MATERIAL TESTING LAB

MATERIAL TESTING LABORATORY

LIST OF EXPERIMENTS

1. TENSION TEST
2. TORSIONAL TEST
3. HARDNESS TEST
4. TEST ON SPRINGS
5. FATIGUE TEST
6. IMPACT TEST
7. DEFLECTION OF BEAMS

GENERAL INSTRUCTIONS

1. Each experiment will be carried out jointly by a group of students.
2. Be prompt and punctual, late entry will not be excused.
3. All students must come to lab with shoes, no exception.
4. Keep your area of work neat and clean environment. Handle things carefully because penalties will be there for misbehaviour and/or damaging of the equipment tools.
5. You must come well prepared with the theory/background of the experiment to be done on a particular day.
6. Show the completed lab report and take the signature from your TAs before leaving the lab, otherwise lab report not considerable during at the time of submission.
7. Submit individual laboratory report by hand written or computer printed within next lab.
8. Before entering in to the lab, see the notice board for latest information and instructions, if any.
9. Before leaving the lab, enter your determined values in common report in lab.
10. Take your seat group wise around the study table for miscellaneous works such as reading, writing, and discussion etc.,
11. Student should stay in the lab till the end of the session.

OBJECTIVES

- Become familiar with the basic types of mechanical tests, including tests in tension, indentation hardness, notch impact, bending, and torsion.
- Analyze data from tension tests to determine materials properties, including both engineering properties and true stress–strain properties.
- Understand the significance of the properties obtained from basic mechanical tests, and explore some of the major trends in behavior that are seen in these tests.

EXPERIMENT 1

TENSILE TEST

AIM

To determine the Young's modulus, upper and lower yield stress and toughness of the given material.

EQUIPMENTS USED

1. Universal Testing Machine
2. Specimen
3. Extenso meter
4. Scale

THEORY

A solid bar when loaded in tension elongates as the applied load to it increases. Then mechanism so separation of atoms is in the direction of loading. The separation of atoms is due to the displacement of atoms from the normal equilibrium position. So long as the mechanism involved is only separation of atoms, by relatively small amounts the release of the applied load will allow the atoms to return to their original position. If the axially loaded bar returns to its original shape and size, then the deformation is said to be elastic deformation.

PROCEDURE

1. A test to express the mechanical properties and to get the behavior of materials is the tensile test. The machine used here is Universal Testing Machine (U T M).

2. In the test, the metal piece is first prepared by turning into one of the standard shapes (either Round or Flat).

3. The ends of the test piece are gripped in the tensile testing machine and a gradually increasing load is applied until failure is approached.

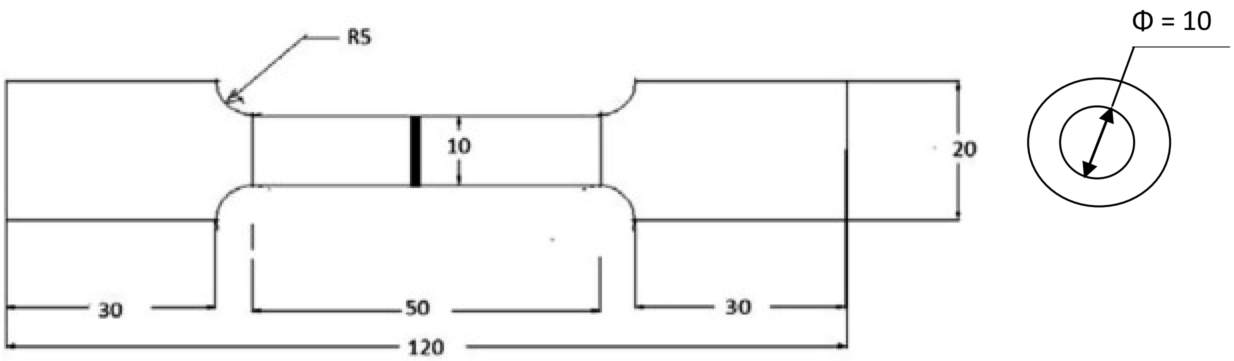
4. The amount of elongation in the test piece caused by load is measured by extensometer.

