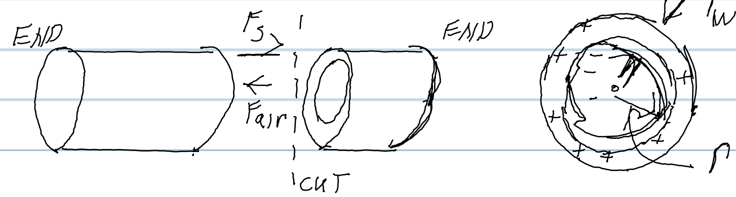
CH. 8.1 THIN WALL PRESSURE VESSELS

FBD AIR COMPRESSOR TANK



$t_w < \frac{1}{10} r$

$\sigma_S = \frac{F_S}{A_S}$, $P_{air} = \frac{F_{AIR}}{A}$

SOLVE:

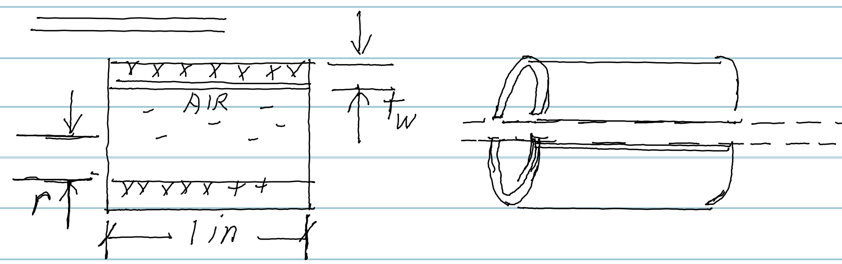
FIND $\sigma_S = P(r, t_w)$

$\sigma_S =$

LONGITUDINAL STRESS

$\sigma_L = \sigma_S = \sigma_2 =$

SAME TANK:

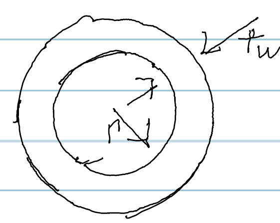


$\sigma_S =$

CIRCUMFERENTIAL STRESS

$\sigma_C = \sigma_S = \sigma_1 =$

SPHERICAL TANK

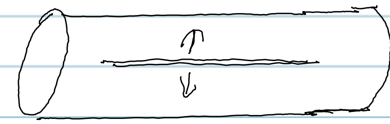


$\sigma_2 = \sigma_{SP} =$

CH. 8.1 THIN WALL PRESSURE VESSELS (CONT.)

CYLINDRICAL PRESSURE VESSEL STRESS

$$* \ \sigma_L = \sigma_1 = \frac{p\,r}{2\,t_w} \qquad \text{NOTE: } \sigma_c = 2\,\sigma_L$$



$$* \ \sigma_c = \sigma_2 = \frac{p\,r}{t_w}$$

SPHERE

$$\sigma_{sp} = \sigma_2 = \frac{p\,r}{2\,t_w} \qquad \left(\text{NOTE } \sigma_{sp} = \sigma_L = \tfrac{1}{2}\sigma_c\right)$$

EXAMPLE: CYL. VS SPHERE

$\sigma_{ALLOW} = 20\text{ ksi}$, $r = 24\text{ in}$, $t_w = 0.25\text{ in}$

CYL (WORST CASE)

$$\sigma_c = \frac{pr}{t_w} \Rightarrow$$

$$20\text{ ksi} = \frac{p\,(24\text{ in})}{0.25\text{ in}} \Rightarrow \underline{\underline{p_{CYL} = 417\text{ psi}}}$$

SPHERE

$$\sigma_{sp} = \frac{pr}{2\,t_w}$$

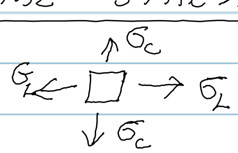
$$20\text{ ksi} = \frac{p\,(24\text{ in})}{0.25\text{ in}} \Rightarrow \underline{\underline{p_{sp} = 833\text{ psi}}}$$

PORTABLE COMPRESSOR W/ TANKS

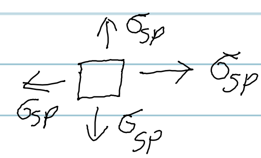
WHY 2 TANKS?

