

Candidate's Exam Number:

**Total Books
Handed In:**

Programme Title: BEng Test Range ENGINEERING

Year/Level/Stage: _____

Examination Paper Title: STRUCTURAL MECHANICS

Examination Paper Ref No.: 113X0066 Desk Letter/Number: _____

Desk Letter/Number:

Date: 20/05/2017 Time: 0900 am/pm Room Name or No.: MT 202.

Time: 0900 am/pm

Room Name or No.: M-1 202.

Summary of Marks

1. 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.
2. Commence each answer on a fresh page.
3. Do all rough work in the answer book and cross through it.
4. No part of this booklet is to be torn out.
5. Supplementary answer books if used must:-
 - (a) bear the candidate's name (concealed, where appropriate), reference number and paper title;
 - (b) be numbered consecutively;
 - (c) be fastened together by the tags available from the invigilator.
6. Every book must be handed in. In no circumstances may answer books, used or unused, be taken out of the exam room.
7. 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.

Question Numbers Answered	1st Examiner	2nd Examiner (optional)	3rd Examiner (optional)
1a	11/12		
1b	6/8		
2a	9/12		
2b	6/8		
TOTAL	32/40		
RESULT	80%		

1a)

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

$$Y = 3 = (1.12 + d(2.91d - 0.64) / (1 - 0.93d))$$

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

$$w = 20 \text{ mm}$$

$$d = a/w$$

$$a = \text{crack length}$$

$$(1 - 0.93d) 3 = 1.12 + d(2.91d - 0.64)$$

$$3 - 2.79d = 2.91d^2 - 0.64d + 1.12$$

$$0 = 2.91d^2 + 2.15d - 1.88$$

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

$$a = 2.91$$

$$b = 2.15$$

$$c = -1.88$$

$$d = 0.515$$

$$K_{Ic} = 150 \times 3 \times \sqrt{\pi a}$$

$$K_{Ic} = 450 \sqrt{32.36 \times 10^{-3}}$$

$$K_{Ic} = 80.948 \text{ MNm}^{-3/2}$$

90.5

$$0.515 = a/w$$

$$0.515 \times 20 \times 10^{-3} = a$$

$$10.3 \times 10^{-3} = a$$

1b)

four methods of practically measuring cracks:

- * Acoustic (ultrasound) imaging
- * Radiography
- * Surface measurement
- * Electronic impedance

(PTO)

1) Acoustic imaging (ultrasound)

- Non destructive
- inexpensive (Relatively)
- Reasonable accuracy
- slow process

2) Radiographic imaging

- Non Destructive
- Reasonable Accuracy with low density materials
- slow process
- Expensive
- High Density materials reduce resolution
- open to interpretation

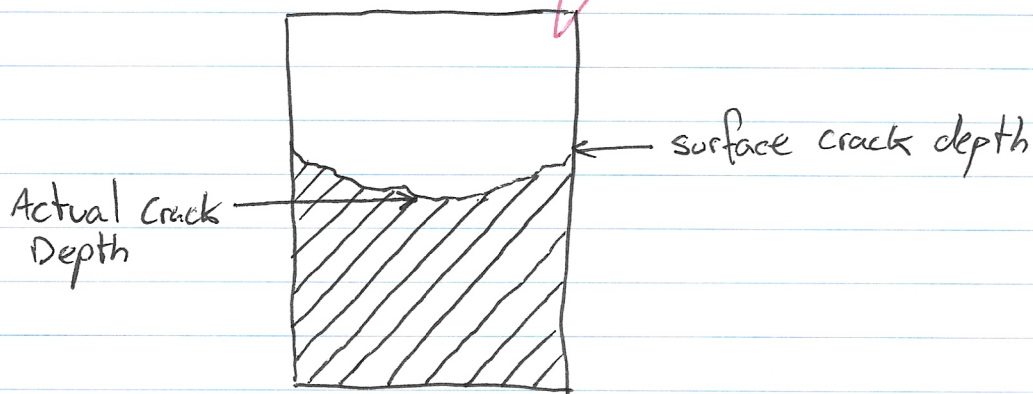
3) Surface measurement

- Non Destructive
- Reasonable accuracy in thin samples
- Fast results
- Inexpensive
- thick samples will always be under measured as the crack propagation is parabolic.