5. As the load increases, elongation increases.

6. The stress is calculated from the load and the original dimensions of the piece.

7. Finally, a graph is plotted with stress on abscissa and strain on ordinate to get the Stress-Strain curve.

SPECIMEN DIMENSIONS



TABULATION :

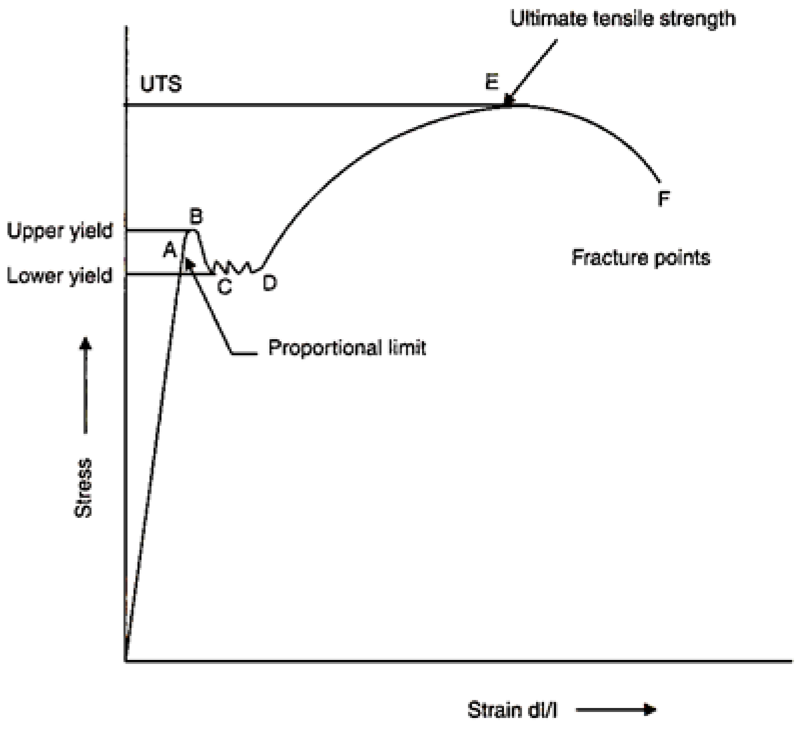
ELONGATION (mm)	LOAD (Kg)	STRESS (N/mm^2)	STRAIN

RESULTS

The tensile test was conducted on the given specimen and the following were found

1. Area of specimen =
2. Fracture stress =
3. Ultimate tensile stress =
4. Upper yield stress =
5. Lower yield stress =
6. Young's modulus =
7. Toughness of material =

MODEL GRAPH



A typical stress-strain curve for mild steel

QUESTIONS

1. Distinguish between Elasticity and Plasticity
2. Define Hooke's law.
3. Differentiate between Ductile and Brittle materials.
4. Whether the given material is Ductile or Brittle? Comment on your answer.
5. Compare the results with standard data book and comment.

1. A brass specimen having a cross-sectional area of 100 mm^2 and gauge length 100 mm is subjected to a tensile test from which the following information is obtained:
   Load at yield point = 45 kN, maximum load = 52.5 kN, final cross-sectional area of waist at fracture = 75 mm^2, and gauge length at fracture = 110 mm.
   For questions 1 to 4, select the correct answer from the following list:

(a) 600 MPa	(b) 525 MPa
(c) 33.33%	(d) 10%
(e) 9.09%	(f) 450 MPa
(g) 25%	(h) 700 MPa

   1. The yield stress. 2. The percentage elongation.
   3. The percentage reduction in area. 4. The ultimate tensile strength.

2. The results of a tensile test are: Diameter of specimen 15 mm; gauge length 40 mm; load at limit of proportionality 85 kN; extension at limit of proportionality 0.075 mm; maximum load 120 kN; final length at point of fracture 55 mm. Determine (a) Young's modulus of elasticity (b) the ultimate tensile strength (c) the stress at the limit of proportionality (d) the percentage elongation.