BIAXIAL STRESS

CYL.



SPHERE



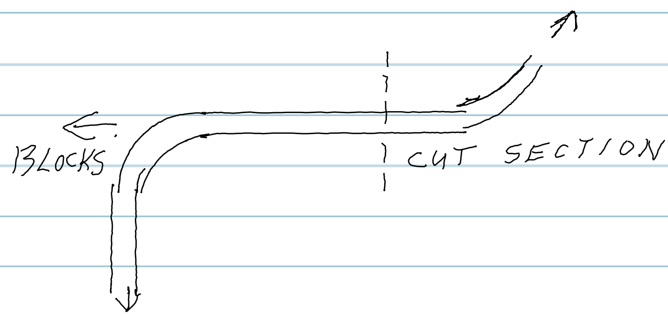
CH. 8.1 THIN WALL PRESSURE VESSEL

EXAMPLE - PROBLEM 8-8

GIVEN: STEEL PIPE, $d_{in} = 12\,in$, $T_w = 0.25\,in$, $P_G = 250\,psi$

FIND: $\sigma_L = ?$, $\sigma_c = ?$ (HOOP STRESS)

SKETCH



SOLUTION:

$$\sigma_c = \frac{pr}{t_w} = \frac{(250psi)(6in)}{0.25in} = \underline{\underline{6\ ksi}}$$

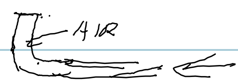
$$\sigma_L = \frac{pr}{2t_w} = \frac{1}{2}\sigma_c = \underline{\underline{3\ ksi}}$$

OTHER EFFECTS ON WATER PIPE

1) KE - STOPS PRESSURE SPIKE

2) BLOCKS

3) BLOCKS - MOMENTUM $F\Delta T = m\Delta V$

4) 

CH. 8.2 STATES OF STRESS CAUSED BY COMBINED LOADINGS

STRESS AT A POINT

REVIEW

1) NORMAL FORCE – $\sigma_n = \frac{N}{A_{cs}}$

2) SHEAR FORCE – $\tau = \frac{VQ}{I\,t_w}$

3) BENDING MOMENT – $\sigma = -\frac{My}{I}$

4) TORSIONAL MOMENT – $\tau = \frac{T\rho}{J}$

5) IN THIN-WALLED PRESSURE VESSELS

FOR CYLINDERS: $\sigma_c = \frac{pr}{t_w}$, $\sigma_L = \frac{pr}{2t_w}$

FOR SPHERE: $\sigma_{sp} = \frac{pr}{2t_w}$

SUPERPOSITION

- ☐ ADD σ TOGETHER @ A POINT BY COMPONENTS
- ☐ ADD τ " " " " "

OBJECTIVE

FIND THE σ_{max} & τ_{max}

CH 8.2 STATE OF STRESS (CONT.)

PROCEDURE FOR ANALYSIS

1) DRAW FBD - SOLVE FOR EXTERNAL REACTIONS

2) DRAW FBD @ CROSS SECTION - EXPOSE CS REACTIONS

3) TRANSLATE "F" + "M" COMPONENTS INTO N, V, M_b, T

4) SOLVE FOR STRESS COMPONENTS USING FORMULA'S

5) DRAW STRESS DISTRIBUTION ON C.S. FOR EACH FORMULA

6) ADD STRESS UP @ POINT SPECIFIED.
   - ☐ ADD COMPONENT σ's $\sigma_B + \sigma_N$
   - ☐ ADD " τ $\tau_T + \tau_V$

