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Examination Answer Books

Candidate's Exam Number: _____

Book No.

Total Books
Handed In:

Complete, fold and seal
(see note 1 below)

SURNAME:

Atkins

FORENAME(S):

George

Programme Title:

Test Range Engineering

Year/Level/Stage:

6

Examination Paper Title:

Structural Mechanics

Examination Paper Ref No.:

M3X0066

Desk Letter/Number:

Date: 20/05/2017

Time: 09:00 am/pm

Room Name or No.:

MT 202

Instructions to Candidates:

- Please give the information requested above and enter your name in the space provided at the top right of this page. If your answers are to be marked under a scheme whereby the examiners will not know your identity, fold over and seal down the top right-hand corner of the page (using the gummed label provided) in order to conceal your name.
- Commence each answer on a fresh page.
- Do all rough work in the answer book and cross through it.
- No part of this booklet is to be torn out.
- Supplementary answer books if used must:-
 - bear the candidate's name (concealed, where appropriate), reference number and paper title;
 - be numbered consecutively;
 - be fastened together by the tags available from the invigilator.
- Every book must be handed in. In no circumstances may answer books, used or unused, be taken out of the exam room.
- Your answers must be legibly written **IN INK**. The Examiners can either ignore illegible script or have it typed and the expense of typing charged to the candidate.

Summary of Marks

Question Numbers Answered	1st Examiner	2nd Examiner (optional)	3rd Examiner (optional)
1a	10/12		
1b	4/8		
2a	6/12		
2b	6/8		
TOTAL	26/40		
RESULT	65%		

1a) $K_{Ic} = \sigma Y \sqrt{\pi a}$

$Y = 3$

$\sigma = 150 \text{ MNm}^{-2}$

$a = ?$

$W = 25 \text{ mm}$

$\alpha = a/W$

$Y = \frac{[1.12 + \alpha(2.91\alpha - 0.64)]}{(1 - 0.93\alpha)}$

$3 = \frac{[1.12 + 2.91\alpha^2 - 0.64\alpha]}{(1 - 0.93\alpha)}$

$3(1 - 0.93\alpha) = 2.91\alpha^2 - 0.64\alpha + 1.12$

$3 - 2.79\alpha = 2.91\alpha^2 - 0.64\alpha + 1.12$

$3 = 2.91\alpha^2 + 2.15\alpha + 1.12$

$0 = 2.91\alpha^2 + 2.15\alpha - 1.88$

using $\alpha = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$a = 2.91$

$b = 2.15$

$c = -1.88$

$\alpha = \frac{-2.91 \pm \sqrt{8.47 - (4 \times 2.91 \times -1.88)}}{5.82}$

$\alpha = \frac{-2.91 \pm \sqrt{8.47 + 21.89}}{5.82}$

$\alpha = \frac{-2.91 \pm \sqrt{30.36}}{5.82}$

$\alpha = \frac{-2.91 + \sqrt{30.36}}{5.82}$

$\alpha = \frac{-2.91 - \sqrt{30.36}}{5.82}$

$\alpha = 0.447$

$\alpha = -1.44$

↑ This value is impossible

using $\alpha = a/W$

$\alpha W = a$

$0.447 \times 20 = 8.94$

$\therefore a = 8.94 \text{ mm}$

error
continued

$$K_{Ic} = \sigma \sqrt{Y\pi a}$$

$$\sigma = 150 \text{ MNm}^{-2}$$

$$Y = 3$$

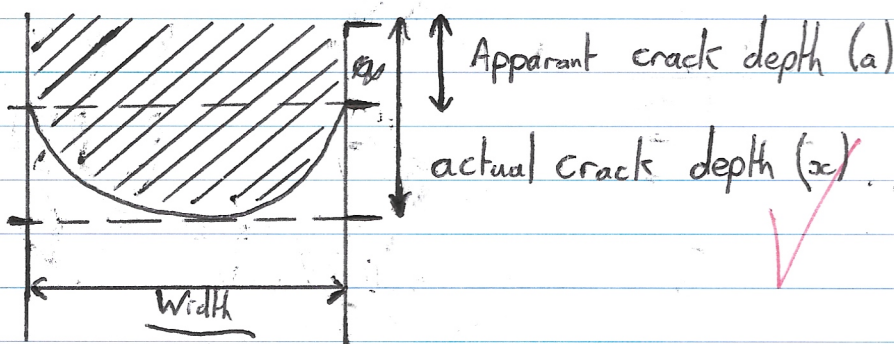
$$a = 8.94 \text{ mm}$$

$$K_{Ic} = 150 \times 3 \times \sqrt{8.94 \times 10^{-3} \pi}$$

$$K_{Ic} = 75.41 \text{ MNm}^{-3/2} \quad 70.5$$

1b)

Method	Advantages	Disadvantages
Visual inspection	- Quick - Simplistic	- Not so accurate - Can't see within the material.
Magnetic particle inspection (MPI)	- Relatively quick - detects even smallest of cracks	- Can't see if the crack goes below the surface.
X-Rays	- Detects small cracks - Can see if the crack is bowed within the material	- Expensive - Time consuming
Acoustics	- Accurate crack detection	- Expensive.



