Name...Student I.D.........................

Department of Mining and Materials Engineering

Faculty of Engineering

Prince of Songkla University

Mid-term Examination for Semester: 1   Academic Year: 2009

Date: July 29, 2009   Time: 09.00-12.00

Subject: 237-407 Failure Mechanics and Analysis   Room: R300

Instructions

    1. There are 3 problem sets. Please do all of them. Write your answers in the space provided after each problem sets.

    2. Dictionary and calculator are allowed.

    3. Text books and course notes are not allowed.

    4. This mid-term exam is accounted for 25 % of total grade.

Asst. Prof. Dr. Thawatchai Plookphol

Problem no.	Full score	Student's score
1	10	
2	20	
3	20	
Total	50	

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Problem 1 Explain the following terms: (please give an example or draw a related diagram to support your answer)

1.1 Mode I loading (2 points)

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1.2 Mode II loading (2 points)

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1.3 Mode III loading (2 points)

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1.4 Plastic zone (2 points)

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1.5 The size and shape of plastic zone is influenced by what factors? (2 points)

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Problem 2 A spherical LPG storage tank with radius of 5 m at Singhanakhon, Songkhla was made of steel plate with thickness of 15 mm. The tank was designed to handle maximum pressure of 5 MPa.

      2.1 What is the yield strength of steel that would be suitable for making the tank according to Tresca's yield theory?   (10 points)

      2.2 If the weldment of the tank shell contains a small internal penny crack of size, $a = 2$ mm, would this crack possibly cause failure by sudden explosion? Please show calculation to support your answer. Assume that $K_{Ic} = 30$ MPa·$\sqrt{m}$, $\sigma_{ys} = 1,700$ MPa.

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Problem 3   A steel plate is 400 mm wide and 5 mm thick. There is a 25 mm crack along each edge.

(a) Calculate the stress required to propagate the crack the remaining 350 mm across the width of the plate. (10 points)

(b) Calculate the force required to break the plate in tension if there were no crack. Assume that the fracture strength is 700 MPa. (10 points)

σ

W

a   a

σ

For steel plate:

$W = 400$ mm

$t = 5$ mm

$a = 25$ mm

$K_{IC} = 85$ MPa·$\sqrt{m}$

$\sigma_f = 700$ MPa

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<u>Given Formula</u>

Tresca yield criterion:

$$\tau_{max} = \frac{\sigma_{max} - \sigma_{min}}{2} \geq \frac{\sigma_{ys}}{2}$$

Strain energy release rate at failure:

$$G_C = \frac{\sigma_f^2 \pi a}{E} \qquad \text{(Plane stress)}$$

For internal penny crack:

$$K_I = \frac{2}{\pi} \cdot \sigma \cdot \sqrt{\pi \cdot a}$$

For edge crack:

$$K_I = 1.12 \sigma \sqrt{\pi a}$$

For thin-walled pressure vessel:

Spherical tank:

$$\sigma_1 = \sigma_2 = \frac{pR}{2t}$$

$$\sigma_3 = 0$$

Cylindrical tank:

$$\sigma_1 = \frac{pR}{t}$$

$$\sigma_2 = \frac{pR}{2t}$$

$$\sigma_3 = 0$$

where p = Internal pressure

R = Radius

t = Thickness