 42 \times 1.3 \times 10^{3}) - \frac{P \times 1.1 \times 10^{3}}{105 \times 10^{3} \times \frac{\pi}{4}(60)^2}$$

$$- \frac{P \times 1.3 \times 10^{3}}{72 \times 10^{3} \times \frac{\pi}{4}(40)^2} = 0$$

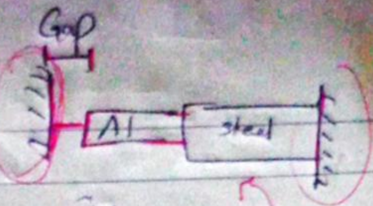
$$\boxed{P = 52428.7 \text{ (N)}}$$

$$\sigma_{AB} = \frac{P}{A} = \frac{-52428.7}{\frac{\pi}{4}(60)^2} = -18.5 \text{ MPa}$$

$$\sigma_{BC} = \frac{P}{A} = \frac{-52428.7}{\frac{\pi}{4}} = - \text{ MPa}$$



$\boxed{\delta_{Thermal} < Gap}$



Gap = 10mm لو

$\delta T = \boxed{9mm}$

9mm δT والغير، 10mm الـ Gap لو قال،

reaction مفيش δ's Gap ما خلص

$$\delta T < Gap \quad \therefore \overset{\delta\, total}{\delta} = \delta T$$

$$\delta T > Gap \quad \overset{total}{\delta} = \delta T + \delta \quad \text{reaction} \rightarrow \text{compression}$$

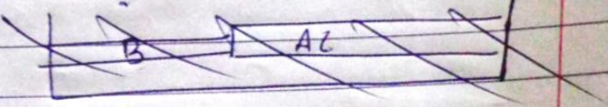
2.58:- knowing that a 0.5mm gap exists when the temprature is 24°C determine (a) the temperature at which the normal stress in the aluminum bar equal -75 MPa

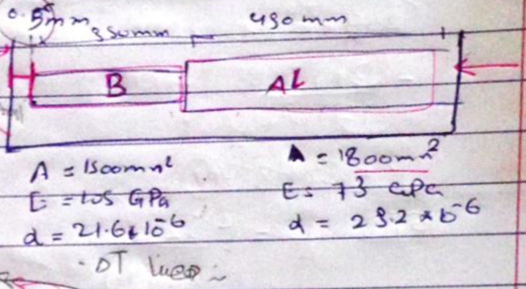
(b) The crossbonding exact length of the aluminum bar.

اذا δT فاتت الـ gab

يبقى كان في reaction

يعني normal stress





$$\overset{Gap}{\boxed{0.5}} = \alpha_B L_B \Delta T + \alpha_{Al} L_{Al} \Delta T - \frac{PL_B}{E_B A_B} - \frac{PL_{Al}}{E_{Al} A_{Al}}$$

$$0.5 = (21.6\times10^{-6} \times 350\, \Delta T) + (23.2\times10^{-6} \times 450 \times \Delta T) - \frac{P\times350}{105\times10^3 \times 1500} - \frac{P\times450}{73\times10^3 \times 1800}$$

$$\sigma_{Al} = \frac{-P}{A} = -75 = \frac{-P}{1800} \qquad \boxed{P = 112500\,N} \rightarrow ②$$

$$\delta_{Al} = \frac{PL}{AE} + \delta_T \quad \frac{112500 \times 450}{1800 \times 73.1} = -0.385 + \alpha \underset{50}{\Delta T} L = \boxed{0.18}$$

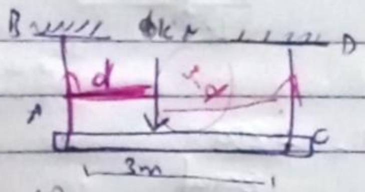
طول الـ aluminum

الأصلي

$$\delta_B = \frac{PL}{AE} + \delta_T - 0.25$$

0.655

a uniform beam is supported by two rods, The rods have cross sectional area of 12mm² For AB and 8m² for CD. Determined the position d. the average stress in both rod is same



stress AB = σCD

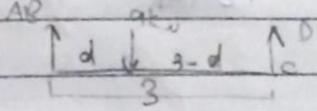
$\frac{(6-2d)}{12} = \frac{2d}{8}$

$\boxed{d = 1.2m}$

$\Sigma M_A = 0 = (6 * d) - T_{CD}(3)$

$3T_{CD} = 6d$

$\boxed{T_{CD} = 2d}$



$\Sigma F_y = 0 = AB + CD - 6$

$AB + 2d - 6 = 0$

$\boxed{AB = 6 - 2d}$

$6d - T_{CD}\,3 = 0$

$\frac{6d}{3} = \frac{3T_{CD}}{3}$

$T_{CD} = 2d$

$\Sigma F_y = 0 = AB + CD = 6$

$AB = 6 - CD$

$6 - 2d$

$\frac{2d}{8} = \frac{6-2d}{12}$

$3d = 6 - 2d$

ductile

: Stress - strain relationship. -

$E = \frac{\sigma}{\varepsilon}$

$\boxed{\text{strain} = E\sigma}$ → Hooke's low → elastic

brittle

normal stress

: shear strain: تغير شكل الجسم فقط (سطح) -

$\sigma = E\varepsilon$ ← normal strain طول

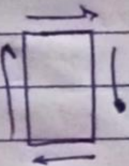
normal strain

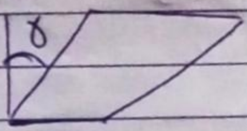
shear " زاوية

تغير

ε strain

ما بحصل تغير في الزاوية





γ shear strain

shear stress ← $\tau = G\gamma$ ← shear strain

modulus