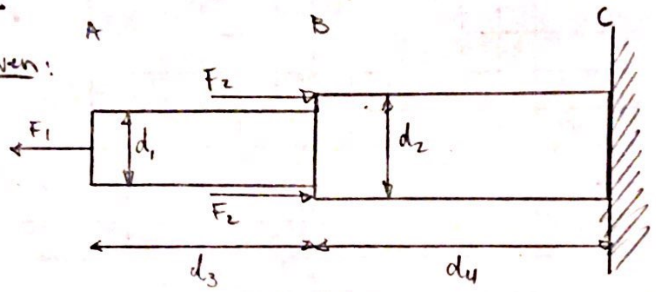
ENGR 213 HW #1 | 4/7/20 | Sean Lai

CH 1 : #'s 1, 7, 10, 15, 18, 21, 23, 32, 36, 46

1.1

Given:



$F_1 = 60\text{ kN}$
$F_2 = 125\text{ kN}$
$d_1 = 30\text{mm}, \quad 0.03\text{m}$
$d_2 : 50\text{mm}, \quad 0.05\text{m}$
$d_3 : 0.9\text{m}, \quad d_4 = 1.2\text{m}$

Find: a) σ_{AB}

b) σ_{BC}

Solution:

a)

$$\sigma_{AB} = \frac{F_1}{A_{AB}}, \quad A_{AB} = \pi\left(\frac{d_1}{2}\right)^2$$

$$\sigma_{AB} = \frac{4F_1}{\pi d_1^2} = 8.49 \cdot 10^4 \frac{\text{kN}}{\text{m}^2}$$

$$\rightarrow \boxed{\sigma_{AB} = 84.9\text{ MPa}}$$

b)

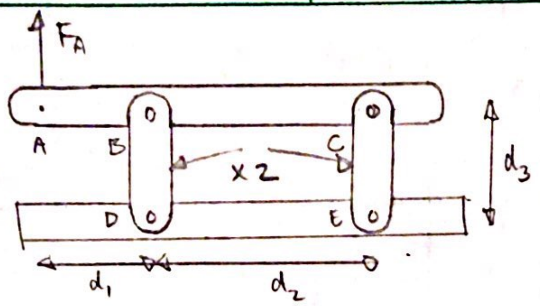
$$\sigma_{BC} = \frac{-2F_2 + F_1}{\pi\left(\frac{d_2}{2}\right)^2}$$

$$= \frac{-8F_2 + 4F_1}{\pi d_2^2} = -9.67 \cdot 10^4 \frac{\text{kN}}{\text{m}^2}$$

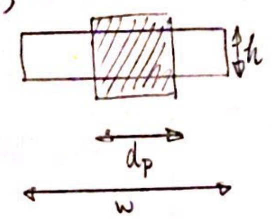
$$\rightarrow \boxed{\sigma_{BC} = -96.7\text{ MPa}}$$

$\underline{1.7}$

Given:



BD, CE cross section w/ pin

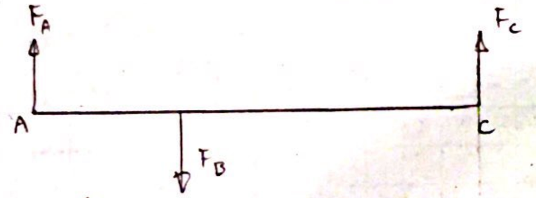


$F_A = 20\text{ kN}$
$d_1 = 0.25\text{m}$, $d_2 = 0.4\text{ m}$, $d_3 : 0.2\text{m}$
$w = 0.036\text{m}$, $h = 0.008\text{ m}$, $d_p = 0.016\text{ m}$

Find: a) normal stress in BD, σ_{BD}
b) " " " CE, σ_{CE}

Solution:

FBD for ABC :



ΣF_y: $F_A + F_C - F_B = 0$ ①

ΣM_C: $F_B(d_2) - F_A(d_1 + d_2) = 0$ ②

ΣM_B $-F_A(d_1) + F_C(d_2) = 0$ ③

from ②: $F_B = F_A \dfrac{d_1 + d_2}{d_2} = 32.5\text{kN}$ $+\sigma$ (tension)

