University of Technology
Building and Construction Engineering Department
Final exam 2012-2013

Subject: Material Technology
Division: All divisions
Examiner:-

Year:First
Time:3Hrs
Date: 28/ 05/2013

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. **Proton and electron**
2. **Resilience and toughness**
3. **Cast iron and mild steel in uses** **(15%)**

<u>Q2/A</u> For the composite bar shown in Fig (2), find the total deformation in x and y directions due to the applied load and change in temperature (increase) of 80°C, knowing that (Es = 200 kN/mm^2, E_{Al} = 70 kN/mm^2, α_s = 11.7*10^{-6}, α_{Al} = 23*10^{-6}, μ_s=0.28 and μ_{al}=0.25 **(15%)**

<u>Q2/B</u> Discuss fatigue damage and creep failure for materials **(10 %)**

<u>Q3/A</u> The steel block shown in Fig. 3 is subjected to a compressive force F on all faces. If the change in X- direction is (-2 mm). Determine the change in the length of the other two directions. E_S = 200 kN/mm^2 and μ = 0.28. **(16%)**

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

a. **Model of failure during compressive test**
b. **Model of failure during torsion test**
c. **Stress – strain diagram for hard steel during tensile test** **(9 %)**

<u>Q4/A</u> A uniform concrete slab of mass M is to be attached to two rods as shown in Fig. 4, whose lower ends are initially at the same level. Determine the ratio of the areas of the rods so that the slab will remain level after it is attached to the rods **(15%)**

<u>Q4/B-</u> Compare between Izod and Charpy method for impact test **(10%)**

<u>Q5</u> Data shows below are obtained during tensile test for steel sample. If the original diameter of the bar is 18mm and its diameter at breaking is 11.4mm, the gauge length is 220mm. Determine:

1. **Modulus of resilience**
2. **Percentage of elongation**
3. **Modulus of toughness**
4. **Maximum load**
5. **True stress at failure** **(25%)**

Stress	N/mm^2	50	100	150	200	250	300	350	400	450	350
Strain	mm/mm	0.003	0.006	0.01	0.0125	0.015	0.018	0.05	0.075	0.1125	0.225

