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EXPERIMENT – 01

TENSILE TEST ON MILD STEEL

Aim

To conduct tensile test on mild steel specimen and determine the following

1. Yield stress
2. Ultimate stress
3. Breaking stress
4. Percentage elongation
5. Percentage reduction in area

Reference IS 1608 Method for tensile testing of steel products.

Apparatus

Universal testing machine, test specimen, steel rule, vernier calipers, micrometer-graph.

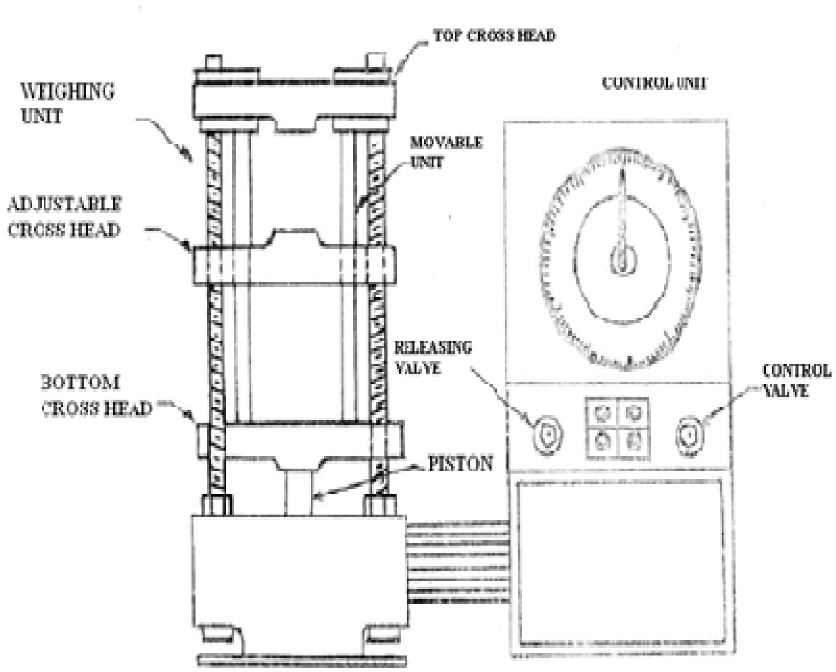


Fig 1.1 **Tension test Apparatus on mild steel**

System description

The machine consists of a weighing unit and control unit connected with each other by means of hydraulic pipes. In the weighing unit there are three cross heads (namely top, bottom and adjustable cross heads). Adjustable cross head can be adjusted in between top and bottom cross heads. The bottom cross head and top cross head are one unit and it is connected with the piston, which moves up and down inside the cylinder.

Theory

A tensile test is generally conducted on a test specimen to obtain the relationship between the stress and the strain which is an important characteristic of a ductile material. In the test, the uniaxial load is applied to the specimen and increased gradually. The corresponding deformations are recorded throughout the loading. Stress-strain diagrams of materials vary widely depending upon whether the material is ductile or brittle in nature. If the material undergoes a large deformation before failure, it is referred to as ductile material or else brittle material.