From ③: $F_C = F_A\left(\dfrac{d_1}{d_2}\right) = 12.5\text{kN}$ $-\sigma$ (compression)

area of BD at pin: $A_{BD} = (w - d_p)h = 1.6 \cdot 10^{-4}\text{ m}^2$

a) $\sigma_{BD} = \dfrac{F_B}{2 \cdot A_{BD}}$, use $2A_{BD}$ because there are two links

$= \dfrac{32.5\text{kN}}{2(1.6 \cdot 10^{-4})\text{m}^2} = \boxed{102\text{MPa} = \sigma_{BD}}$

b) $\sigma_{CE} = \dfrac{-F_C}{2 \cdot A_{BD}}$ use bearing $\sigma_{CE} \rightarrow A_{CE} = w, \cdot h = 2.88 \cdot 10^{-4}\text{m}^2$

$= \dfrac{-12.5\text{ kN}}{2(2.88\ 10^{-4})\text{m}^2} = \boxed{-21.7\text{MPa} = \sigma_{CE}}$

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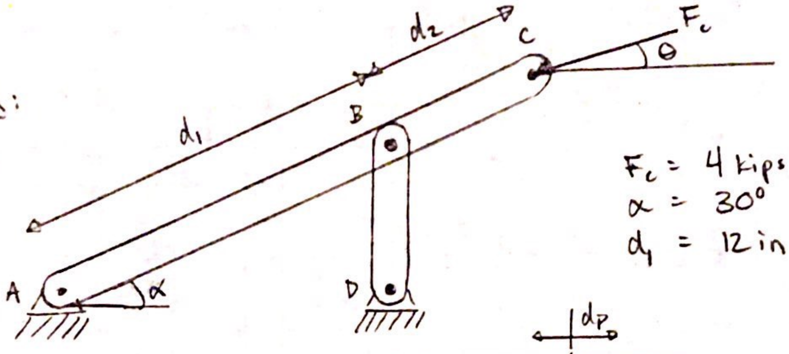
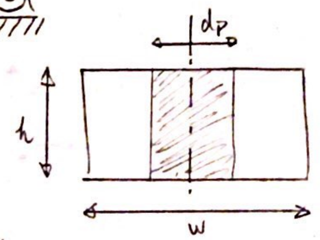
1.10

Given:



$F_c = 4$ kips
$\alpha = 30^\circ$
$d_1 = 12$ in , $d_2 = 6$ in

BD cross-section @ pin →

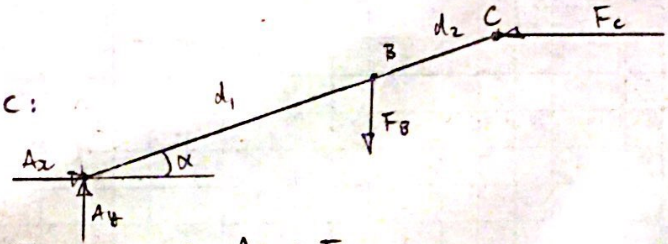


$h = 0.5$ in
$w = 1$ in
$d_p = 3/8$ in

Find: a) σ_{BD} when $\theta = 0$
b) σ_{BD} when $\theta = 90^\circ$

Solution:

a) FBD of ABC:



$\Sigma F_x : A_x - F_c = 0 \rightarrow A_x = F_c$

$\Sigma F_y : A_y - F_B = 0 \rightarrow A_y = F_B$

$\Sigma M_A : -F_B(d_1 \cos\alpha) + F_c[(d_1 + d_2)\sin\alpha] = 0$

$$\rightarrow F_B = F_c \frac{(d_1+d_2)}{d_1} \frac{\sin\alpha}{\cos\alpha}$$

$F_B = 3.46$ kips $+\sigma$, tension

$\sigma_{BD} = \dfrac{F_B}{A_{BD}}$, $A_{BD} = (w - d_p)\cdot h = 0.3125 \text{ in}^2$