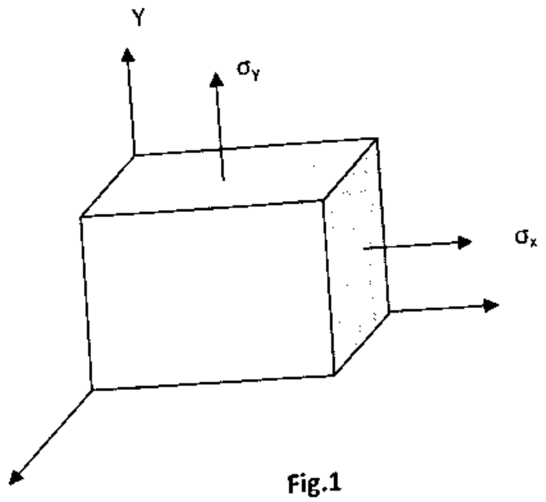


Fig.1

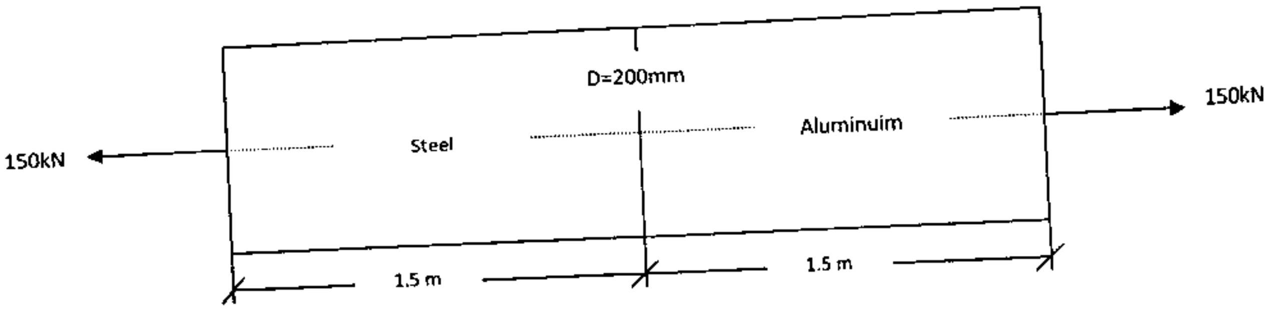


Fig.2

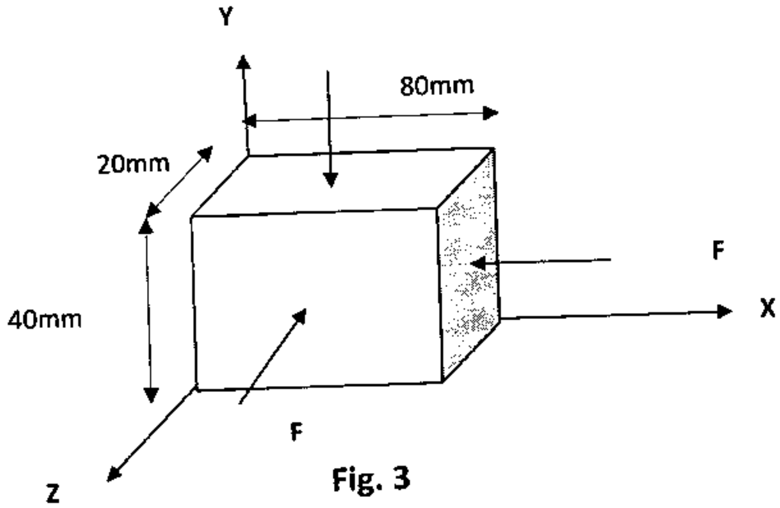


Fig. 3

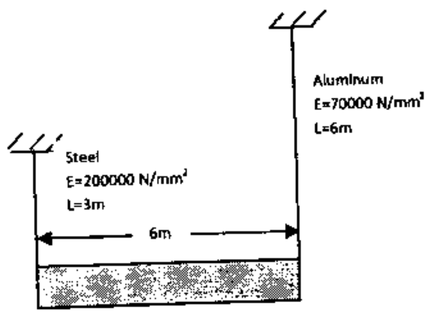


Fig.4

Answers

Q1/A:

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

A – Direct strain $\epsilon_x = +\sigma_x / E$

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 ($\epsilon_y = -\mu \epsilon_x = -\mu (\sigma_x / E)$
3. Induced strain in Z – direction due to X- stress ($\epsilon_z = -\mu \epsilon_x = -\mu (\sigma_x / E)$

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

A – Direct strain $\epsilon_y = +\sigma_y / E$

B – Induced strain due to Y- stress:

1. Induced strain in X – direction due to Y- stress ($\epsilon_x = -\mu \epsilon_y = -\mu (\sigma_y / E)$
2. Induced strain in Y – direction due to Y- stress = 0
3. Induced strain in Z – direction due to Y- stress ($\epsilon_z = -\mu \epsilon_y = -\mu (\sigma_y / E)$

Therefore, generalized Hook's law equations are:

$\epsilon_x = + (\sigma_x / E) - \mu (\sigma_y / E)$

$\epsilon_y = - \mu (\sigma_x / E) + (\sigma_y / E)$

$\epsilon_z = - \mu (\sigma_x / E) - \mu (\sigma_y / E)$

Q1/B

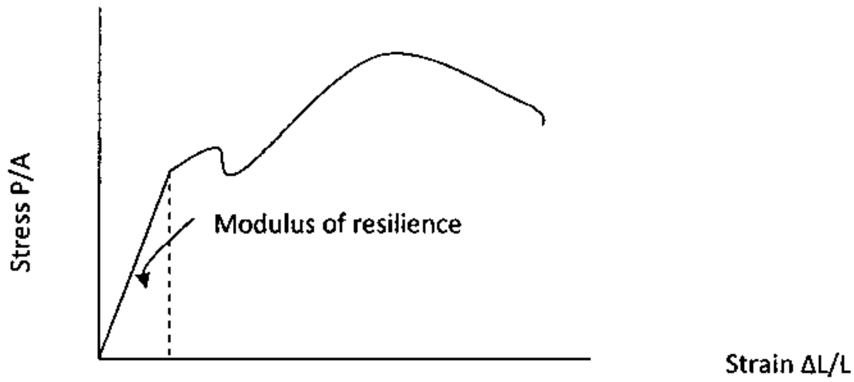
1. Proton: It is positive charged particles in nucleus. The number of Proton is also known as the atomic number (Z)

Electron: It is negative charged particles surrounded nucleus. The charge is equal in magnitude, but opposite in sign to the charge of Proton. Also the number of electrons in an atom equals the number of Proton.