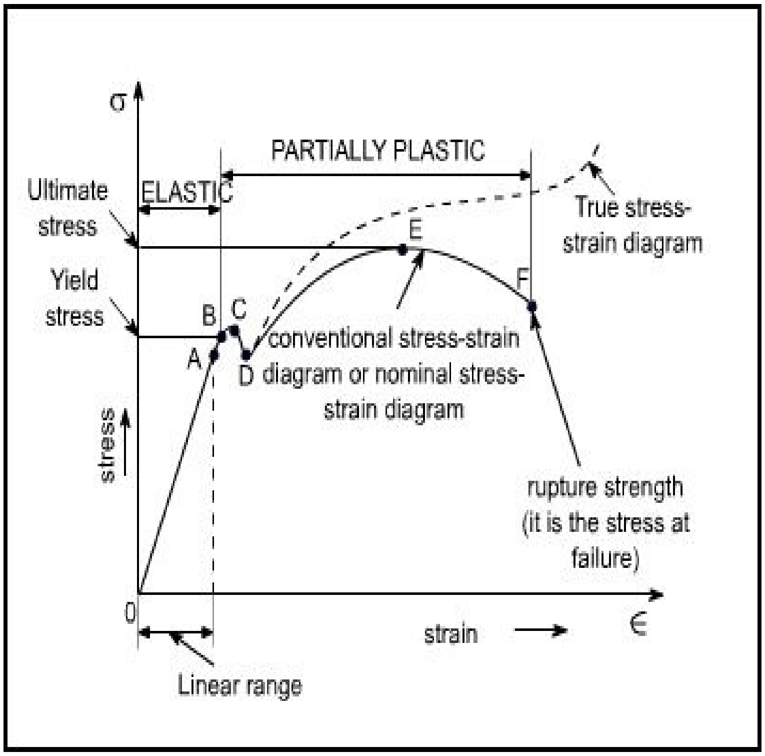


Fig 1.2 **Schematic showing typical tensile responses of a mild steel bar under tensile loading**

The stress-strain diagram for a mild steel specimen is shown in figure. The diagram begins with a straight line O to A, in which stress is directly proportional to strain. Point A marks the limit of proportionality beyond which the curve becomes slightly curved, until point B, the elastic limit of the material. If the load is increased further, yielding takes place. Point C is the point of sudden large extension, known as yield point. After the yield point stress is reached, the ductile extensions take place, the strains increasing at an accelerating rate as represented by C and D. The material becomes perfectly plastic in this region (C to D), which means that it can deform without an increase in the applied load. If the load is further increased, the steel begins to strain harden. During strain hardening, the material appears to regain some of its strength and offers more resistance, thus requiring increased tensile load for further deformation. The point E is the maximum load or ultimate load up to which the bar extends uniformly over it's parallel length, but if straining is continued, a local deformation (neck formation) starts at E and after considerable local extension, the specimen breaks at F called breaking stress.

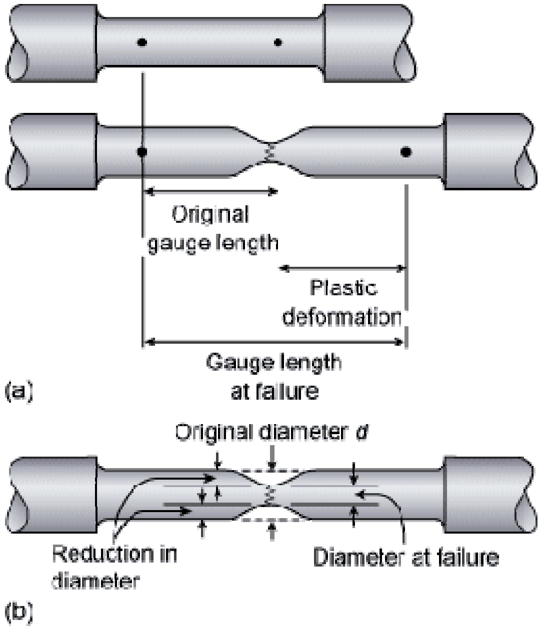


Fig 1.3 **Schematic showing the *necking* behavior in a metal**

Formulae

A measure of the *ductility* of a material is the magnitude of the plastic strain at fracture. Ductility can be specified in terms of either % elongation (% EL) or % reduction in area (% RA)

$$\% \text{ EL} = \left[\frac{(l_f - l_o)}{l_o}\right] \text{ x } 100 \qquad [4]$$

$$\% \text{ RA} = \left[\frac{(A_f - A_o)}{A_o}\right] \text{ x } 100 \qquad [5]$$

Where l_o and l_f refer to the initial and final specimen lengths, respectively and A_o and A_f refer to the initial and final cross-sectional areas of the specimen.

