

2020-5-7

CAE and Stress Analysis

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Question 1

a) The bursting in the cylinder will take place if the force due to the internal pressure acting vertically upwards and downwards becomes more than the resisting force due to hoop stress (σ_H) developed in the cylinder

total diametrical bursting force = $P \cdot \text{Project area of the curved surface}$
 $= P \cdot d \cdot L$

resisting force due to hoop stress = $2 \cdot \sigma_H \cdot t \cdot L$

then $P \cdot d \cdot L = 2 \cdot \sigma_H \cdot t \cdot L$

therefore $\sigma_H = \frac{Pd}{2t}$

b) Similarly,

total longitudinal bursting force (on the ends of cylinder) = $P \cdot \frac{\pi}{4} \cdot d^2$

Area of cross-section where longitudinal stress is developed = $\pi \cdot d \cdot t$

resisting force due to longitudinal stress = $\sigma_L \cdot \pi \cdot d \cdot t$

then $P \cdot \frac{\pi}{4} \cdot d^2 = \sigma_L \cdot \pi \cdot d \cdot t$

$\sigma_L = \frac{Pd}{4t} = \frac{1}{2} \sigma_H$

as hoop stress is twice the longitudinal stress, hoop stress is the limiting factor when choosing materials and designing geometric shape of thin cylinder.

c) the density should be 1.0275 g/cm^3

~~$\sigma_H = \frac{Pd}{2t}$~~
 ~~$d = 2.3 \text{ m}$~~
 ~~$t = 2.3 \times 10^{-3} \text{ m}$~~
 ~~$P = \rho g h$~~ (neglect the atmospheric pressure above sea)
 ~~$\frac{\rho g h d}{2t}$~~
 ~~$\rho \leq \frac{2t}{g h d}$~~
 ~~$\rho \leq \frac{2 \times 2.3 \times 10^{-3}}{9.81 \times 2.3}$~~
 ~~$\rho \leq 1.0275 \times 10^3 \text{ kg/m}^3$~~
 ~~$\rho \leq 1.0275 \text{ g/cm}^3$~~
 ~~$h \leq 72.63 \text{ m}$~~
~~maximum depth is 72.63 m~~

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CAE and Stress Analysis's

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Question 1

d) $\sigma_H = \frac{Pd}{2t}$ $P = \rho g h$ $d = 2.3m$ $t = 2.3 \times 10^{-3}m$

then

$$\frac{\rho g h d}{2t} \leq 1.9 \times 10^6 \times 10^6$$

$$h \leq \frac{(2 \times 2.3 \times 10^3) \times (1.9 \times 10^6 \times 10^6)}{1.0275 \times 10^3 \times 9.81 \times 2.3}$$

$$h \leq 72.63$$

maximum depth is 72.63m

e) similar to (d)

$$\frac{(\rho g h_1 - 0.1 \times 10^6) \cdot d}{2t} \leq 1.9 \times 10^6 \times 10^6$$

$$\rho g h_1 \leq \frac{(2 \times 2.3 \times 10^3) \times (1.9 \times 10^6 \times 10^6)}{2.3} + 0.1 \times 10^6$$

$$h_1 \leq 81.5m$$

$$\text{increased depth} = 81.5 - 72.63 = 8.87m$$

f) similar to e)

$$h_2 = h_1 + 8.87 = 90.37m$$

g) the maximum depth which the submarine can reach can be magnified by increasing the pressure inside the submarine.

h) the pressure of the air above sea is not calculated.

i) The temperature at different depth is different resulting in different density

j) the submarine is not an ideal cylinder.

