University of Technology
Building and Construction Engineering Department
Final exam 2013-2014

Subject: Material Technology
Division: All divisions
Examiner:-

Year:First
Time:3Hrs
Date:5 /6 /2014

Note: Answer only <u>four</u> questions

<u>Q1/A</u> Derive the generalized Hook's law equation for the body shown in Fig.1 (10%)

<u>Q1.B.</u> Differentiate between the following:

1. **Bonding of H_2O and bonding of NaCl**
2. **Elasticity and Plasticity**
3. **Hard steel and mild steel in uses (15%)**

<u>Q2/A</u> A steel shaft shown in Fig. 2 has diameter 6mm and length equal to 60mm subjected to axial tensile force 10kN and to increase in temperature (ΔT) 110°C. Determine the change in length and diameter due to combined effect of load and temperature. Solve assuming that the modulus of elasticity of steel is $150*10^3 N/mm^2$, Poisson ratio equal to 0.25, and $\alpha = 24*10^{-6}/ °C$. (15%)

<u>Q2/B</u> Write a brief about behavior of material during fracture under creep and fatigue; enhance your answer with drawings (10 %)

<u>Q3/A</u> For the bar shown in Fig. 3, determine the ratio between change in length L_0 to change in diameter D_0 due to a tensile force F, assuming that the modulus of elasticity is E , Poisson ratio is μ and $L_0 = 10\ D_0$ (16%)

<u>Q3/B</u> Show by sketch only:

a. **Steps of failure during tensile test for ductile material**
b. **Model of failure during torsion test**
c. **Stress – strain diagram for all types of steel during tensile test (9 %)**

<u>Q4/A</u> During a stress – strain test, the unit deformation at a stress 35 N/mm^2 was observed to be $167 * 10^{-6}$ and at a stress 140 N/mm^2 it was $667 * 10^{-6}$ mm/mm. If the proportional limit was 200 N/mm^2, what is the modulus of elasticity? What is the strain corresponding to a stress of 80 N/mm^2? Would these results be valid if the proportional limit were 150 N/mm^2 (10%)

<u>Q4/B</u> Compare between drying and burning stage during manufacture of clay brick. (15%)

Q5 **Fig.4 shows the stress – strain curve for copper in tension. If the original diameter of the bar is 22mm, the gauge length is 200 mm. Determine:**

1. **Load at Failure**
2. **Percentage of reduction in cross sectional area if the diameter of the specimen at failure was 9.5mm**
3. **Stress at yield point**
4. **Maximum load that the material can be carried without failure.**
5. **Modulus of toughness** **(25%)**

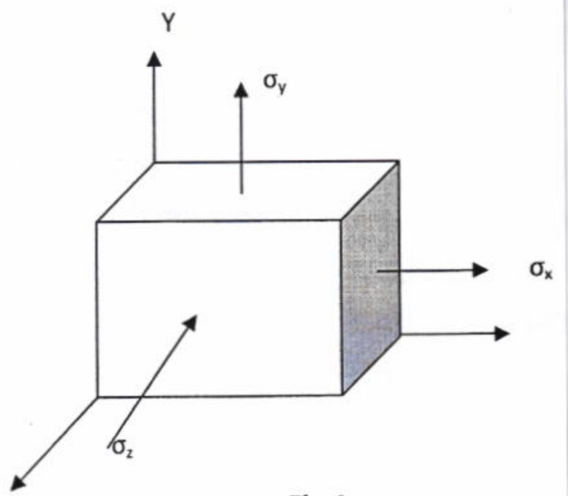


Fig.1

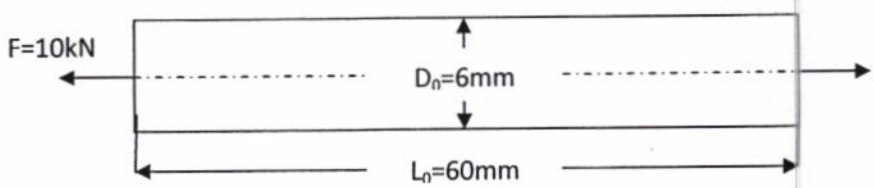


Fig. 2

(2-3)