$$\text{Yield strength} = \frac{\text{Yield Load}}{\text{original cross sectional area}} \text{.......... ....} N/mm^2$$

$$\text{Ultimate strength} = \frac{\text{Maximum tensile Load}}{\text{original cross sectional area}} \text{.......... ....}$$

$$\text{Breaking strength} = \frac{\text{Breaking Load}}{\text{original cross sectional area}} \text{.......... ....} N/mm^2$$

Young's modulus= Slope of the stress –strain curve

$$E = \frac{d_Y}{d_X} \text{................} N/mm^2$$

$$\text{Percentage of elongation} = \frac{\text{Final length(at fracture) - Original length}}{\text{original length}}$$

$$\text{\% of elongation} = \frac{L_f - L}{L} \text{.......... ....\%}$$

$$\text{Percentage of reduction in area} = \frac{\text{Original area - Area at fracture}}{\text{original area}}$$

$$\text{\% of reduction in area} = \frac{A - a}{A} \text{.......... ....\%}$$

$$\text{Cross sectional area of neck } (a) = \frac{\pi}{4} x d^2 \text{.......... .... } mm^2$$

$$\text{Original area of the rod (A)} = \frac{\pi}{4} x D^2 \text{......................} mm^2$$

Where

d –Neck diameter of the mild steel rod in millimeters
D-original diameter of the rod in millimeters

Procedure

1. Clean the M.S rod and measure the original length (L) and diameter (d) of the specimen. The length may either be length of gauge section which is marked in the specimen with a preset punch or the total length of the specimen.
2. Mark the gauge length to determine the elongation by marking punch marks at 2.5times diameter distance on the specimen.
3. Fix the extensometer at the center of the specimen and adjust the extensometer reading to zero position. Also set the Vernier scale on the vertical column on machine on zero position to take reading in the plastic range.
4. Apply the load gradually and note down the value of load for every five division of increase in the extensometer reading.
5. Remove the extensometer after 70% of the yield load is applied .Yield load may be calculated by product of projected yield stress (250 N/mm² in case of steel) and the area of cross section.
6. Note down the load at yield i.e., the short deviation of time when the pointer remains stationary.
7. Increase the load and note down the ultimate load. At the ultimate load the red pointer will be left in position and the black point which indicates the instantaneous applied load will move in to reverse direction.
8. Note down the break point load at which the specimen fails.
9. Measure the distance between the two points A and B. This distance is known as final gauge length of the specimen.
10. Draw a graph between stress Vs strain by taking stress along Y axis and strain along X axis.
11. Take the slope of straight line portion of the curve which gives Young's Modulus of the material.

Tabulation

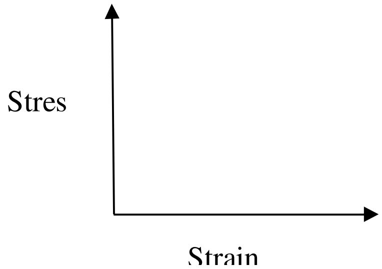
Table 1.1

Sl. No	Load (P) kN	Elongation in divisions	Elongation in mm	Stress (σ) N/mm^2	Strain (ε)	Young's Modulus (E) N/mm^2
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						

Graph

The following graph is drawn by taking **strain** along X-axis and **stress** along Y - axis.

- Stress Vs Strain



Observation

1. Material of the specimen =…………………..
2. Original gauge length of the specimen = ……
3. Original diameter of the specimen =………..
4. Neck diameter of the specimen =…………..
5. Initial gauge length of the specimen =………
6. Final length of the specimen =………………
7. Yield Point load =…………………
8. Ultimate load =……………………………….
9. Breaking load =………………………………

Precaution

1. If the strain measuring device is an extensometer it should be removed before necking begins.
2. Measure deflection on scale accurately & carefully

Result Tension test for given specimen was conducted and the results are as follows

1. Yield stress = …………………….. N/mm^2
2. Ultimate stress = ………………… N/mm^2
3. Breaking stress = ………………… N/mm^2
4. Percentage elongation = …………
5. Percentage reduction in area = …….