2. **Resilience**

Is that property of an elastic body by which energy can be stored up in the body by loads applied to it and given up in recovering it\s original shape when the loads are removed. The area under the straight portion of stress - strain curve represent the modulus of resilience.

Modulus of resilience = 1/2 ($\epsilon_{P.L.} * \sigma_{P.L.}$)

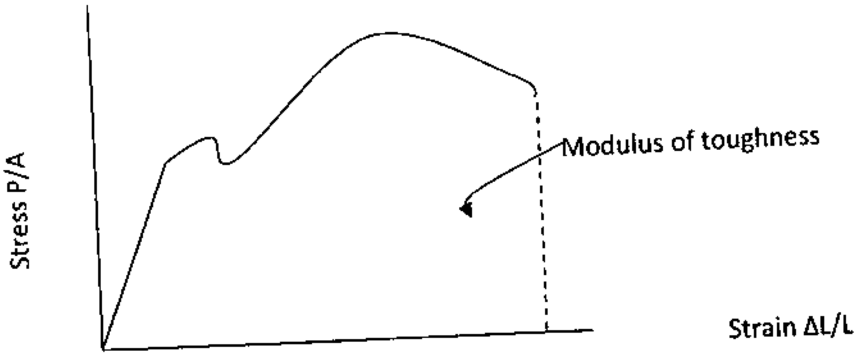


Toughness

The resistance to impact. Toughness is also considered to mean resistance to fracture when the material is deformed above the elastic limit.

It is a measure of the work required to cause fracture to occur. The area under stress – strain curve represent modulus of toughness.

Modulus of toughness $\leq$ 2/3 (ϵ_f * σ_f)



3. Uses of cast Iron:
   1. It is used for manufacture of steel and wrought iron.
   2. Its high compressive strength makes it suitable for use in making such parts which are subjected to compressive stresses such as supports of heavy machinery.
   3. Since it does not rust easily, therefore it is used for parts generally exposed to atmosphere such as lamp posts.
   4. It is also used for making rail chairs and carriages wheels.

Uses of mild steel:
   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.

Q2/A:

$\Delta L_{total} = \Delta L_{steel} + \Delta L_{Aluminum}$

ΔL_{steel} = $(F*L/E*A)+(L*\alpha*\Delta T)=(150000*1500/200000*(200^2\pi/4))+1500*11.7*10^{-6}*80=1.439$ mm

$\Delta L_{Aluminum}$ = $(F*L/E*A)+(L*\alpha*\Delta T)=(150000*1500/70000*(200^2\pi/4))+1500*23*10^{-6}*80=2.862$ mm

ΔL_{total} = 1.439+ 2.862= 4.301 mm

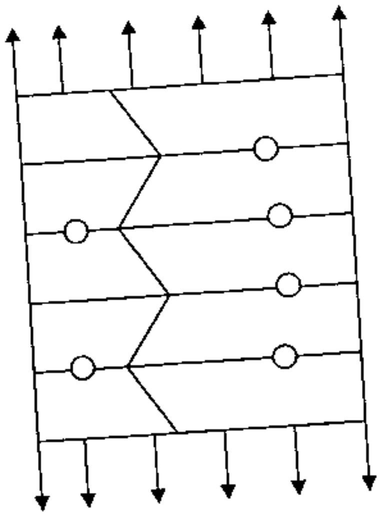
ΔD_{steel} = $(D*\alpha*\Delta T)-(\mu*\epsilon L*D)=200*11.7*10^{-6}*80-(0.28*(150000/200000*(200^2\pi/4))*200)=0.185$ mm

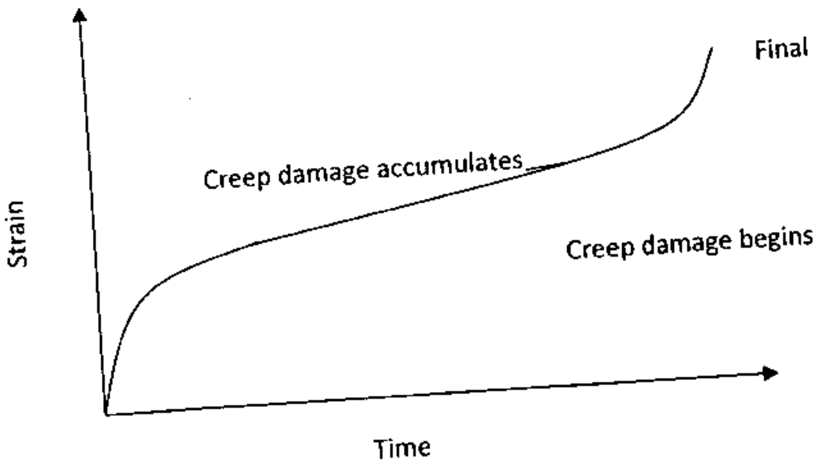
$\Delta D_{Aluminum}$ = $(D*\alpha*\Delta T)-(\mu*\epsilon L*D)=200*23*10^{-6}*80-(0.28*(150000/70000*(200^2\pi/4))*200)=0.364$ mm