EXPERIMENT 2

TORSION TEST

AIM

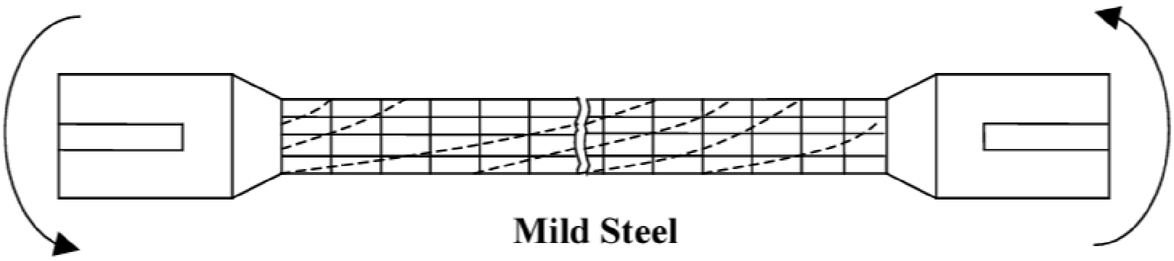
To determine the rigidity modulus and maximum shear stress for the given material.

EQUIPMENTS USED

1. Torsion testing machine
2. Specimen
3. Vernier caliper
4. Scale

THEORY

A structural member subjected to a twist about an axis is said to be loaded in torsion. A shaft, which has strength normally greater, is set for transmission of power and components of control system and for determining the properties of material. The shear stress is maximum at outer radius.



FORMULAE

$T / J = G \theta / l = \tau / r$ -------------- (1)

Where,

G = Modulus of rigidity (GPa)

θ = angle of twist in the rod (Radians) r = radius of specimen (mm)

T = torque applied (N-m)

l = length of the specimen (mm)

J = polar moment of inertia (mm^4)

τ = shear stress (N/ mm^2)

PROCEDURE

1. Initially the specimen to be tested is fixed in the machine and machine calibrated by adjusting the needle to read zero in the dial.
2. Now a mark is made near the operating wheel.
3. The specimen is twisted at a rate of angle 0.4^{o} per rotation of the operating wheel and the torque values are tabulated.
4. The polar moment of inertia is calculated using the formula,

$$J = \pi d^4 / 32$$

5. The shear stress and rigidity modulus are calculated using the formula (1).
6. A graph is drawn between angle of twist and shear stress.
7. The slope of the curve will give the rigidity modulus. The same is compared with theoretical value.

RESULT

The torsion testing was conducted on the following specimen.