Inference

Significance of the test

The stress characteristics of mild steel and for steel can be found with help of this test. The yield stress of steel is important in design of flexural members. As per IS, the yield stress for mild steel is 250 N/mm^2.

Viva-voce Questions

1) Define the following properties of structural materials
   i) Ductility ii) Brittleness iii) Malleability
2) What happens if we unload the specimen after the material has yielded? (Draw sketch of the curve for unloading).
3) Define proof stress and Secant Modulus. When these are used?
4) How has the surface of the specimen changed at various load levels?
5) Are the Hardness and ductility related in anyway?
6) Which steel have you tested? What is its carbon content?
7) In what region of a stress vs. strain graph do you find Young's Modulus?
8) Why do you think we remove the extensometer after yielding occurs?
9) What general information is obtained from the tensile test regarding the properties of the material?
10) Which stress have you calculated Nominal stress (Engineering stress) or true stress?
11) What kind of fracture has occurred and why?
12) Which is the most ductile material? What is its elongation?

Space for Calculations

Graph paper to be added

Date:

EXPERIMENT 2

DEFLECTION TEST ON A SIMPLY SUPPORTED BEAM

Aim

To conduct deflection test on a simply supported beam carrying a point load at a distance '**a**' from left support.

Apparatus required

1. Deflection beam apparatus
2. Weights
3. Dial gauge
4. Magnetic dial stand
5. Vernier calipers
6. Scale/Steel tape

Theory

When the beam is subjected to load, the beam is deflected from its original position. The deflection of a member should always be within the specified limits. We can determine the deflection of beams subject to any type of loading by using standard deflection formulae. The actual deflection of the member is directly proportional to the load and cube of span (if subjected to point load) and is inversely proportional to flexural rigidity (EI). Actual deflection so calculated should be less than the permissible deflection.

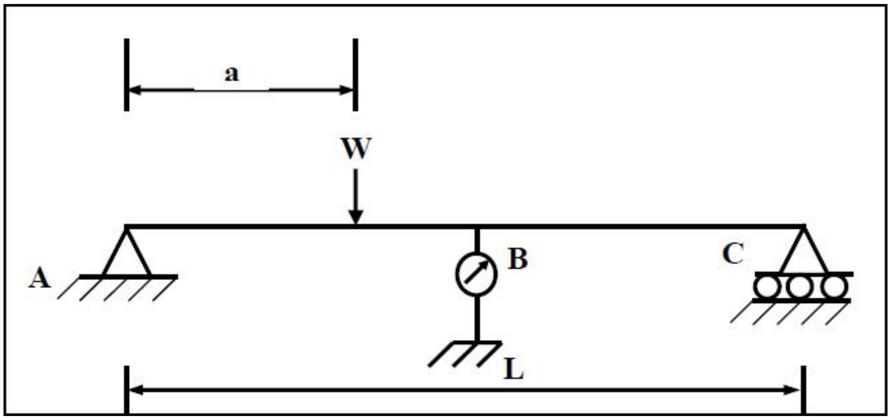


Fig 2(a)-1. **Deflection apparatus beam set up**

Where,

L-Span of the beam
W-Load applied

a-The distance of the load from left support

As the loading applied is transverse loading as shown in the Fig. 2(a)-2 which is perpendicular to the plane containing the neutral axis, and hence the member is a beam.