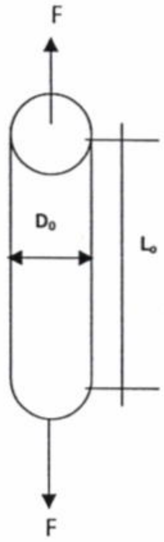

F
D₀
L₀
F

Fig. 3

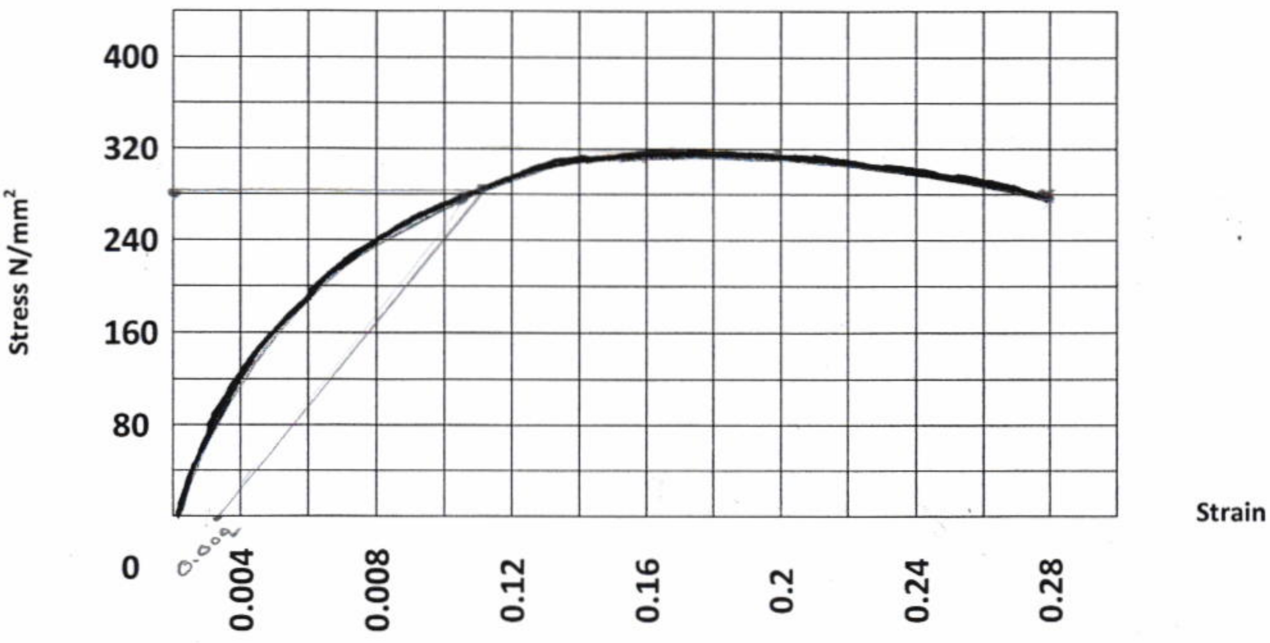

Stress N/mm²
400
320
240
160
80
0
0.002
0.004
0.008
0.12
0.16
0.2
0.24
0.28
Strain

Fig.4

(3-3)

Ans. of Q2/A

D_o=6 mm , L_o=60 mm , Load=10 kN , ΔT= +110 °C
$E = 150 * 10^3\ N/mm^2$, $\alpha = 24 * 10^{-6}$

Find the change in length and diameter?

Area (A) $= \pi . D^2/4 = \pi * 6^2/4 = 28.26\ mm^2$

Change in length ΔL

a. change in length due to force (ΔL_m)

$\Delta L_m = F.L_o/A.E = 10*10^3 * 60/28.26 * 150*10^3 = +0.141$ mm

b. change in length due to change in temp. ΔT (ΔL_{th})

$\Delta L_{th} = \alpha . \Delta T . L_o = 24*10^{-6} * 110 * 60 = +0.158$ mm

$\Delta L_{total} = \Delta L_m + \Delta L_{th}$

$\Delta L_{total} = +0.141 + 0.158 = 0.299$ mm

Change in diameter ΔD

a. change in diameter due to force (ΔD_m)

$\mu = \Delta D_m / D_o \,/\, \Delta L_m / L_o$

$\Delta D_m = -3.525 * 10^{-3}$ (Shorten)

b. change in diameter due to change in temp. ΔT (ΔD_{th})

$\Delta D_{th} = \alpha . \Delta T . D_o = 24*10^{-6} * 110 * 6 = +0.0158$ mm

$\Delta D_{total} = -3.525 * 10^{-3} + 0.0158 = 0.0125$ mm

The negative charged ion is now attracted to a positive ion, thus, forming the basic for ionic bonding.