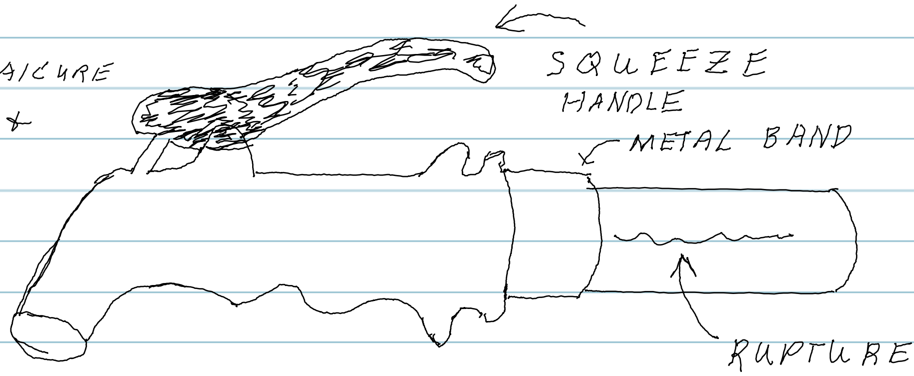
7) RESULT IN $\sigma = A_i + B_j + C_k$ (MPa)

   $\tau = D_i + E_j + F_k$ (MPa)

CH. 8 CONCEPTUAL PROBLEM – WATER HOSE

C8-1 A WATER HOSE @ 30psi RUPTURED LONGITUDINALLY ABOUT ½" FROM ITS METAL BAND HOLDING ITS END CONNECTOR IN PLACE.

EXPLAIN WHY THIS FAILURE OCCURED NEAR ITS END & WHY THE TEAR OCCURED ALONG ITS LENGTH. USE NUMERICAL VALUES TO HELP EXPLAIN YOUR CONCLUSIONS.



YOU SHOULD BE ABLE TO CITE 2 or 3 FACTORS THAT CONTRIBUTED TO THIS FAILURE, MAKE ANY REASONABLE ASSUMPTIONS NECESSARY.

CITE YOUR REASONS ~~BELOW~~ BELOW (W/ MOST IMPORTANT FIRST):

1)

2)

3)

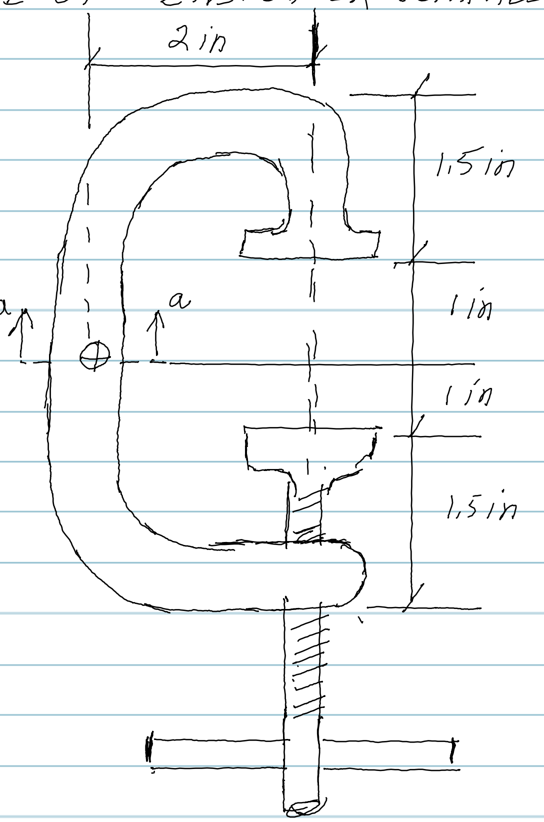
4)

CH 8. GROUP PROBLEM – "C" CLAMP

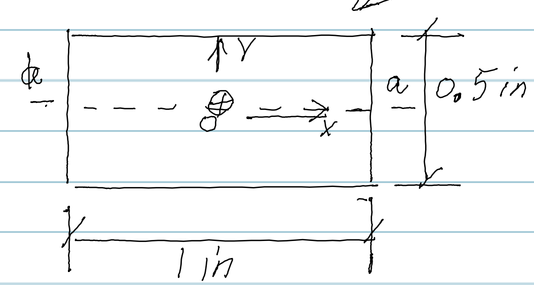
TASK: A "C" CLAMP IS USED TO APPLY A FORCE OF 300 Lbs TO HOLD TWO BOARDS TOGETHER. THE DIMENTIONS & CROSS SECTION (CS) ARE AS SHOWN.

