

Candidate's Exam Number:

**Total Books
Handed In:**



1

Programme Title: STR TEST LANGU ENGINEERING

Year/Level/Stage: 6

Examination Paper Title: STRUCTURAL MECHANICS

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

Date: 20/5/2017 Time: _____ am/pm Room Name or No.: _____

Complete, fold and seal
(see note 1 below)

SURNAME: PHILLIPS

FORENAME(S): PETER ELIOT

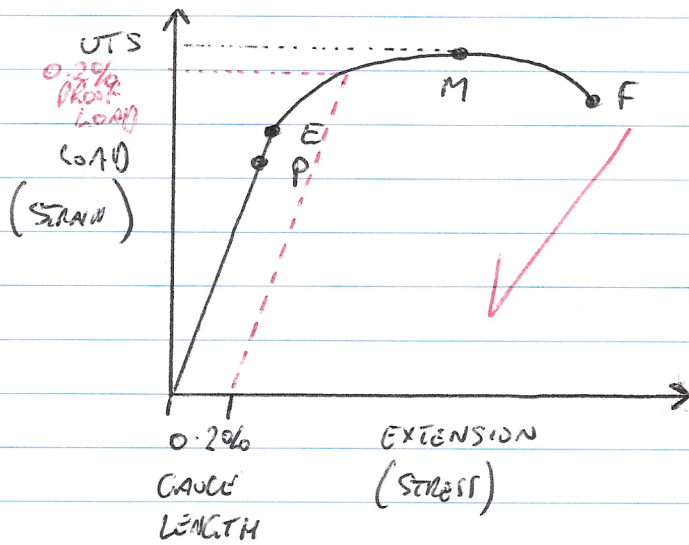
Instructions to Candidates:

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)
3a	12/12.		
16	6/8.		
3a	8/10		
3b	6/10		
TOTAL	32/40		
RESULT	80%		

3/a) A Typical stress strain curve.

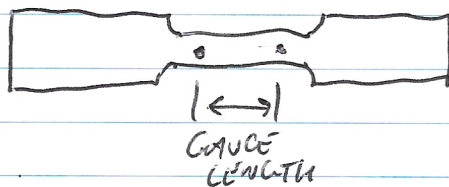


$$\text{GAUGE LENGTH} = 5.65 \times \sqrt{\frac{\text{CROSS SECTIONAL AREA}}{\text{AREA}}}$$

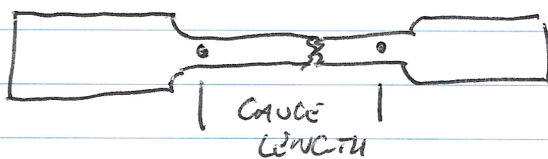
Point P is the limit of proportionality and is a point on the straight line from which Young's Modulus can be calculated.

$$\text{Young's Modulus} = \frac{\text{Stress}}{\text{Strain}}$$

% Elongation is calculated after the sample has finally fractured. The two pieces are rejoined and the extension between the gauge length measured.



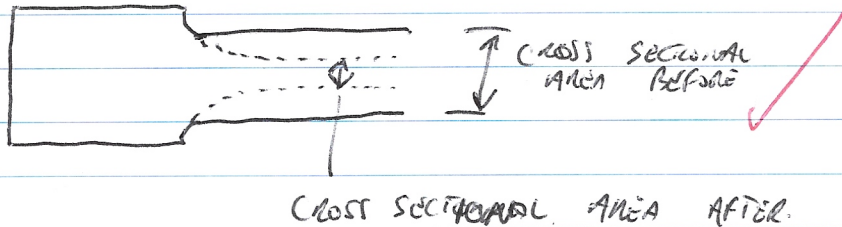
ORIGINAL SAMPLE



POST TEST

$$\% \text{ ELONGATION} = \frac{\text{NEW LENGTH} - \text{ORIGINAL LENGTH}}{\text{ORIGINAL LENGTH}} \times 100$$

% Reduction in area is calculated by measuring the cross sectional area before and after the test. The amount of necking is a measure of the ductility of the specimen.



$$\% \text{ REDUCTION IN AREA} = \frac{\text{ORIGINAL C.S.A} - \text{NEW C.S.A}}{\text{ORIGINAL C.S.A}} \times 100$$

The ULTIMATE TENSILE STRENGTH (M at the graph) is the point at which the specimen fails at the maximum load, and is calculated by

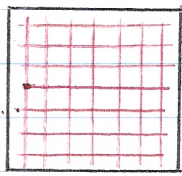
$$\text{UTS} = \frac{M}{\text{ORIGINAL C.S.A}}$$

The Yield Strength (E) which is the ELASTIC LIMIT is the point on the line where the specimen will no longer return to its original shape, and will be ~~elast~~ plastically deformed, although a small return will occur.

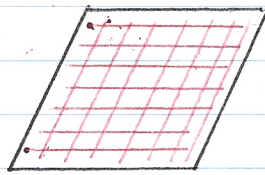
0.2% Proof Load is calculated by drawing a parallel line to the graph at a distance equal to 0.2% of the gauge length. Where this intersects the graph the 0.2% proof load is read off.

3) b) During Tensile testing both Elastic and Plastic deformation can occur.

