

Date 07/05/2020

Time: 1.00pm

Module CAE and stress analysis, M5202064

Name Seffrey Ellis

Student Number: 1802644

Questions 1

a)

$$\sigma_H = \frac{pd}{2t}$$

$$\text{Stress} = \frac{F}{A}$$

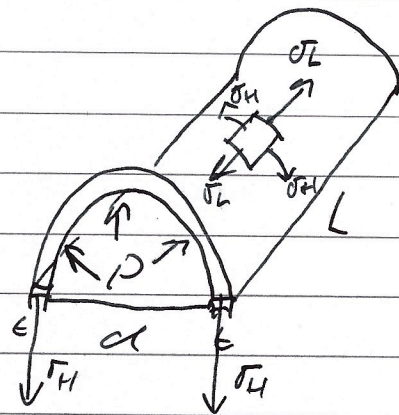
$$P \times A = F$$

$$F = PdL$$

$$\text{Downwards force} = 2\sigma_H \times t$$

$$2\sigma_H \times t = Pd$$

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



b) Longitudinal stress = $\frac{pd}{4t}$, half the hoop stress value. This comes from the area acted $4t$ or defined by $\frac{\pi d^2}{4}$ to find the force it is $\frac{P\pi d^2}{4}$.

c) 1.0280 g/cm³

1028 kg/m³

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d) $P = \sigma_y h$

$d = 2.3 \text{ m}$

Safety factor = 1.9

$t = 2.3 \text{ mm} = 0.00023 \text{ m}$

$H_{max} = 3$

Yield stress = 190 MPa

$1.9 P_{max} = \frac{2 \sigma_y t}{d}$

$1.9 P_{max} = \frac{2 \times 190 \times 10^6 \times 0.00023}{2.3} = 38000 \text{ Pa}$

$P_{max} = \frac{38000}{1.9} = 20,000 \text{ Pa}$

$20,000 = 1028 \times 9.81 \times h$

$h = \frac{20,000}{1028 \times 9.81} = 1.98 \text{ m}$

e) $P_{inside} = 0.1 \text{ MPa}$
 $= 100,000 \text{ Pa}$

$1.9 P_{max} = 100,000 + \frac{2 \times 190 \times 10^6 \times 0.00023}{2.3}$

$1.9 P_{max} = 120,000 \text{ Pa}$

$P_{max} = 63157.89 \text{ Pa}$

$h = \frac{63157.89}{1028 \times 9.81} = 6.263 \text{ m}$

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F) $P_i = 0.1 \text{ MPa} \times 2 = 0.2 \text{ MPa}$

$$1.9 P_{\text{max}} = 200000 + 201000 \\ = 220,000 \text{ Pa}$$

$$P_{\text{max}} = 115789.474 \text{ Pa}$$

$$h = \frac{115789.474}{1028 \times 9.81} = 11.482 \text{ m}$$

g) The depth a sub can dive to is controlled by the difference in pressure between the interior and the exterior. Higher internal pressure as in e and f will increase the max dive depth.

h) Results may differ from a real sub as there are no joints considered, a real sub may be made of multiple sheets riveted together. The material properties of a submarine skin may also differ. As well as this some subs are not uniform cylinders having those towers on the top of them and rounded ends.

As well as this a submarine cope with under water currents which could apply normal stress adding to the pressures.

Furthermore submarines have reinforcing structures inside and larger subs will have crew compartments and complex internal structures.

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Question 2a

- a) A) Define the problem, list of customer requirements regarding necessary function and features. Also understand if it is a design or analysis problem.
- B) Gather Information, research other solutions for reference, identify pertinent information needed to design the product. e.g. This could go for a scanning rivet products.
- C) Generate multiple solutions, using inputs from tests, manufacturing necessities, and marketing team to come up with multiple solutions and concept designs
- D) Analyse and select final design, Using Criteria such as cost, safety and efficiency select the best of the concept designs to begin testing. This will also involve creating a more detailed design to properly analyse
- E) Test and implement, create a prototype and test it to confirm it meets all the requirements and identify possible refinements.

These steps may not be purely sequential and can be used

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to iteratively come to a best solution

- b) FEA can be applied in the analysis step, this would help to reduce risk by confirming if a part meets structural requirements. Integrating FEA may reduce the need for expensive prototyping of multiple designs by eliminating flawed concepts with computer analysis. Depending on the design model tools such as FEA could be applied earlier to evaluate the viability of a project. This can also reduce the time and cost as less CAD iterations can be used having started with a better understanding of the load scenarios.

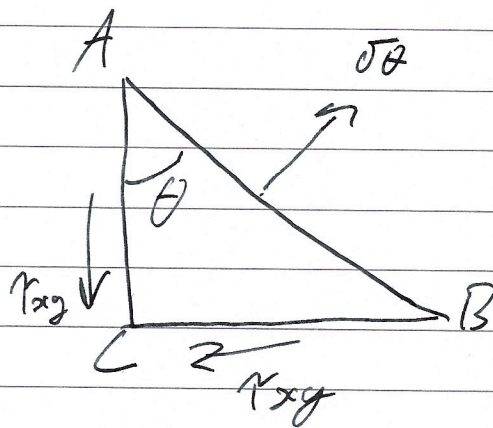
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Question 4

d) Prove that $\sigma_\theta = \tau_{xy} \sin 2\theta$



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

$$\frac{AC}{AB} = \cos \theta \quad \sigma_\theta = \frac{AC}{AB} \tau_{xy} \sin \theta + \frac{BC}{AB} \tau_{xy} \cos \theta$$

$$\frac{BC}{AB} = \sin \theta \quad \sigma_\theta = \tau_{xy} \sin \theta \cos \theta + \tau_{xy} \cos \theta \sin \theta$$

$$\cos \theta \sin \theta = \frac{1}{2} \sin 2\theta$$

$$\sigma_\theta = \tau_{xy} \frac{1}{2} \sin 2\theta + \tau_{xy} \frac{1}{2} \sin 2\theta$$

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

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b) $\theta = 33^\circ$

$\tau_{xy} = 58 \text{ MPa}$

$$\begin{aligned}\sigma_\theta &= 58 \times 10^6 \sin(2 \times 33) \\ &= 52985636.54 \text{ Pa} \\ &= 52.99 \text{ MPa}\end{aligned}$$

X

c) $\tau_\theta = -\tau_{xy} \cos 2\theta$ plane AB

$$\begin{aligned}\tau_\theta &= -58 \times \cos(2 \times 33) \\ &= -23.59 \text{ MPa}\end{aligned}$$

X

d) A drive shaft may be ~~subject~~ to only shear stress as only a torque force is applied and a resistance at the other end.

e) This is unlikely as if the suspension moves the shaft may be subject to other forces. As well as this if the torque is not applied through the exact centre of the shaft, but is misaligned due to ~~tolerances~~ or a fault a bending moment may be applied.