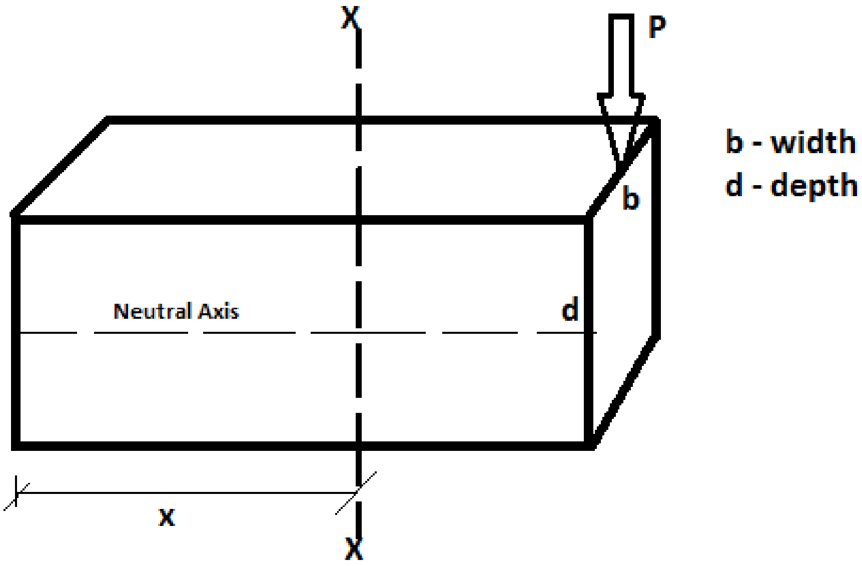


Fig 2(a)-2 **Beam carrying the Transverse loading**

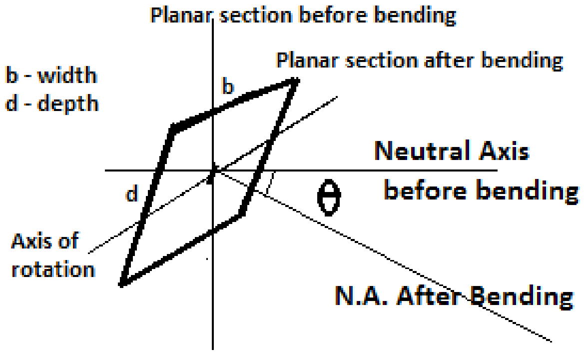


Fig 2(a)-3 **The cross section at XX**

Moment of Inertia is calculated about the axis of rotation = I = $\frac{bd^3}{12}$

Formulae

The general formula for deflection at mid span when load is applied at a distance 'a' is given by

$$\delta = \frac{Wa(3L^2 - 4a^2)}{48EI}$$

If load at 'a'=L/4 from left support and substituting in above equation,

Modulus of Elasticity, $E = \frac{11WL^3}{768\delta_{central} I}$ N/mm^2

(Deflection at the centre of the beam, span L is in 'mm' and W in N)

Modulus of Elasticity from graph, E = $slope X \frac{11L^3}{768I}$ =……………..N/mm^2

Procedure

1. Note the initial reading of the Vernier Scale.
2. Measure the breadth and depth of the given beam using Vernier Caliper.
3. Adjust cast iron blocks along the bed so that they are symmetrical with respect to the length of the bed.
4. Place the beam on the knife edges on the blocks so as to project equally beyond each knife edge. See that the load is applied at the centre of the beam.
5. Set the dial gauge below the center of the beam and note down the reference point from the dial gauge.
6. Measure the effective length of the beam by using scale or steel tape
7. Place the load frame at exact position on the specimen and note down the corresponding deflection from the corresponding deflection from the dial gauge
8. Similarly note down the dial gauge readings by placing different weights on the load frame.
9. Remove the load gradually and record the dial gauge readings while unloading.