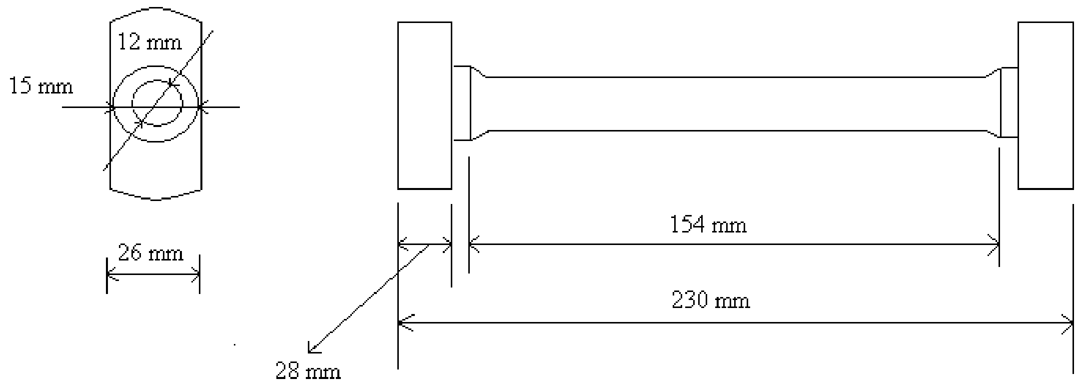
Maximum shear stress =

Rigidity modulus of material =

GRAPH

TABULATION

S. No	ANGLE OF TWIST (Deg)	TORQUE APPLIED(N-m)	ANGLE OF TWIST (Deg)	TORQUE APPLIED (N-m)



QUESTIONS

1. Derive the relation between Young's modulus and Rigidity modulus.

2. Mention the advantages in selecting tubular components over solid components for torque transmission.

3. A shaft of uniform solid circular section is subjected to a torque of 1500 N m. Determine the maximum shear stress in the shaft and its resulting angle of twist, if the shaft's diameter is 0.06 m, the shaft's length is 1.2 m, and the rigidity modulus, G = 77 × 109 N/m^2. What power can this shaft transmit if it is rotated at 400 rev/min?

EXPERIMENT 3

HARDNESS TEST

AIM

To find the hardness of given material by using Rockwell hardness tester, Brinell and Vickers hardness testing machines.

EQUIPMENTS USED

1. Brinell harness testing machine
2. Vickers hardness testing machine
3. Materials
4. Microscope

THEORY

Hardness of a substance can be defined as the resistance to indentation. There is direct relation between the hardness and other mechanical properties. Hardness can be measured in the following ways

1. Resistance to indentation is static or dynamic load.
2. Resistance to scratching.
3. Resistance to abrasion.
4. Resistance to cutting.

On the metallurgical sense, it has become a practice to understand hardness as the indentation hardness only. Other hardness may be used for routine check up. Unfortunately the different types of hardness are not related to each other. However the different indentation hardness values measured are to a certain extent inter-convertible.

FORMULA

$$\textbf{BHN} = \frac{2P}{\pi D(D - (\sqrt{D^2 - d^2}))}$$

Where,

BHN = Brinell hardness number

P = Load applied in ‘kg’

D = Diameter of indenter in ‘mm’

d = Diameter of indentation in ‘mm’

Usually,

P / D^2 = 30 for Steel

= 10 for non-ferrous metals

= 2 for soft materials like Lead

VHN = 1.854 P / d^3

Where,

VHN = Vickers hardness Number,

P = Load applied

d = Diagonal length of indentation

PROCEDURE

1. In Brinell hardness test, a hardened steel ball of 10 mm diameter is indented on a flat polished surface of the sample under a load, usually 500 to 3500 kg.

2. The load is maintained for 10 to 15 seconds and the diameter of the indentation made on the test piece is subsequently measured by means of microscope in the order of accuracy being 0.01 mm.

3. The Brinell hardness number is obtained from the equation,

   BHN = load on ball / area of indentation

TABULATION Brinell Hardness – Steel ball D = 10 mm

Material	Load	Dia of indentation	BHN number
MILD STEEL			
DURALUMIN			
PURE ALUMINIUM			

TABULATION Vickers Hardness – Diamond Indenter

Material	**Load**	**Length of diagonal**	**VHN number**
H S S			
18% C_r - SS			
ALUMINIUM			

PROCEDURE

1. The Vickers hardness HV is the ratio of the test load ‘P’ to the surface area ‘F’ of the permanent impression made by a four-sided diamond pyramid.
2. The angle of which is 136^0 between the sides facing each other.
3. The length of the diagonal ‘d’ should be measured with an accuracy of 2 microns.
4. If the length of the diagonal exceeds 0.5 mm an uncertainty of 5 microns is permissible.
5. It is calculated from the following formula.

$$HV = P / F = Px1.854 / d^2$$

RESULTS

The hardness test was conducted on the given material, the BHN and VHN values were found to be

The BHN for Mild steel	=
The BHN for Duralumin	=
The BHN for Aluminium	=
The VHN for HSS	=
The VHN for 18% Cr – SS	=
The VHN for pure Aluminium	=

QUESTIONS

1. Define hardness
2. Derive BHN = $\frac{2P}{\pi D(D-(\sqrt{D^2-d^2}))}$
3. Derive VHN = 1.854 / d^2
4. Is this hardness test is destructive? Why?
5. For higher hardness whether Brinell or Vickers is preferred?
6. Compare the significance of different types of hardness test.