2. **Elasticity and Plasticity**

Elasticity

Is the property by which a body, when deformed by the application of forces, recovering the original shape, when the force is removed.

Plasticity

Is the property by which a body, when deformed by the application of forces, remains in the deformed shape without recovering the original shape, when the force is removed.

3. **Hard steel and mild steel in uses**

The chief uses of hard steel are:

1. It is used for parts of structures and machinery where hard, tough, elastic, shock- proof and durable material is required.
2. It is used in pre stressed concrete.
3. It is used for making knifes, needles, bolts and surgical instruments.

The chief uses of mild steel are:

1. It is used for making rolled structural steel sections like girders, angle sections, channel and T- sections... etc.
2. It is extensively used for making bars and rods which are used as a reinforcing material in reinforced concrete.
3. It is used for making refrigerators and air conditioners.
4. It is used for making plain and corrugated sheets.
5. Structural mild steel is most commonly used for general construction purposes of buildings, bridges, towers and industrial buildings.
6. It also used for making tubes.

Answers

Q1/A:

Case 1 : When the tensile stress effect in X- direction only :

A – Direct strain € x = + б x/ E

B – Induced strain due to X- stress:

1. Induced strain in X – direction due to X- stress = 0
2. Induced strain in Y – direction due to X- stress (€ y = - µ € x = - µ (б x/ E)
3. Induced strain in Z – direction due to X- stress (€ z = - µ € x = - µ (б x/ E)

Case 2 : When the tensile stress effect in Y- direction only :

A – Direct strain € y = + б y/ E

B – Induced strain due to Y- stress:

1. Induced strain in X – direction due to Y- stress (€ x = - µ € y = - µ (б y/ E)
2. Induced strain in Y – direction due to Y- stress = 0
3. Induced strain in Z – direction due to Y- stress (€ z = - µ € y = - µ (б y/ E)

Case 3 : When the compressive stress effect in Z- direction only :

A – Direct strain € z = - б z/ E

B – Induced strain due to Y- stress:

1. Induced strain in X – direction due to Z- stress (€ x = + µ € z = + µ (б z/ E)
2. Induced strain in Y – direction due to Z- stress (€ y = + µ € z = + µ (б z/ E)
3. Induced strain in Z – direction due to Z- stress = 0

Therefore, generalized Hook's law equations are:

€ x = + (б x/ E) - µ (б y/ E) + µ (б z/ E

€ y = - µ (б x/ E) + (б y/ E) + µ (б z/ E

€ z = - µ (б x/ E)- µ (б y/ E) - б z/ E

Q1/B:

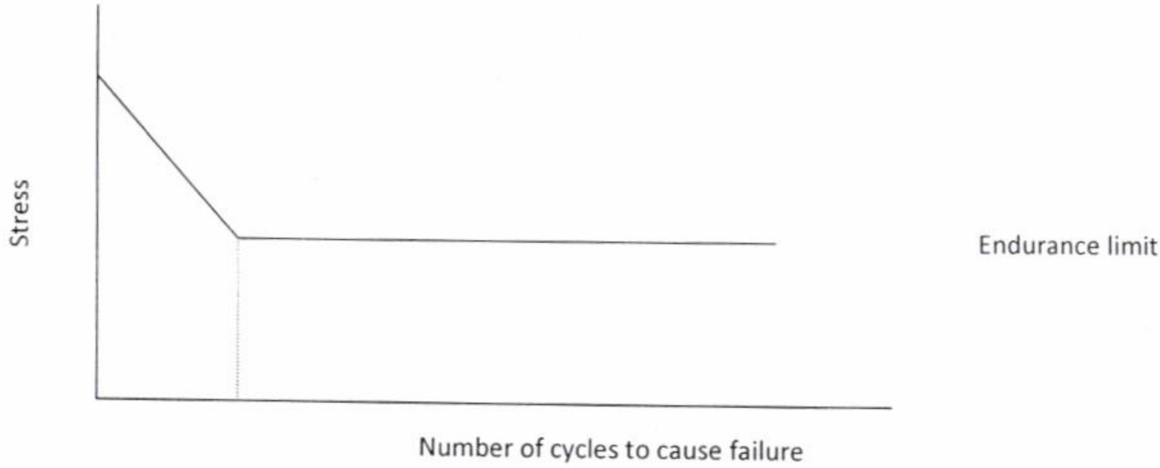
1. **Bonding of H_2O and bonding of NaCl**

   Bonding of H_2O is covalent bonding. Sometimes, an atom will share valence Electrons with a neighboring atom in order to satisfy such a stable configuration. This sharing of Electrons produces very strong attractive forces between the atoms and is termed Covalent bonding.