Q2/B:

Creep damage and creep fracture:

During creep, damage, in the form of internal cavities, accumulates. The damage first appears at the start of the tertiary stage of the creep curve reflects this as the holes grows. The section of the sample decreases and (at constant load) the strains goes up and the creep rate goes up even faster than the stress does.





Fatigue failure:

Fatigue failure appears to begin with a crack at a point of weakness in the material, with the crack. Progressing long crystal boundaries. During the stress cycle, these small cracks open and close. The cracks cause highest stress at the base of the crack as compared to the stress if there is no crack. Under this repeated concentration of stress, the cracks will gradually extend a cross the section of the member, finally causing complete failure of the member.

Q3/A

Generalized Hook's law equations in compression are:

€ x = - (6 x/ E) + μ (6 y/ E) + μ (6 z/ E)

-2/80=F/200((-1/20*40)+(0.28/20*80)+(0.28/40*80))

-5=F(-0.0009875)   F=5063kN

€ y = + μ (6 x/ E) - (6 y/ E) + μ (6 z/ E)

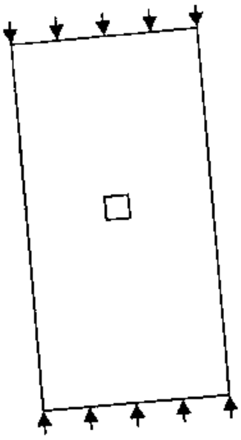
Δy/40=5063/200((0.28/20*40)-(1/20*80)+(0.28/40*80))   Δy= -0.1898 mm

€ z = + μ (6 x/ E)+ μ (6 y/ E) - (6 z/ E)

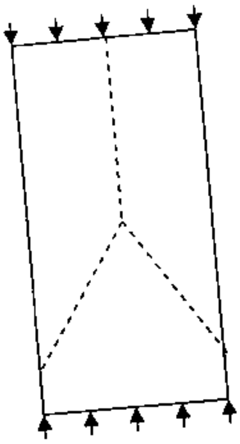
Δz/20=5063/200((0.28/20*40)+(0.28/20*80)-(1/40*80))   Δz =0.107 mm

Q3/B

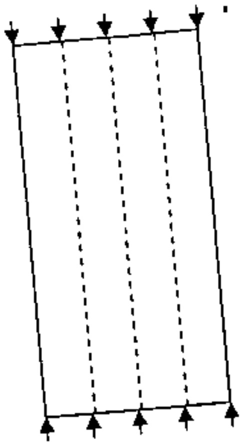
1.



Shear Failure

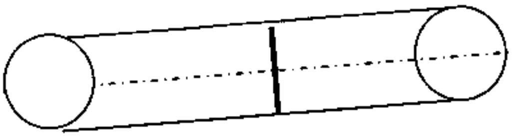


Combination
shear Failure and
splitting failure

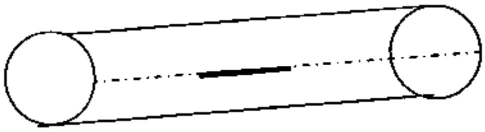


Splitting Failure

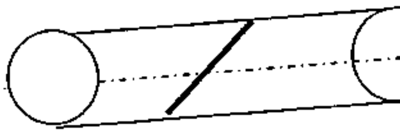
2.



Shear plane perpendicular

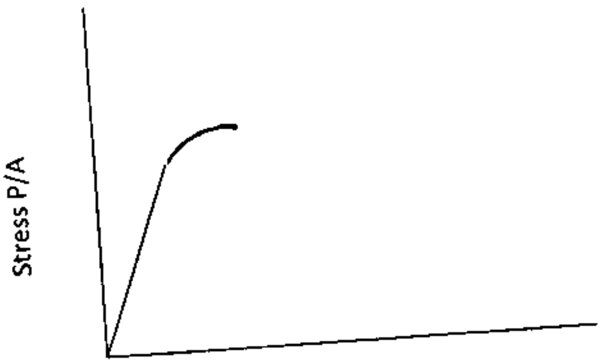


Shear plane parallel



Shear plane making an angle

3.