a) FIND THE ABSOLUTE VALUE OF THE MAXIMUM STRESS THAT EXISTS ALONG THE DASHED LINE SHOWN ON THE CROSS SECTION. NOTE THE LOCATION OF THIS STRESS AND ITS STATE OF TENSION OR COMPRESSION. X = 0 @ CENTROID

b) FIND THE LOCATION OF THE LOWEST ABSOLUTE VALUE OF STRESS ON THE DASHED LINE. GIVE ITS POSITION, ABSOLUTE STRESS VALUE, & STATE OF TENSION OR COMPRESSION.



SECTION "a-a"



a) ABS. σ_{max} = ________ Ksi X = ________
"T" or "C"

b) ABS σ_{min} = ________ Ksi X = ________
"T" or "C" or "NEITHER"

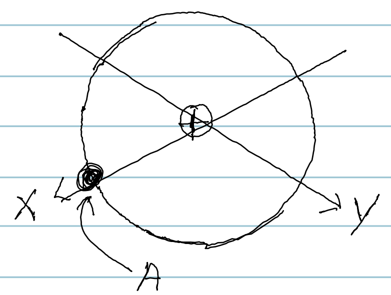
CH 8.2 COMBINED STRESS 3-D PROBLEM

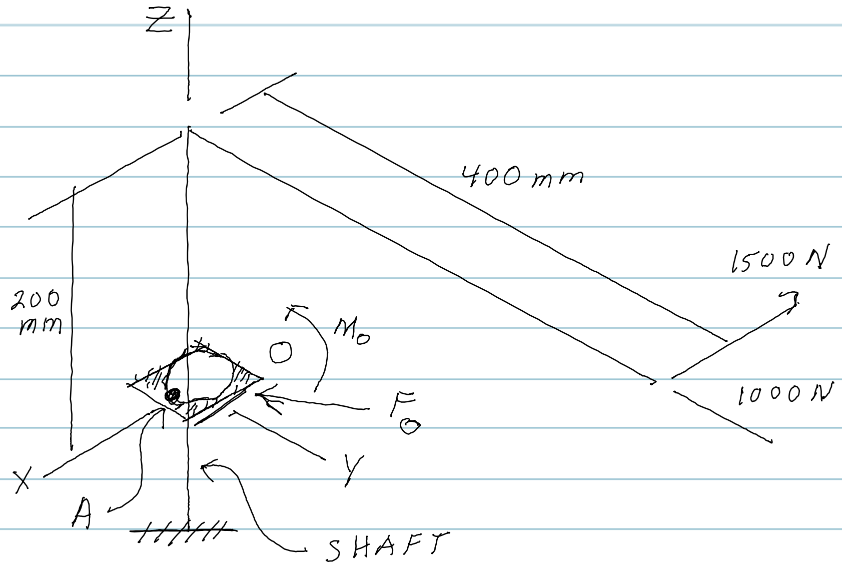
F 8.6

GIVEN: SOLID ROD $r = 20\,mm$, $F = -1500i + 1000j$ (N) @ POSITION VECTOR $R = 0i + .4j + .2k$ (m) MEASURED FROM CENTROID ON CS "a-a".

FIND: STRESS + SHEAR STRESS ON POINT "A" (SEE CS)

SKETCH





SOLUTION

$\Sigma F_o = 0 \Rightarrow F_o + (-1500i + 1000j) = 0$

$F_o = +1500i - 1000j$ (N)

$\Sigma M_o = 0 \Rightarrow M_o + r \times F = 0$

$$r \times F = \begin{vmatrix} i & j & k \\ 0 & .4 & .2 \\ -1500 & 1000 & 0 \end{vmatrix} \begin{matrix} i & j \\ 0 & .4 \\ -1500 & 1000 \end{matrix} = -300j - [200i - 600k]$$

$= -200i - 300j + 600k$ (N·m)

$M = -r \times F = +200i + 300j \mp 600k$ (N·m)

CH. 8 PROB F 8.6 (CONT.)