Observations & Tables

Table 2(a)-1 Calculation of width of the beam

S.No.	Main scale reading (M.S.R.) in mm	Vernier scale coincidence (V.C.) div	Width=M.S.R+L.C.xV.C.
1			
2			
3			

Average width in mm=

Table2(a)-2 Calculation of depth of the beam

S.No.	Main scale reading (M.S.R.) in mm	Vernier scale coincidence (V.C.) div	Depth=M.S.R+L.C.xV.C.
1			
2			
3			

Average depth in mm=

1. Least count of Dial gauge= ………
2. Least count of vernier calipers=……..
3. Material of the beam =…………...
4. Length of beam =…………………mm
5. Breadth of beam =……………mm
6. Depth of beam =………………mm
7. Moment of Inertia of the beam=…………………....mm^4

Table 2(a)-3

Sl. No	Load		Deflection				Young's modulus
	W		Loading (δ1)	Unloading (δ2)	Avg. (δ)		E
Units	Kg	N	mm	mm	mm	m	N/mm^2
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							

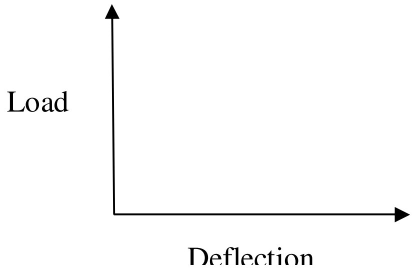
Precautions

1. Make sure that the beam and load are placed at desired positions.
2. Measure the dimensions of the beam carefully.

Graph

The following graph is drawn by taking **load** along Y-axis and **deflection** along X-axis.

- Load Vs Deflection



Result

The deflection test on given simply supported beam is conducted.

The Young’s modulus of the given beam from calculation = …………………… N/mm^2.

The Young’s modulus of the given beam from graph = ……………………..N/mm^2

Significance of the test

If the Young’s Modulus of the material of the specimen is equal to the standard value specified for the material, the deflection found to be correct.

Inference

Viva-voce Questions

1) Give assumptions in the theory of simple bending.
2) Is the theory of simple bending applicable to the beams used? Explain.
3) Draw SFD for the beam with given loading.
4) Draw BMD for the beam with given loading.
5) At which section of the beam, maximum bending stresses are induced?
6) At which section of the beam maximum shear stresses are induced?

Space for Calculations

Graph paper to be added

Date:

EXPERIMENT 03

DEFLECTION TEST ON A CANTILEVER BEAM

Aim

To conduct deflection test on the cantilever beam carrying a concentrated load at mid span.

Apparatus required

1. Deflection beam apparatus
2. Load frame
3. Weights
4. Dial gauge
5. Magnetic dial stand
6. Vernier Caliper
7. Scale / Steel tape

Theory

When the beam is subjected to load, the beam is deflected from its original position. Due to the load acting on the beam, it will be subjected to bending moment and the beam bend like arc of circle. All structural and machine elements whether, cantilever, simple supported, fixed or continuous undergoes deflection when subject to external loads. The deflection of a member should always be within the specified limits. We can determine the deflection of beams subject to any type of loading by using standard deflection formulae. The actual deflection of the member is directly proportional to the load and span cube (for point load application) and is inversely proportional to flexural rigidity (EI). Actual deflection so calculated should be less than the permissible deflection.

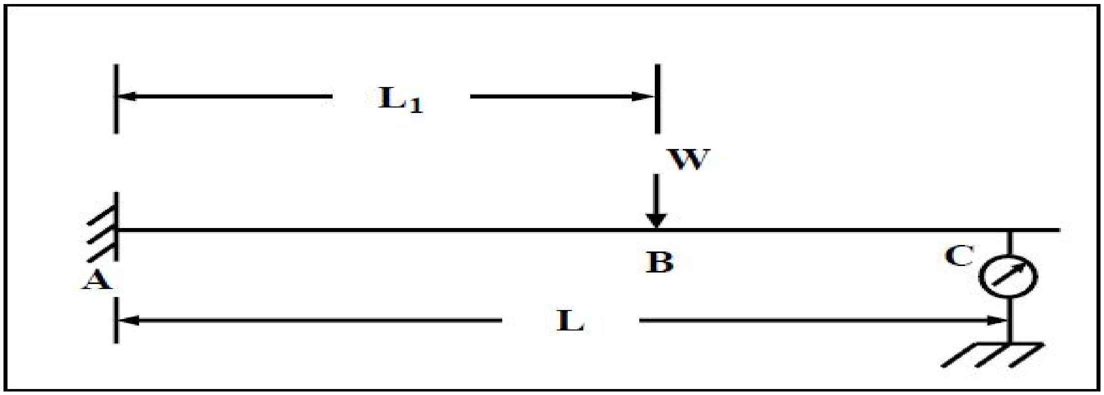


Fig 2(b)-1. **Deflection apparatus beam set up for Cantilever beam**

As the loading applied is transverse loading as shown in Fig.2(b)-2 which is perpendicular to the plane containing the neutral axis, and hence the member is a beam.