Stress – Strain curve for hard steel

Q4/A

$\Delta L_S = \Delta L_{Al}$

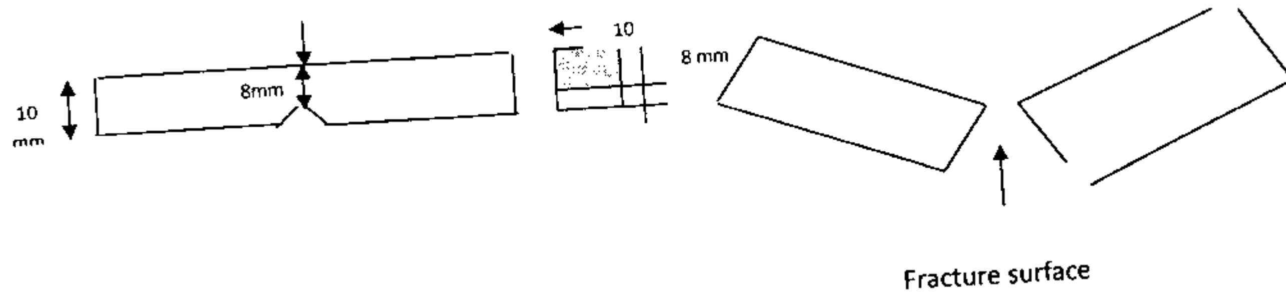
$(0.5M*3/200000A_s)=(0.5M*6/70000A_{Al}$

$A_{Al}/ A_S = 5.71$

Q4/B

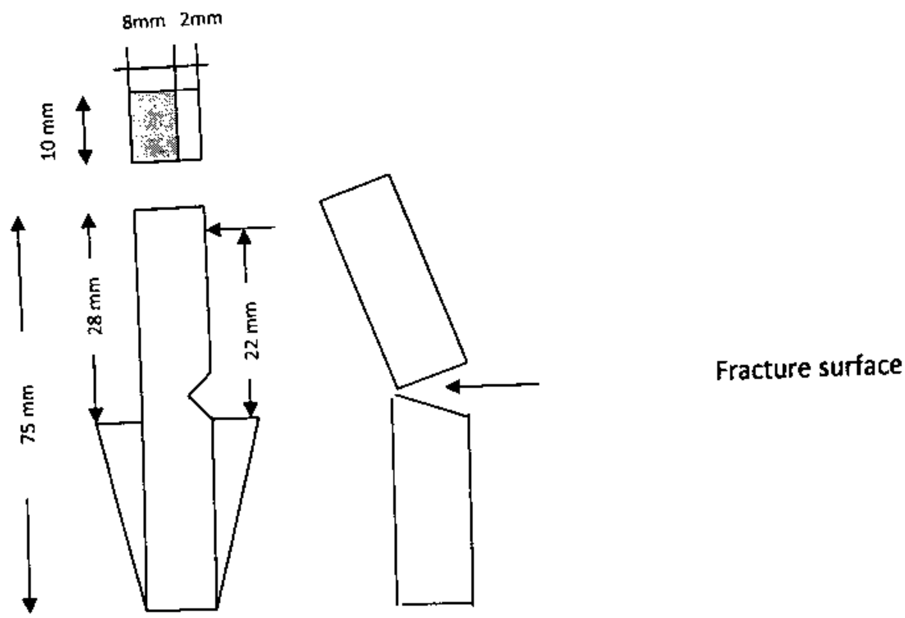
Charpy method

This method is well adapted for examining metals that break with a relatively low absorption of energy. The presence of notch eliminates the influence of surface effects.



Izod method

For tough metals the notched Izod type of specimen tested as a cantilever is used. For extremely brittle metal that test specimen requires no notched, because the first suddenly applied stress causes a brittle failure.



Q5

1. Modulus of resilience = $0.5*\sigma_{PL}*\epsilon_{PL}$ = 0.5*150*0.01= 0.75 N/mm^2
2. Percentage of elongation = 0.225*100% = 22.5%
3. Modulus of toughness = $(2/3)*\sigma_f*\epsilon_f$ = (2/3)*350*0.225 = 52.5 N/mm^2
4. Maximum load = $450*18^2*\pi/4$=114708 N
5. True stress at failure

P at failure = $350*18^2*\pi/4$=89217 N

True stress at failure = $89217/(11.4^2*\pi/4)$=872.5 N/mm^2