EXPERIMENT 4

TEST ON SPRINGS

AIM

To determine the rigidity modulus of given spring material.

EQUIPMENTS USED

1. Spring
2. Weights
3. Screw Gauge
4. Scale
5. Vernier Caliper

THEORY

Springs may be made of carbon steel, silicon steel and manganese steel or some completely alloyed steel. It is essential to know the rigidity modulus, because springs are used most of the engineering parts.

FORMULAE

Deflection, $\alpha = 8nPD^3 / Gd^4$

Where,

n = Number of effective turns

D = Mean diameter of springs (outer dia – wire dia)

G = Torsional or Rigidity modulus

d = Wire diameter

P = Load

PROCEDURE

1. The given spring is fixed on the experimental setup initially.
2. The length of the spring is found without adding any load.
3. A load of 0.5 kg is added to the spring and the compressed length of the spring is noted.
4. The 0.5 kg loads are gradually increased up to 10 kg and corresponding lengths are noted..
5. Now the loads are removed in steps of 0.5 kg and the corresponding lengths are also noted.
6. The number of effective turns of the spring is noted.
7. Mean diameter of the spring is calculated using a vernier caliper.
8. For a load ‘P’ kg with the deflection ‘α’, the rigidity modulus of the given spring can be calculated using the formula,

   $$\mathbf{G = 8nPD^3 / \alpha d^4}$$

9. A graph is drawn between deflection and load. From the slope, the stiffness of the spring or spring constant is calculated as,

   Spring constant = Slope X 9.81 N / m

RESULT

BULK MODULUS OF THE SPRING

1. From the graph ……………..GPa
2. From tabulation ……………GPa

STIFFNESS

3. From the graph …………N - m
4. From the tabulation ……..N – m

TABLATION

S. NO	LOAD APPLIED	DEFLECTION LOAD	DEFLECTION UNLOAD	MEAN LENGTH	MEAN DEFLECTION	STIFFNESS LOAD / DEFLECTION

GRAPH

LOAD Vs DEFLECTION

QUESTION

1. What are the uses of springs?
2. What are the materials used in the manufacture of springs?
3. For the same spring, if P = Kg., what will be the D / d ratio?
4. A spring for a balance to measure 0 to 1000 N over a scale of length 80 mm is to be designed. The spring is to be enclosed in a casing of 25 mm diameter. The approximate number of turns is 30. The modulus of rigidity is 85 kN/mm^2. Calculate the outer diameter, mean diameter of the spring coil. Wire diameter of spring = 4 mm.

EXPERIMENT 5

FATIGUE TEST

AIM

To determine the fatigue strength of the given specimen, which is subjected to completed reversed stress cycle.

EQUIPMENTS USED

1. Fatigue testing machine
2. Specimen
3. Vernier caliper

THEORY

Like human, metals also experience fatigue. To avoid human fatigue we take some rest or food whereas this is not possible for metals and alloys.

Fatigue is generally defined as the breakage of the material when it is subjected to cyclic loads. The fatigue is time dependent phenomenon. The fatigue characters are generally represented as stress – no. of cycles diagram.

SIGNIFICANCE OF FATIGUE FAILURE

The stress required for fatigue failure is less compared to the stress required for other failures. All vibrating parts experiencing consistent reversal of load undergo failure. It occurs without any warning. Fatigue failure is a brittle one.