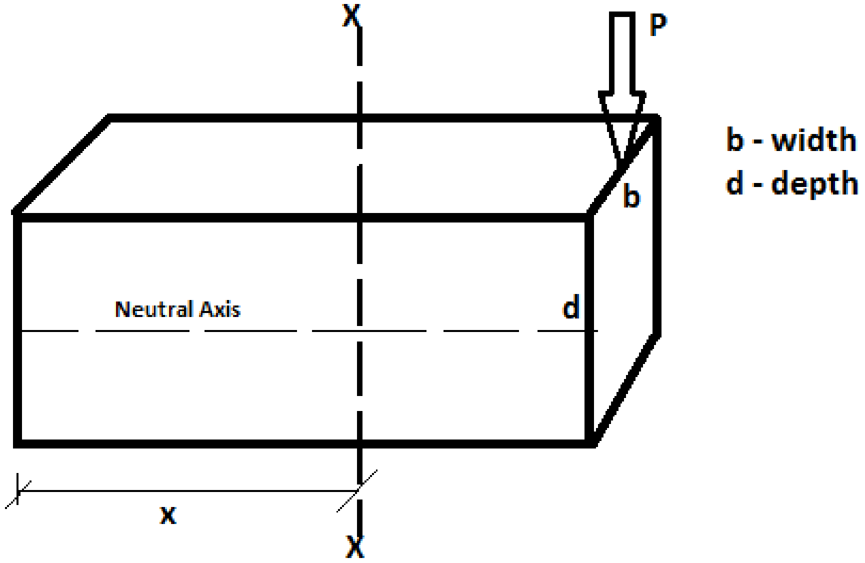


Fig 2(b)-2 **The beam carrying transverse loading**

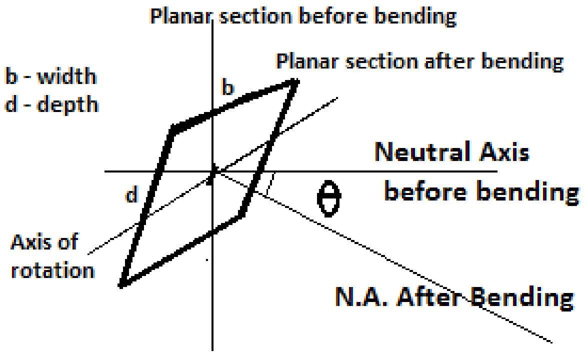


Fig 2(b)-3 **The cross section at XX**

Moment of Inertia is calculated about the axis of rotation = I = $\frac{bd^3}{12}$

Formulae

The general formula for deflection at free end when load is acting at a distance L_1 is given by

$$\delta = \frac{WL_1^3}{3EL} + \frac{WL_1^2(L-L_1)}{2EL}$$

If load applied at $L_1 = L/2$, applying in the above equation,

Modulus of Elasticity, $E = \frac{5WL^3}{48\delta I}$

Where

W= applied point load at mid span
L=length of beam
δ=deflection of the beam at dial gauge (free end)
I=Moment of Inertia of the beam

Modulus of Elasticity from graph, E = $slopeX\,\frac{5L^3}{48I}$ =……………………….N/mm^2

Procedure

1. Measure the breadth and depth of the given specimen using vernier calipers.
2. Mark the end of the beam.
3. Fix the beam at one end on the test rig support and other end of the beam is free.
4. Set the dial gauge below the free end of the beam and note down the reference point from the dial gauge.
5. Measure the effective length of the beam from the free end to fixed end by using scale or steel tape
6. Place the load frame at exact position on the specimen and note down the corresponding deflection from the corresponding deflection from the dial gauge
7. Similarly note down the deflections by placing different weights on the load frame.
8. Remove the load gradually and record the dial gauge reading while unloading.