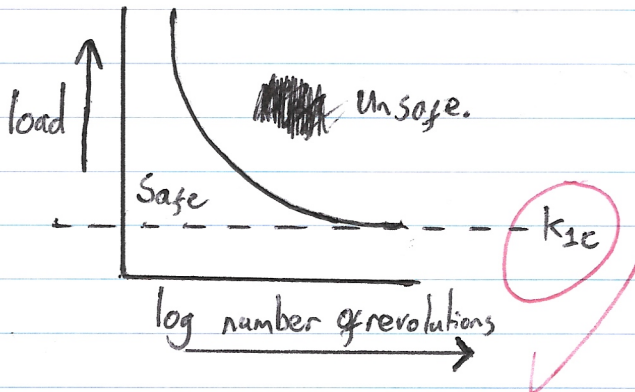
To get an average crack depth. add $\frac{2}{3}x$ to 'a':

$$w \left(\frac{2x}{3} + a \right) = \text{average crack length.}$$

bawny?

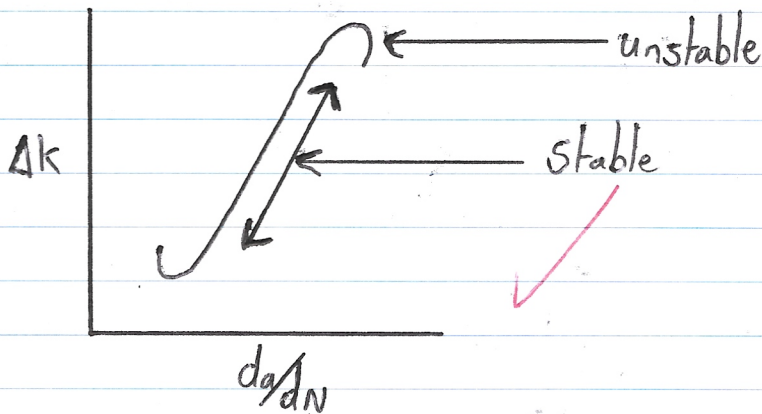
4/8

2ai)



2

2aii)



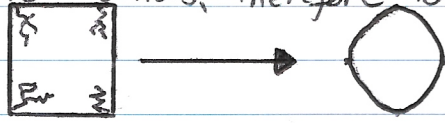
2

The S-N fatigue curve shows that if the load is small enough then the material shall be able to turn forever. This is not accurate because the material used in the test is highly machined and polished, which is not how materials in the real world are. However, this test is useful for comparing different metals.

2

6/12

- 2b) Rounding off all of the corners of a specimen, giving less places for a crack to start. Because a crack's likely to start in a corner. No corners, therefore no cracks.



1 1/2

Highly polishing the specimen, to ensure that there are no surface defects, scratches, pitting, etc. that may weaken the material and cause an early onset of fatigue.

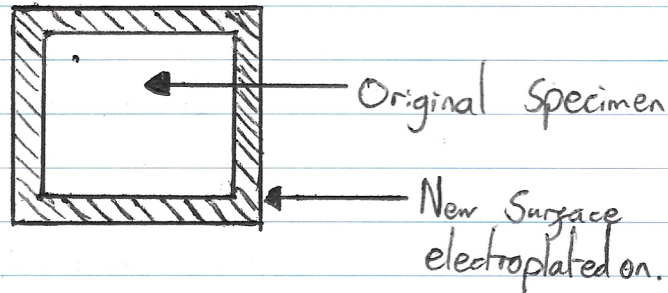
1 1/2

Placing the surface part of the specimen under compression can prevent fatigue. This is done by a process known as shot peening or blasting. Where lots of little balls are fired at the surface to hammer it into a state of compression.

1 1/2

Another method of changing the surface part of the specimen is to coat the specimen with a metal less susceptible to fatigue. This is done by electroplating.

1 1/2



6/8