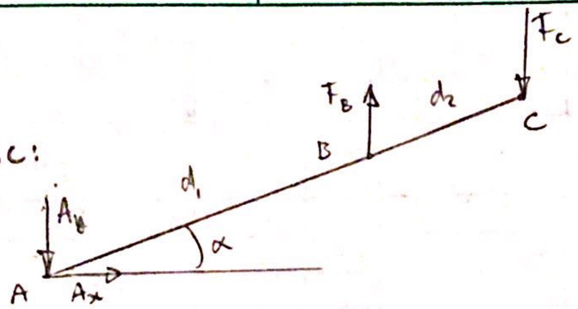
$$\rightarrow \sigma_{BD} = \frac{3.46 \text{ kips}}{0.3125 \text{ in}^2}$$

$$\boxed{\sigma_{BD} = 11.07 \text{ ksi}}$$

b) on next sheet →

b)

FBD of ABC:



from FBD, $A_x = 0$

ΣF_y : $F_B - F_c - A_y = 0$

ΣM_A : $F_B \cdot d_1 \cos\alpha - F_c \cdot (d_1 + d_2) \cos\alpha = 0$

$\rightarrow F_B = F_c \cdot \frac{d_1 + d_2}{d_1}$

$F_B = 6 \text{ kips}$ $-\sigma$, compression

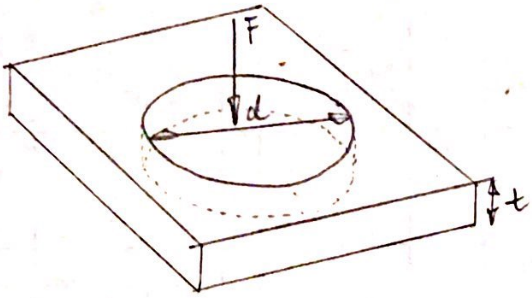
$\sigma_{BD} = \frac{-F_B}{A_{BD}}$ $\quad A_{BD} = w \cdot h = 0.5 in^2$ compression

$= \frac{6 \text{ kips}}{0.5}$

$\rightarrow \boxed{\sigma_{BD} = -12 \text{ ksi}}$

1.15

Given:



$F = 45\,kN$
$\tau = 55\,MPa$
$t = 6\,mm = 0.006\,m$

Find: maximum value of d where F is applied to material requiring τ to fail.

Solution:

$$\tau = \frac{F}{A} \rightarrow A = \frac{F}{\tau}$$

for punch, $A = \pi d \cdot t$

$$\rightarrow \pi d t = \frac{F}{\tau}$$

$$d = \frac{F}{\pi \tau t}$$

this makes sense. d can be larger for larger F, smaller t, smaller τ

$$\rightarrow d = \frac{45\,kN}{\pi \cdot 55\,MPa \cdot 0.006\,m}$$

$$d = \frac{45 \cdot 10^3\,N}{\pi \cdot 55 \cdot 10^6\,N/m^2 \cdot 0.006\,m}$$

$$\boxed{d = 0.043\,m = 4.3\,cm}$$

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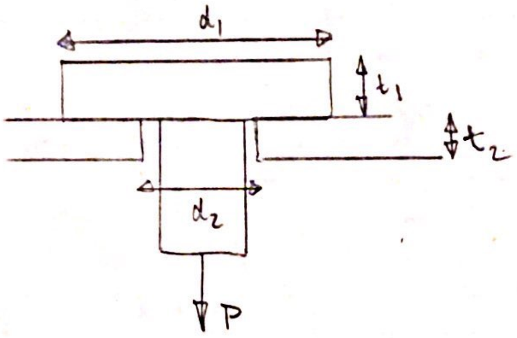
1.18

given



$d_1 = 40mm$, $d_2 = 12 mm$
$t_1 = 10 mm$, $t_2 = 8 mm$
$\tau_1 = 180 MPa$, $\tau_2 = 70 MPa$

$1 \to$ steel , $2 \to$ Al

Find: largest P that can be applied

Solution:

$$\tau_1 = \frac{P}{A_1} \quad , \quad A_1 = \pi d_2 t_1$$

$$\tau_2 = \frac{P}{A_2} \quad , \quad A_2 = \pi d_1 t_2$$

to find largest allowable P, find smallest $\tau \cdot A$

steel
$$\tau_1 A_1 = 180 MPa \cdot (\pi \cdot 0.012 m \cdot 0.01 m)$$
$$= 6.78 \cdot 10^{-2} MPa/m^2$$
$$= 6.78 \cdot 10^{4} N$$