FBD REACTION @ C.S.	NAMED COMPONENTS	STRESS & SHEAR COMPONENTS	COMBINED STRESS & SHEAR COMPONENTS
$F_{oz} = 0\ N$	$N_{oz} = 0\ N$	$\sigma_{NZ} = 0\ MPa$	
$F_{ox} = 1500\ N$	$V_{ox} = 1500\ N$	$\tau_{AXV} = 0\ MPa$	
$M_x = -200\ N{\cdot}m$	$M_{bx} = -200$	$\sigma_{AZX} = 0\ MPa$	$\sigma_{AZ} = -47.7\ MPa$
$M_y = 300\ N{\cdot}m$	$M_{by} = 300$	$\sigma_{AZY} = -47.7\ MPa$	
$M_z = -600\ N{\cdot}m$	$T_z = -600$	$\tau_{AYT} = -47.7\ MPa$	$\tau_{ay} = -48.8\ MPa$
$F_{oy} = -1000\ N$	$V_{oy} = -1000$	$\tau_{AYV} = -1.061\ MPa$	

MOMENTS OF INERTIA: $I_x = I_y = \frac{\pi}{4} r^4 = \frac{\pi}{2}(.02m)^4 = 1.257 \cdot 10^{-7} m^4$; $J = \frac{\pi}{2} r^4$

$J = 2.513 \cdot 10^{-7} m^4$

BENDING STRESS

FOR M_{bx} & M_{by} POINT "A" LOCATION $x = r = \pm .02\ m$, $y = 0\ m$

$$\sigma_{AZ} = \frac{M_{bx} \cdot Y}{I_x} + \frac{M_{by} \cdot X}{I_y} = \frac{M_{bx} \cdot 0}{0} + \frac{-200 N{\cdot}m \cdot (.02m)}{1.257 \cdot 10^{-7} m^4} = -47.7\ MPa$$

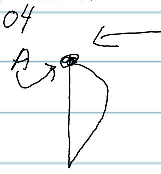
SHEAR STRESS $A = \pi r^2 = \pi(.02)^2 = 1.257 \cdot 10^{-3} m^2$, $A' = \frac{1}{2}A = 6.283 \cdot 10^{-4} m^2$

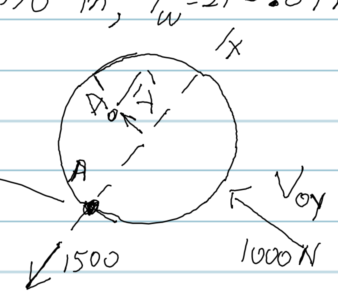
$\bar{y}' = \frac{4r}{3\pi} = 8.488 \cdot 10^{-3} m$, $Q = A' \cdot \bar{y}' = 5.333 \cdot 10^{-6} m^3$, $t_w = 2r = .04\ m$

FOR V_{oy}

$$\tau_{AYV} = \frac{V_{oy} \cdot Q}{I_x\, t_w} = \frac{-1000 \cdot 5.333 \cdot 10^{-6}}{1.257 \cdot 10^{-7} \cdot .04} = -1.061\ MPa$$

FOR V_{ox} $\tau_{AXV} = 0$





TORSION STRESS

$$\tau_{AYT} = \frac{T_z \cdot r}{J} = \frac{-600 N{\cdot}m \cdot (.02m)}{2.513 \cdot 10^{-7} m^4} = -47.7\ MPa$$

$$\Sigma \tau_{Ay} = \tau_{AYT} + \tau_{AYV} = -47.7\ MPa + (-1.06\ MPa) = -48.8\ MPa$$

END