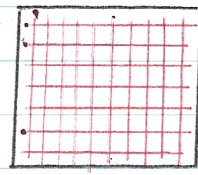
ELASTIC DEFORMATION



NO LOAD

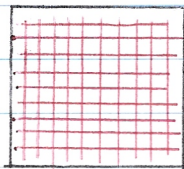


LOAD APPLIED

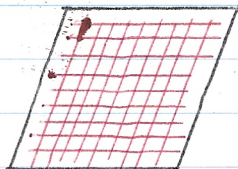


LOAD REMOVED

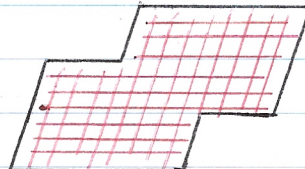
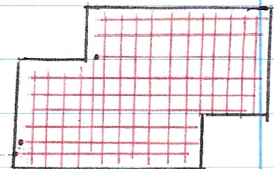
PLASTIC DEFORMATION



NO LOAD



LOAD APPLIED

LOAD APPLIED
PAST LIMIT

LOAD REMOVED

ELASTIC Deformation occurs when the load applied is less than the Yield Strength of the material. The atomic structure of the sample remains unchanged and will recover its original shape when the load is removed.

PLASTIC Deformation occurs when the load applied exceeds the Yield Strength of the material. In this case the atoms are forced past each other and they are unable to return. Bond Atomic bonds are broken and remade in the new shape. When the load is removed there is a small return towards the original shape, but the sample remains deformed.

The Tensile test is limited in a number of ways.

The samples have to be accurately prepared and machined so to be ~~flaw~~ free. This is expensive and time consuming.

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1. a) First find α from :

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

2

and $Y = 3$, so

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

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

2

$$0 = 2.91\alpha^2 + 2.79\alpha - 0.64\alpha - 3 + 1.12$$

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

Therefore $\alpha = \frac{-2.15 \pm \sqrt{2.15^2 - 4 \times 2.91 \times -1.88}}{2 \times 2.91}$

2

$$\alpha = \frac{-2.15 \pm \sqrt{26.5057}}{5.82}$$

So ~~the~~ $\alpha = 0.515$ ~~or~~ α (to 3 dp)

2

Find a from $\alpha = \frac{a}{W}$ ~~so~~ $a = \alpha W$
 $= 0.515 \times 25$
 $= 12.875 \text{ mm}$

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

2

$$= 150 \times 3 \times \sqrt{\pi \times 0.012875}$$

$$= 450 \times 0.2011$$

$$= 90.50 \text{ MNm}^{-\frac{3}{2}} \quad (\text{to 2 dp})$$

2

1.) b) The table below shows the crack measurement techniques.

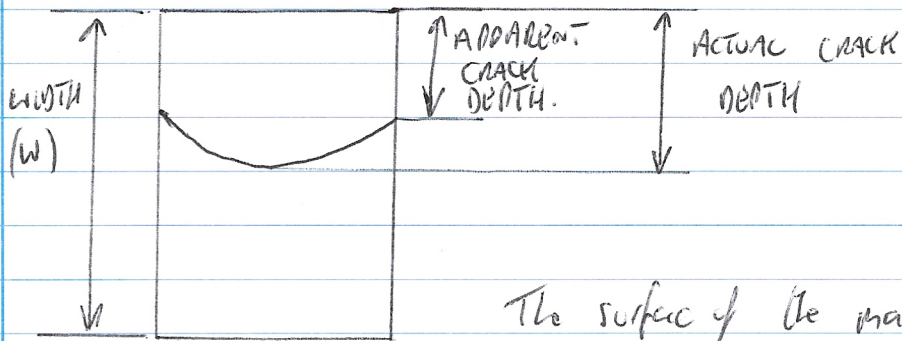
TEST	ADVANTAGE	LIMITATION
VISUAL	RELIABLE	CAN ONLY SEE CRACK ON EDGE OF SPECIMEN.
ULTRASONIC	RELIABLE - GOOD FOR FINDING POINT OF CRACK	CALIBRATION ISSUES
EDDY CURRENT	GOOD FOR FINDING CRACK	UNABLE TO ACCURATELY FIND CRACK TIP.
DSP TEST	REPEATABLE	POSSIBLE ARCING ACROSS THE CRACK SURFACES GIVING FALSE READINGS.

Visual Inspection can only define the crack on the surface of the sample.

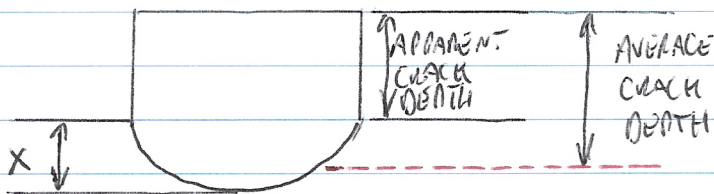
The ULTRASONIC Test method can accurately find the tip of the crack but calibration is an issue as no two samples will be the same.

The EDDY current method will reliably measure the crack but may not be so good at locating the crack tip.

The DSP Test requires the soldering of wires to the sample which essentially changes the sample before testing.



The surface of the material is in more stress and the centre is in plane strain. The crack propagates through the centre of the material as there is less resistance because of the smaller plastic zone within the body of the material. Towards the surface of the sample the plastic zone is much larger and offers greater resistance to crack propagation.



If it is assumed that the crack propagates as a parabola then the area of a parabola is

$$\frac{2}{3} \times \text{height} \times \text{width}.$$

So it can be seen in the sample above that the average crack depth will be.

$$\text{AVERAGE CRACK DEPTH} = \text{APPARENT CRACK DEPTH} + \frac{2}{3} X.$$

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