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CAE and Stress Analysis (M5X02064)

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Question 3:

a)

$$M = \frac{W}{2} \cdot \left(\frac{L}{2} - x \right)$$

then $M = EI \frac{d^2 y}{dx^2}$

$$\frac{W}{4} L - \frac{W}{2} x = EI \frac{d^2 y}{dx^2}$$

$$\frac{W}{4} L x - \frac{W}{4} x^2 + A = EI \frac{dy}{dx}$$

$$\frac{W}{8} L x^2 - \frac{W}{12} x^3 + Ax + B = EI y$$

when $x = \frac{L}{2}$ $y = 0 \Rightarrow \frac{WL^3}{32} - \frac{WL^3}{96} + \frac{L}{2} \cdot A + B = 0$

when $x = 0$ $\frac{dy}{dx} = 0 \Rightarrow A = 0$

Therefore: $y = \frac{1}{EI} \left(\frac{WLx^2}{8} - \frac{Wx^3}{12} - \frac{WL^3}{48} \right)$

$$\Rightarrow \begin{cases} A = 0 \\ B = -\frac{WL^3}{48} \end{cases}$$

b) the maximum deflection occurs where $x = 0$, i.e. the midpoint of the beam

when $x = 0$ $y = \frac{-WL^3}{48EI}$

c) according to the conclusion of (b)

$$|y_{\max}| = \frac{WL^3}{48EI} \leq 9.5 \times 10^{-3}$$

$$L^3 \leq \frac{48 \times 203 \times 10^9 \times 48 \times 10^{-6} \times 9.5 \times 10^{-3}}{47 \times 10^3}$$

$$L \leq 4.555 \text{ m}$$

the maximum safe span for the unsupported section of track is 4.555 m.

d) the wheels have width ^{and deformation}, which means there is a contact patch. Therefore, the load should be a distributed load instead of concentrated load.

② the load on each wheel may vary as the train runs.

③ the supported force at each end is also distributed instead of concentrated.

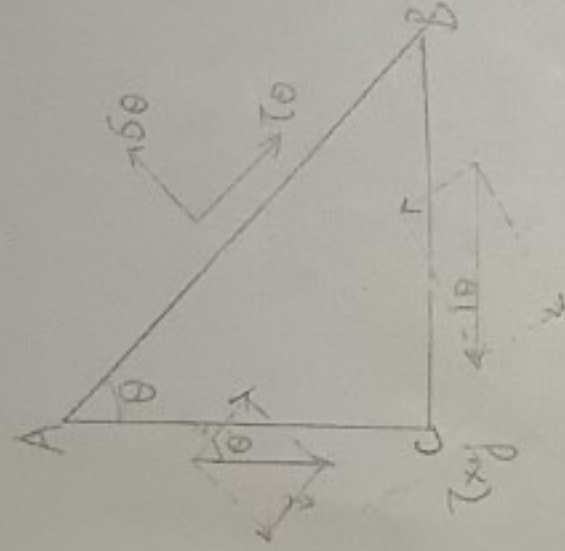
e) the stress on the supports and ground to keep safe

2020.5.7 CAE and Stress Analysis (MSX02064)

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Question 4:



According to the left diagram, equilibrium is maintained by σ_θ and two normal components of τ_{xy} along the direction of σ_θ

Force due to the τ_{xy} :

$$F_1 = \tau_{xy} \sin \theta \cdot AC + \tau_{xy} \cos \theta \cdot BC$$

$$\text{Force due to } \sigma_\theta : F_2 = \sigma_\theta AB$$

also we have:

$$AC = AB \cos \theta \quad BC = AB \sin \theta$$

$$\text{Hence: } F_1 = F_2$$

$$\tau_{xy} \sin \theta \cdot AB \cos \theta + \tau_{xy} \cos \theta \cdot AB \sin \theta = \sigma_\theta AB$$

$$2\tau_{xy} \cos \theta \sin \theta = \sigma_\theta$$

From the given relationship: $\cos \theta \sin \theta = \frac{1}{2} \sin \theta$
we can get: $\sigma_\theta = \tau_{xy} \sin \theta$

b) according to the conclusion of (a)

$$\text{direct stress } \sigma_\theta = \tau_{xy} \sin \theta = 58 \times \sin 66 = 52.99 \text{ MPa}$$

$$\text{c) } \tau_\theta = -\tau_{xy} \cos 2\theta = -58 \times \cos 66 = -23.59 \text{ MPa}$$

d) the cross-section of a ~~bar~~ spar when it is twisted and deforms little.

e) considering the above ~~scenario~~ scenario, the spar can not be connected if there is no normal stress between ~~sections~~ cross-sections.