FORMULA

$M = \sigma\, b\, h^2 / 6$

Where,

M = Bending moment

σ = Stress applied

b = lowest breadth of the specimen

h = thickness of the specimen

Number of cycles = Time of fracture x Motor rpm

PROCEDURE

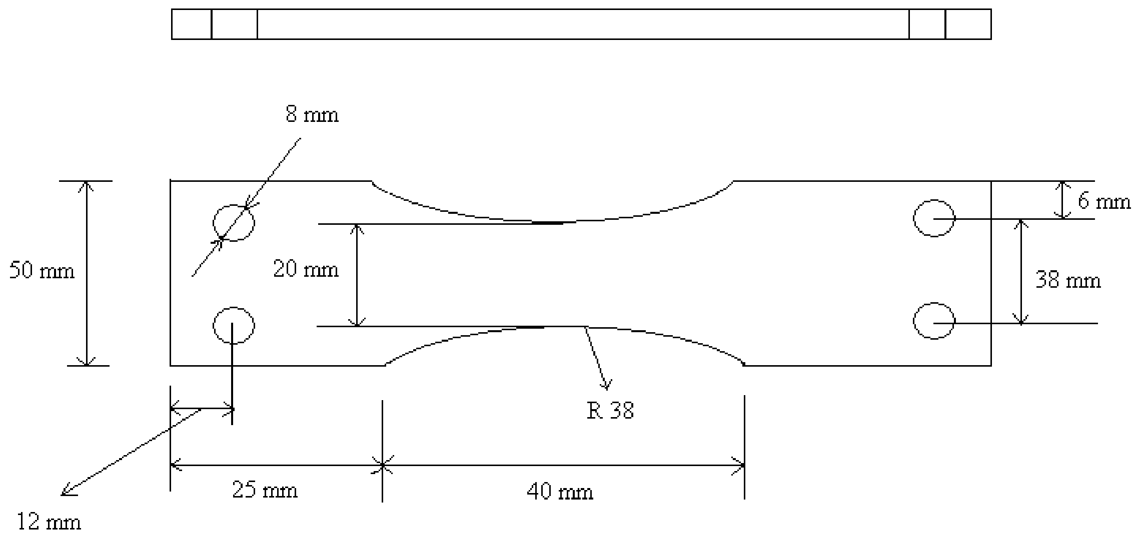
1. A fatigue testing machine attempts to simulate stress developed in parts by vibration of cyclic loads as in service.
2. The specimen is rotated at any given position and it attenuates between two positions.
3. Then the dial gauge is adjusted to zero.
4. The tip is adjusted for the dial gauge to read the reading corresponding to the bending moment.
5. Then the motor is started on to fatigue, the specimen attains fracture after some time.
6. The time taken for fracture is noted. The number of cycles is then calculated.

RESULTS

For the given specimen the number of cycles for the fatigue fracture is ……………………revolutions.

QUESTIONS

1. Define fatigue.
2. What is meant by endurance limit?
3. Write shirt notes on effect of composition, size, surface condition, etc on fatigue test.
4. Describe briefly about Orawans' s theory for fatigue failure.


8 mm
50 mm
20 mm
6 mm
38 mm
R 38
12 mm
25 mm
40 mm

EXPERIMENT 6

IMPACT TEST

AIM

To find the toughness of material.

EQUIPMENTS USED

1. Impact testing machine
2. Specimen

THEORY

Some materials such as Cast Iron shows a very high tensile strength however, if it is hammered it breaks. The material may be strong in static loading and may fail quickly in dynamic loading. The knowledge of dynamic effect is much needed in practical applications. A simple tensile test does not reveal the nature of metals and hence it is necessary to test the metals under shock or sudden loads.

The principle employed in the test is that almost all materials absorb some energy before it breaks. If it is brittle, it breaks readily i.e., it absorbs less energy. If it is tough, it needs more energy to fail.

PROCEDURE

1. The specimen is supported in a block, which fits in place of gripping dies.
2. A centering gauge for setting the specimen in correct position is located in the test.
3. The supports are 40mm apart, as required for 10mm specimen.
4. The specimen is square section of 10x10 mm and 50mm long, with 45^o, 2mm V- notch across the center of one side and is supported horizontally at both the ends.
5. The pendulum is released from the top to strike the specimen.
6. The toughness is directly measured from the reading of the pointer.

Corrections and Calibration

In the illustration,

W = Weight of the pendulum

R = Length of the pendulum (distance from its center of gravity to the point of support).