4) Electrical Impedance

- Non Destructive

- * ~~the~~ fatigue cracks bow during propagation as a result of stresses and strains in the material.
- * plane strain occurs in the "bulk" of material where the plastic zone does not reach the material surface.
- * plane stress occurs at the edges of the material where the plastic zone causes physical deformation of the material surface.
- * this surface deformation allows plane stress to better resist crack propagation



the average crack depth can be calculated using

$$\frac{2}{3}x + \text{Surface Crack depth} = \text{Average Crack depth}$$

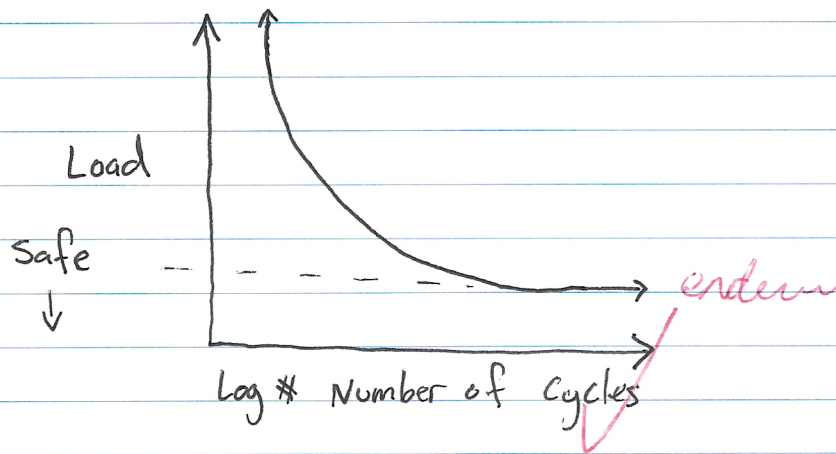
where:

$$\text{Actual Crack Depth} - \text{Surface crack depth} = x$$

~~this is~~

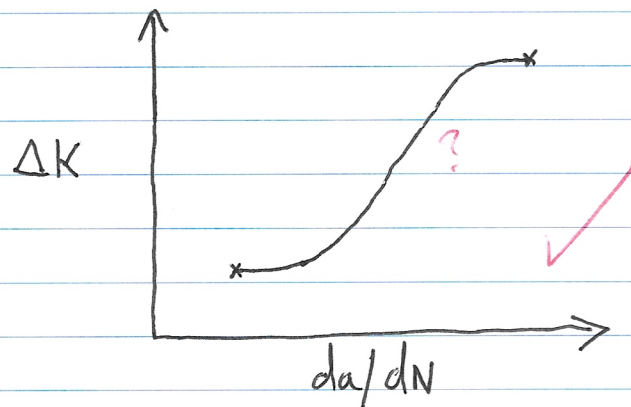
2a)

i)



2 1/2

ii)



2 1/2

S-N

- * An S-N curve is a simplistic method of analysing data.
- * it suggests a "safe load" below which the material will never suffer fatigue failure. This is unrealistic with modern thinking.
- * it considers applied load to be static where fatigue is cyclic and sinusoidal.
- * Test samples for the cantilever test are produced with a very high quality finish to reduce stress concentrations
- * This is not representative of real life applications

2

 $\Delta K da/dN$

- * A $\Delta K da/dN$ curve is a far improved system for data analysis
- * it suggest that, through the proportional range, crack propagation is consistent, this is untrue.
- * Cracks propagation gradually accelerates over time.

- * Data Capture is difficult and expensive due to a high amount of scatter in the results.
- * the graph is produced from a line of best fit.
- * Samples are prepared to a high quality finish and may be work hardened to achieve the correct dimensions, this is still not representative of real-world application

2

9/13

b)

1) Grain Size

- * with the exception of single crystal structures, reducing the grain size to the ~~minimum~~ practicable minimum will increase the fatigue toughness and strength of a material
- * Single crystal structures are the best available materials to prevent fatigue as they have no grain boundaries.

1 1/2

2) Reduction of defects

- * Defects, introduced in the material composition, ~~are~~ locate within the grain boundaries of a material.
- * A reduction of the impurities in a material will allow for greater fatigue toughness.
- * these defects reduce the strength of the bond in the ~~metal~~ crystal lattice, allowing a ~~reduced~~ load to propagate a crack more easily.

1 1/2

3) Stress Concentrations

- * Sharp edges or material working (such as welding) can create stress concentrations that increase the likelihood of fatigue failure
- * polished, well manufactured and worked metals will have a significant reduction in stress concentrations, and a greater resistance to fatigue.

1 1/2

4) Material form

- * thick homogenous materials are subject to plane strain, ~~causing a reduction in~~
- * plane stress is far more effective at resisting the effects of fatigue.
- * Fibrous Materials, ~~are~~ woven around each other for structure, are far less susceptible to fatigue, and sport greater tensile strength.

1 1/2

6/8