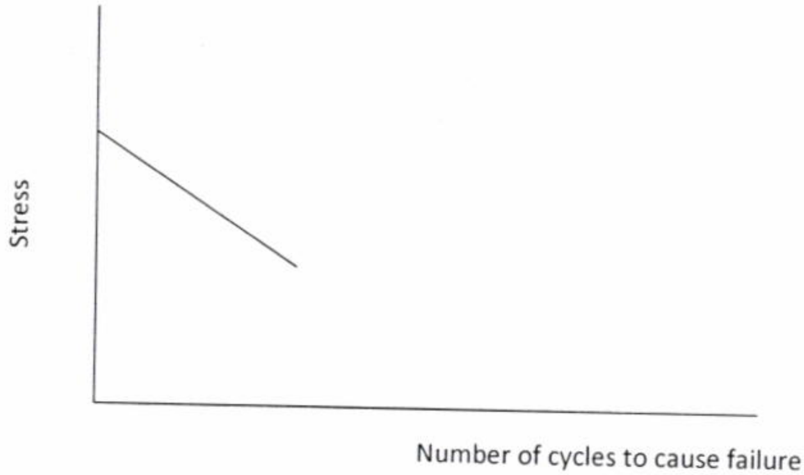
   Bonding of NaCl is ionic bonding. This type of atomic bonding results from mutual attraction of positive (+) and negative (-) charges. It depends on the ability of the atoms to gain or lose electrons.

   If an electron is removed from the outer shell, the atom becomes positively charge (electropositive). When an electron is added to outer shell, the atom becomes negatively charge (electronegative).

   An atom which has lost or gained an electron is called ion and the atoms are said to ionized. Electropositive and electronegative ions attract each other and ionic bond is established between them.



S-N diagram for ferrous metals



S-N diagram for concrete materials

Ans. of Q3/A

Find $\Delta L / \Delta D$?