A = angle of fall

B = angle of rise

H = height of fall

h = height of rise

Initial energy (the energy in the pendulum before it breaks the specimen) = WH

= WR(1-CosA)

Final energy (the energy remaining in the pendulum after it broken the specimen) = Wh

= WR(1-CosB)

Energy of rupture of specimen = W(H-h)

= WR(CosB – CosA)

A correction to the angle of rise is necessary. The bearing friction is calculated by swinging the pendulum in the air (without any specimen) and noting the pointer readings for a certain number of swings. The decrease in the pointer reading per swing is estimated. This is added to the angle 'B'. The pendulum not only breaks the specimen but also throws out the fragment. The energy expended in this process should also be taken into account. This should be subtracted from the value of the energy indicated as absorbed by the material in fracture.

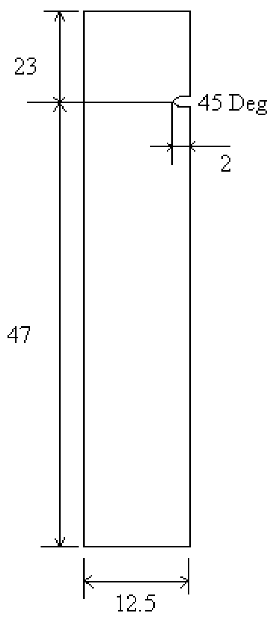
If the weight of the fragment be 'w' and 's' the distance of the specimen from the rotational axis of the pendulum, the energy expended moving the broken fragments will be, e = w.s. (1-Cos B).

RESULT

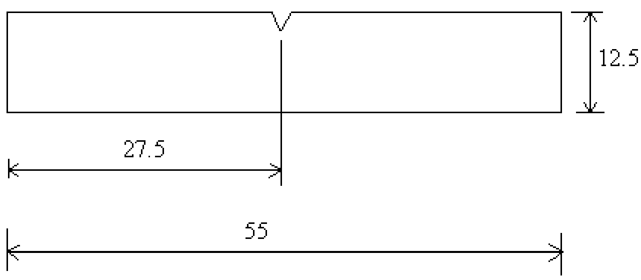
The toughness of given material is ……………….. Joule

QUESTIONS

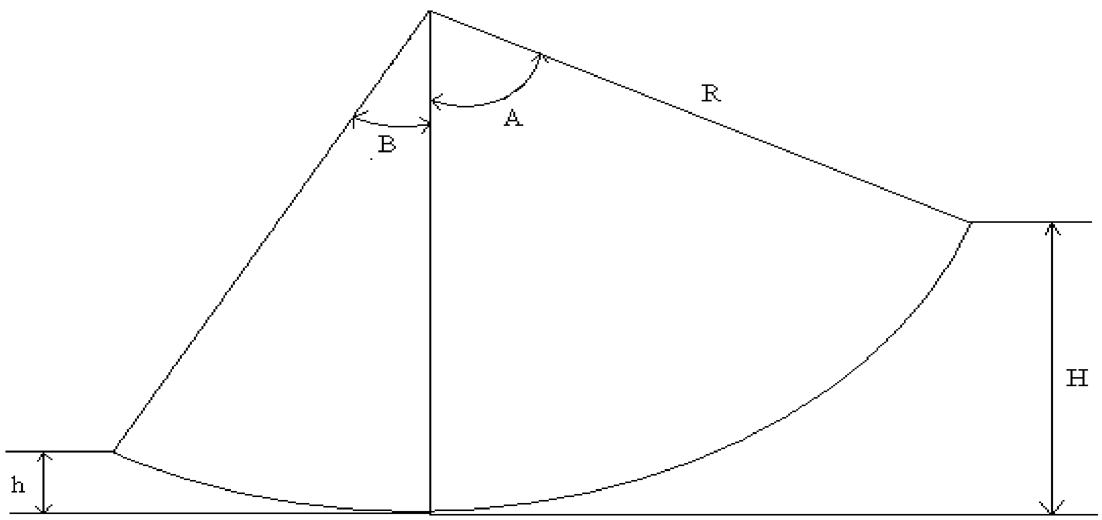
1. Explain Ductile to Brittle Transition Temperature(DBTT)
2. Write briefly on effect of test variables on absorbed energy.