Al
$$\tau_2 A_2 = 70 MPa \cdot (\pi \cdot 0.04 m \cdot 0.008 m)$$
$$= 7.03 \cdot 10^{-2} MPa/m^2$$
$$= 7.03 \cdot 10^{4} N$$

$\to$ allowable $\boxed{P = 6.78 \cdot 10^{4} N}$

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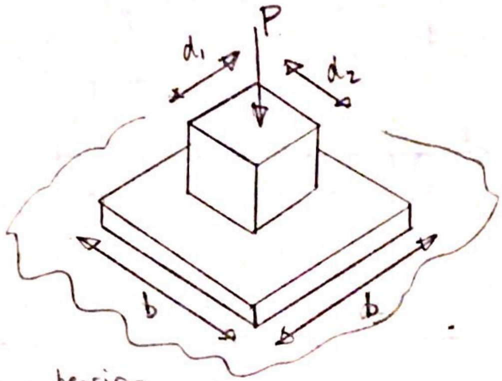
1.21:

Given:



$P = 40\,kN$
$d_1 = 100\,mm = 0.1\,m$
$d_2 = 120\,mm = 0.12\,m$

Find: a) bearing stress on footing from block
b) footing size; b^2, for $\sigma = 145\,kPa$

Solution:

a) $\sigma_c = \frac{P}{A}$, $A = d_1 d_2$

$$\sigma_c = \frac{40\,kN}{0.1\,m \cdot 0.12\,m}$$

$$\boxed{\sigma_c = 3.33\,MPa}$$

b) $\sigma_s = \frac{P}{A}$, $A = b^2$, $\sigma_s = 145\,kPA$

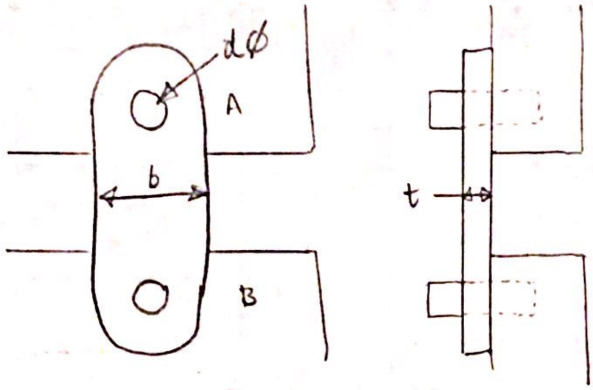
$$\rightarrow b^2 = \frac{P}{\sigma_s}$$

$$b = \sqrt{\frac{40\,kN}{145\,kPa}}$$

$$\boxed{b = 0.53\,m}$$

1.23:

Given:



$b = 2$ in
$t = 0.25$ in

$\sigma_{AB} = -20$ ksi
$\tau_p = 12$ ksi

Find: a) diameter d
b) σ_b in link (bearing stress)

Solution: let A_c, A_s, A_t, A_b be areas in comp., shear, tension, bearing

a) $\sigma_{AB} = \frac{F}{A}$ since $\sigma_{AB} < 0$, stress is compression

$\rightarrow F = A\sigma_{AB}$, $A_c = b \cdot t$
$F = \sigma_{AB} \cdot bt$
$F = 10$ kips

$\tau = \frac{F}{A_s}$, $A_s = \frac{\pi d^2}{4}$

$\rightarrow \tau = \frac{4F}{\pi d^2}$

$d = \sqrt{4F/\pi\tau}$

$d = \sqrt{\frac{4 \cdot 10\text{kips}}{\pi \cdot 12\text{ksi}}}$

$\boxed{d = 1.03\text{ in}}$

b) $\sigma_B = \frac{F}{A_b}$, $A_b = d \cdot t$

$\sigma_B = \frac{10\text{ kips}}{1.03\text{in} \cdot 0.25\text{in}}$

$\boxed{\sigma_B = 38.8\text{ ksi}}$

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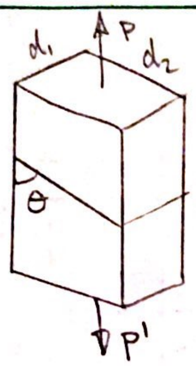
1.32:

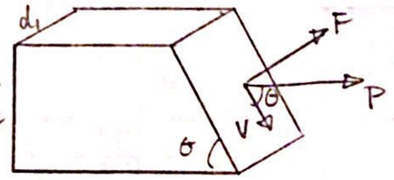
Given:



$d_1 = 3.0\text{ in}$, $d_2 = 5.0\text{ in}$
$\theta = 60^\circ$
$\sigma_T = 75\text{ psi}$

Find: a) largest P that can be supported
b) τ, shearing stress in joint

Solution:



a) $\sigma_T = \frac{F}{A}$, $A = d_1 \cdot \frac{d_2}{\sin\theta}$

$\downarrow$

$F = \sigma_T A$

also, $P = \frac{F}{\sin\theta} \longrightarrow P = \frac{1}{\sin\theta}\sigma_T \cdot \frac{d_1 d_2}{\sin\theta}$

$P = \sigma_T d_1 d_2 \frac{1}{\sin^2\theta}$

$\boxed{P = 1500\text{ lbs}}$

b) $\tau = \frac{V}{A}$, $V = P\cos\theta$

$\rightarrow \tau = \frac{P\cos\theta\sin\theta}{d_1 d_2}$

$\boxed{\tau = 43.3\text{ psi}}$

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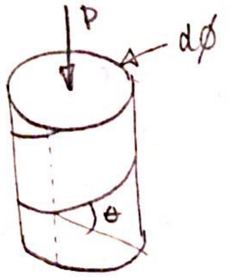
1.36:

Given:



$d = 0.4\,m$

$t = 0.01\,m$

$\theta = 20^\circ$

$\left.\begin{array}{l} \sigma = 60\,MPa \\ \tau = 36\,MPa \end{array}\right\}$ checks out $\sigma = \tau$ for $\theta = 45^\circ$

Find: $|P|$ given allowable σ, τ

Solution:

$$A_0 = \pi d^2 - \pi (d-t)^2$$
$$A_0 = 2.48 \cdot 10^{-2}\ m^2$$

$$\sigma = \frac{P}{A_0}\cos^2\theta \quad , \quad \tau = \frac{P}{A_0}\sin\theta\cos\theta$$

$$\rightarrow P_\sigma = \frac{\sigma A_0}{\cos^2\theta} \quad , \quad P_\tau = \frac{\tau A_0}{\sin\theta\cos\theta}$$

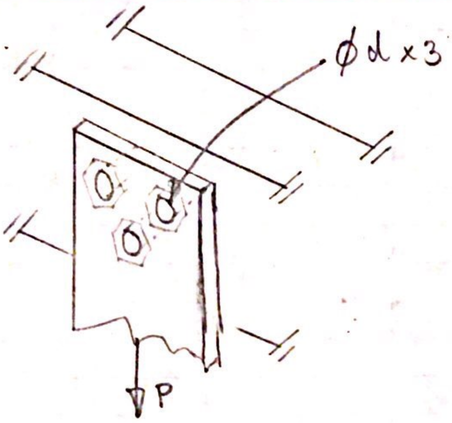
$$P_\sigma = 1.69\ MN \quad , \quad P_\tau = 2.78\ MN$$

$$P_\sigma < P_\tau$$

$$\boxed{\rightarrow P_{allowable} = 1.69\ MN}$$

1.46:

Given:



$\tau = 52$ ksi
FOS = 3.25
P = 28 kips

Find: d, diameter of bolts

Solution:

$$\tau = \frac{P}{A}, \quad A = 3 \cdot \pi \frac{d^2}{4}$$

let τ_s be safe shear stress where $\tau_s = \frac{\tau}{FOS}$

$$\rightarrow \tau_s = \frac{P \cdot 4}{3 \cdot \pi \cdot d^2}$$

$$d = \sqrt{\frac{4}{3} \frac{P \cdot FOS}{\pi \cdot \tau}}$$

$$\boxed{d = 0.862 \text{ in} \sim \frac{7}{8} \text{ in}}$$