$\epsilon_x = \Delta D / D_o$, $\epsilon_y = \Delta L / L_o$

$\mu = \epsilon_x / \epsilon_y$

$\mu = \Delta D / D_o \,/\, \Delta L / L_o$

$\Delta L / \Delta D = L_o / \mu * D_o$

For $L_o = 10\, D_o$

$\Delta L / \Delta D = 10 * D_o / \mu\, D_o = 10/\mu$

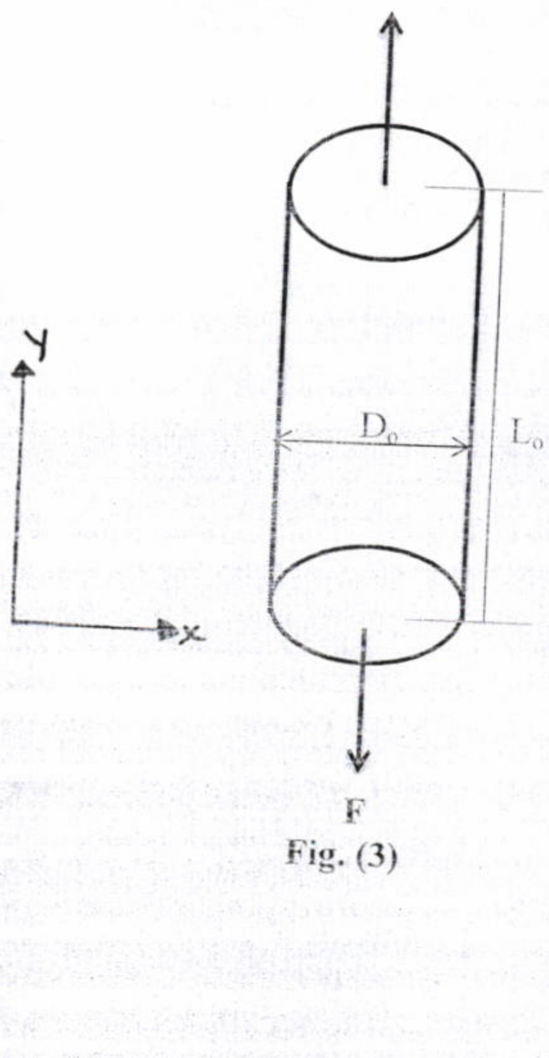
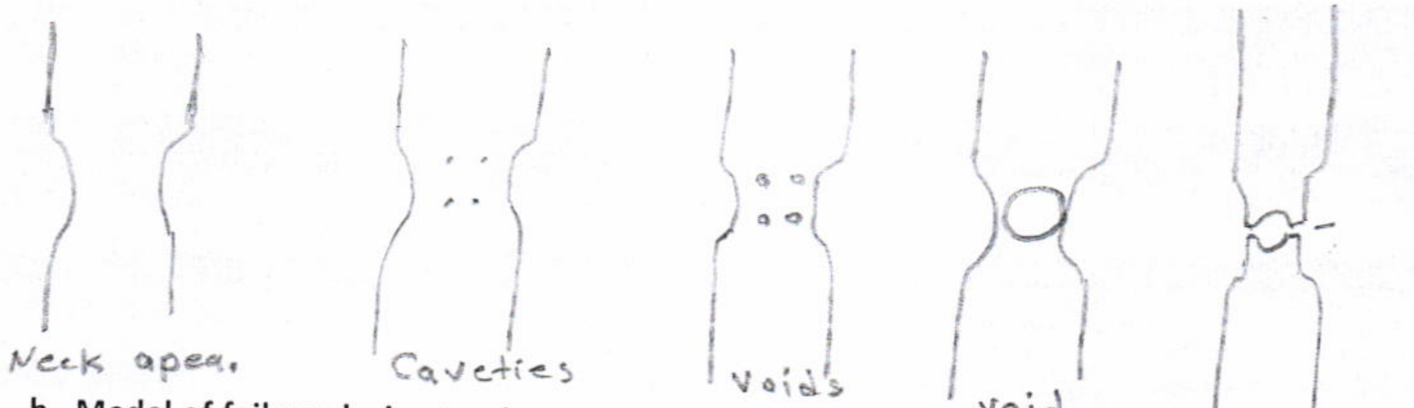


Fig. (3)

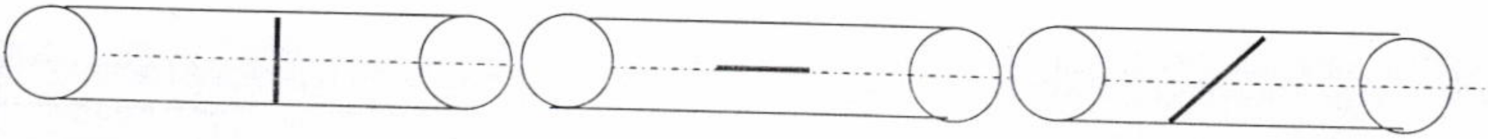
(6-8)

Q3/B:

a. **Steps of failure during tensile test for ductile material**



b. **Model of failure during torsion test**

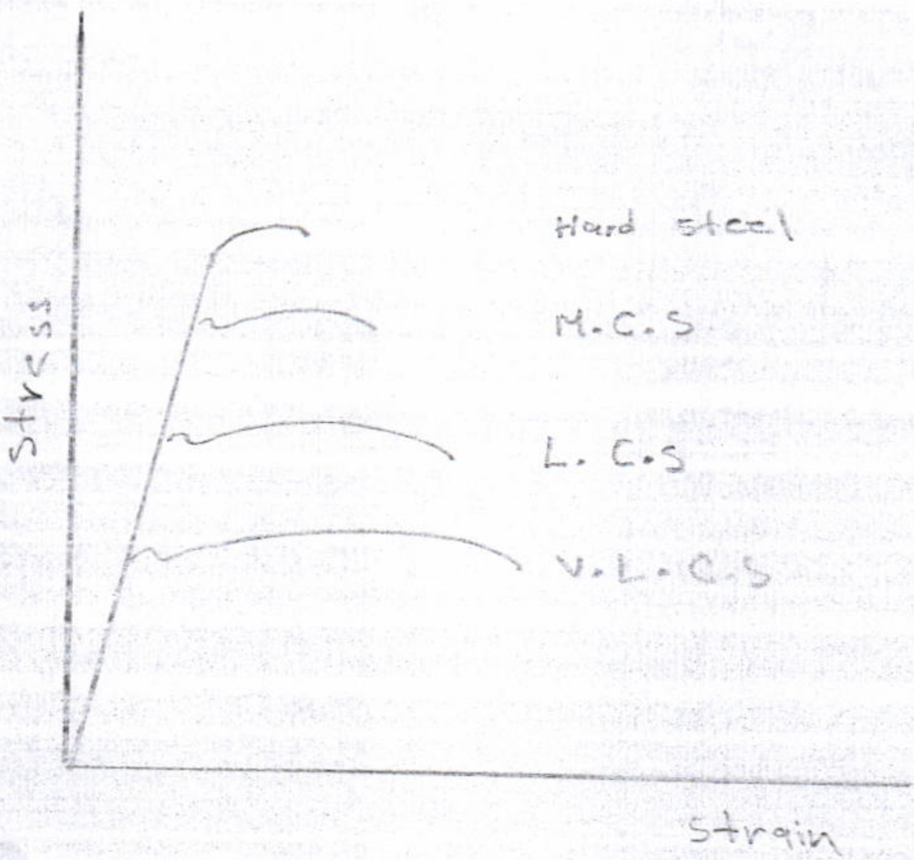


Shear plane perpendicular to the longitudinal axis

Shear plane parallel to the longitudinal axis

Shear plane making an angle to the longitudinal axis

c. **Stress – strain diagram for all types of steel during tensile test**



Q4/A:

$$E= \frac{\sigma_2 - \sigma_1}{€_2 - €_1}$$

$$E= \frac{140-35}{(667-167)*10^{-6}} = 210000\ N/mm^2$$

$$210000= \frac{140-80}{(667)*10^{-6}-€}$$

€ = 381*10-6 mm/mm

All the results will be valid if the proportional limit were 150 N/mm^2

Q4/B:

Drying stage:

As wet clay bricks come from different brick machine, they contain from 7-50% moisture depend on whether dry press stiff mud or soft mud process has been used moisture in clay may be classified as:

- Equilibrium moisture: is that moisture in the material which exerts a vapor pressure equal to that exerted by the surrounding air of a given temperature and humidity.
- Free moisture: is held strongly in the pore spaces.

Most of the free water is removed in the drying process and the remaining moisture during the burning process. Mechanical dryer, who permit of automatic control of temperature, humidity and air velocity, have come into general use. As the free water of the clay body is removed, the clay particles tend to coalesce causing shrinkage. The general effect of such shrinkage is to increase the resistance to moisture flow in the dried layers. If the drying is carried on too rapidly as by means of hot dry air, the moisture is removed from the surface of the solid more rapidly than the interior of the solid so that the surface harden and cracking occur. It is desirable to dry clay with moist air, reducing the drying rate to the point where diffusion of water to the surface can keep up with the vaporization at the surface. The average time necessary for drying clay brick is about 3 days, and the temperature required is from 38 °C to 149 °C.

Burning stage:

The burning of clay in a kiln requires an average time of 3 to 4 days. The process of burning may be divided into the following stages:

a. Water smoking:

During this period which remove most of the water in the clay under temperature ranging from 125 °C to 175 °C.

b. Dehydration:

Dehydration consists of expelling chemically combined water by breaking down the clay molecules. It begins at about 425 °C and complete at about 750 °C.

c. Oxidation:

Oxidation begins during the dehydration stage. All combustible matter is consumed, carbon is eliminated, the fluxing materials are changed to oxides, and sulfur is removed.

Q5:

1. Load at failure:

   $A_o = \pi D_o^2/4 = \pi*22^2/4 = 380.787\ mm^2$

   Stress at failure = 280 N/mm^2 .... From diagram

   $280 = F_{at\ failure} / 380.787$

   $F_{at\ failure} = 106620.36\ N$
2. Percentage of R.A.

   $A_f = \pi D_f^2/4 = \pi*9.5^2/4 = 71\ mm^2$

   $\%\ R.A. = (A_o - A_f)/A_o = (380.787 - 71)/380.787 = 81.3\%$
3. Stress at Yield point

   From diagram where offset strain = 0.2% and after drawing straight line from original point parallel to initial tangent, we will find that the stress at Yield point is 160 N/mm^2.
4. Maximum load that the material can be carried without failure

   From diagram ultimate strength = 320 N/mm^2

   $A_o = 380.787\ mm^2$

   $320 = F_{max.} / 380.787$

   $F_{max.} = 121851.84\ N$
5. Modulus of Toughness

   $M.T. \approx ⅔\ \sigma_f * \epsilon_f = 280*0.28 \approx 78.4\ N.mm/mm^3$

(9-9)