IZOD TEST



CHARPY TEST



EXPERIMENT 7

DEFLECTION OF BEAMS

AIM

To complete the various (both theoretical and practical values) of the deflection if beams of different materials.

APPARATUS REQUIRED

1. Vernier caliper
2. Weights
3. Measuring gauge (for measuring deflection of beam)
4. Different rods of different materials (such as Aluminium, Mild steel and Stainless steel).

FORMULA USED

1.Theoretical deflection

$$\delta = WL^3 / (48\ EI) \quad (m)$$

Where,

δ = Deflection of beam (cm)

W =Weight of dead load + weight of 79 cm of the rods + added weight (kg)

(Weight of dead load = 79 cm)

L = Length of the rod between the knife edges (in 'm')

E = Young's modulus of the material (N/m^2)

I = Moment of inertia of the rod (m^4)

If the rod is of rectangular cross section,

$$I = b\ d^3 / 12 \quad (m^4)$$

Where,

b = Breadth of the rod (m)

d = Width of the rod (m)

If the rod is of circular cross section,

$$I = \pi D^4 / 64 \ (m^4)$$

D = diameter of the wire (m)

2. Practical deflection

δ = Reading shown in the gauge (m)

THEORY

The axis of the beam deflects from its position under action of applied forces. Accurate values for this beam deflection are sought in many practical cases. Elements of machines must be sufficiently rigid to prevent misalignment and to maintain dimensional accuracy under load.

PROCEDURE

1. The given rod is fixed in between the two knife edges of the apparatus.
2. The dial head is set in zero condition.
3. Now the load is applied to the rod at its centre.
4. Reading for the load is measured from the gauge head. The measured reading gives the practical deflection of the beam directly.
5. Now the reading is taken for increasing loads of 0.5 kg to 2.5 kg.
6. The values are tabulated and the dimension of the rod is measured.
7. In the similar way the practical deflection is measured for different materials with various cross sections.
8. The theoretical deflection is measured using the relation.

   $$\delta = WL^3 / (48 EI) \quad (m)$$

9. The error % in the value is calculated using

   $$\text{Error } \% = \frac{(Practical\ Value - Theoretical\ value) * 100}{Theoretical\ Value}$$

W = Dead load = 79 gm

'E' for Stainless steel and Mild steel = 2 × 10^5 N/mm^2

'E' for Aluminium = 0.675 × 10^5 N/mm^2

RESULT COMMENT

Thus the deflection of the beam of different materials are found and compared. Thus practical deflection value of the beam is comparatively less than that of the theoretical value because the device used to measure the deflection is not exactly kept in the middle, so we get some error in practical deflection value. Some errors may be in the measuring device due to the above reasons the errors may occurred.

RESULT

Thus the theoretical and practical values of the deflection of beams are compared and percentage error is calculated.

1. **STAINLESS STEEL**

Maximum error =

Minimum error =

2. **MILD STEEL (RECTANGULAR CROSS SECTION)**

Maximum error =

Minimum error =

3.MILD STEEL (CIRCULAR CROSS SECTION)

Maximum error =

Minimum error =

4.ALUMINIUM

Maximum error =

Minimum error =

MEAN DEFLECTION

1.STAINLESSS STEEL

Theoretical deflection =

Practical deflection =

2.MILD STEEL (RECTANGULAR CROSS SECTION)

Theoretical deflection =

Practical deflection =

3.MILD STEEL (CIRCULAR CROSS SECTION)

Theoretical deflection =

Practical deflection =

4.ALUMINIUM

Theoretical deflection =

Practical deflection =

S.No.	Material	Dimension of the Material	Weight	Deflection Shown In Gauge (mm)	$\Delta = WL^3 / (48 EI)$	Error %
1.	Stainless Steel	Φ = 10mm				
2.	Mild Steel (Circular Cross Section)	Φ = 10 mm				
3.	Mild Steel (Rectangular Cross Section)	10 ×10 mm				
4.	Aluminium	Φ = 12.4 mm				

QUESTIONS

1. Why theoretical deflection values are not coincided practical deflection values?

2. Mention the significant of the experiment?