Observations & Tabulation

Table 2(b)-1 Calculation of width

S.No.	Main scale reading (M.S.R.) in mm	Vernier scale coincidence (V.S.C.) div	Width = M.S.R+L.C.xV.S.C.
1			
2			
3			

Average width of the beam in mm=

Table 2(b)-2 Calculation of depth

S.No.	Main scale reading (M.S.R.) in mm	Vernier scale coincidence (V.S.C.) div	Depth=M.S.R+L.C.xV.S.C.
1			
2			
3			

Average depth of the beam in mm=

1. Least count of Dial gauge= ………
2. Least count of vernier calipers=……..
3. Material of the beam =…………...
4. Length of beam =……………
5. Breadth of beam =……………mm
6. Depth of beam =………………mm
7. Moment of Inertia of the beam (I) = mm^4

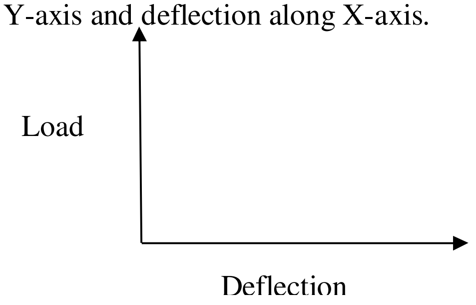
Table 2(b)-3 Observations from the test on……………

Sl. No	Load		Deflection				Young's modulus
	W		Loading (δ1)	Unloading (δ2)	Avg. (δ)		E
Units	Kg	N	mm	mm	mm	m	N/mm^2
1							
2							
3							
4							
5							
6							
7							

Graph

The following graph is drawn by taking load along Y-axis and deflection along X-axis.

- Load Vs Deflection



Precautions

1) Make sure that the beam and load are placed at proper positions.
2) Measure the dimensions of the beam accurately.
3) Note the readings of the Vernier accurately.

Result

The deflection test on given cantilever beam is conducted.

The Young's modulus of the given beam from calculation = ………………..… N/mm^2.

The Young's modulus of the given beam from graph = ………………..… N/mm^2

Inference

Significance of the test

If the Young's Modulus of the material of the specimen is equal to the standard value specified for the material, the deflection is found to be valid.

Viva-voce Questions

1. Draw deflected shape of the cantilever beam with Point Load at free end.
2. Draw the BMD and for given loading.
3. Draw the BMD if the load is applied at free end.
4. Draw the Free Body Diagram of the cantilever beam.

Space for Calculations

Graph paper to be added

Date:

EXPERIMENT 04

TORSION TEST

Aim

To find the Modulus of Rigidity of the given test specimen.

Material and Equipment

Torsion testing machine, Standard specimen of mild steel or cast iron, steel rule, and Vernier calipers (or) Micrometer.

Theory

Torsion test is quite instrumental in determining the value of modulus of Rigidity (ratio of shear stress to shear strain) of a metallic specimen. The value of modulus of rigidity can be found out through observations made during the experiment by using the torsion equation.

$$\frac{T}{I_p} = \frac{C\theta}{l} = \frac{q}{r}$$

Where, T = Torque applied

C = Modulus of rigidity

l = length of the shaft

q = shear stress

r = distance of element from centre of shaft

θ = Angle of twist (radians)

I_p = Polar moment of inertia.

In the torque equipment (refer figure shown in the next page), one end of the specimen is held by a fixed support and the other end to a pulley. The pulley provides the necessary torque to twist the rod by addition of weights (w). The twist meter attached to the rod gives the angle of twist.

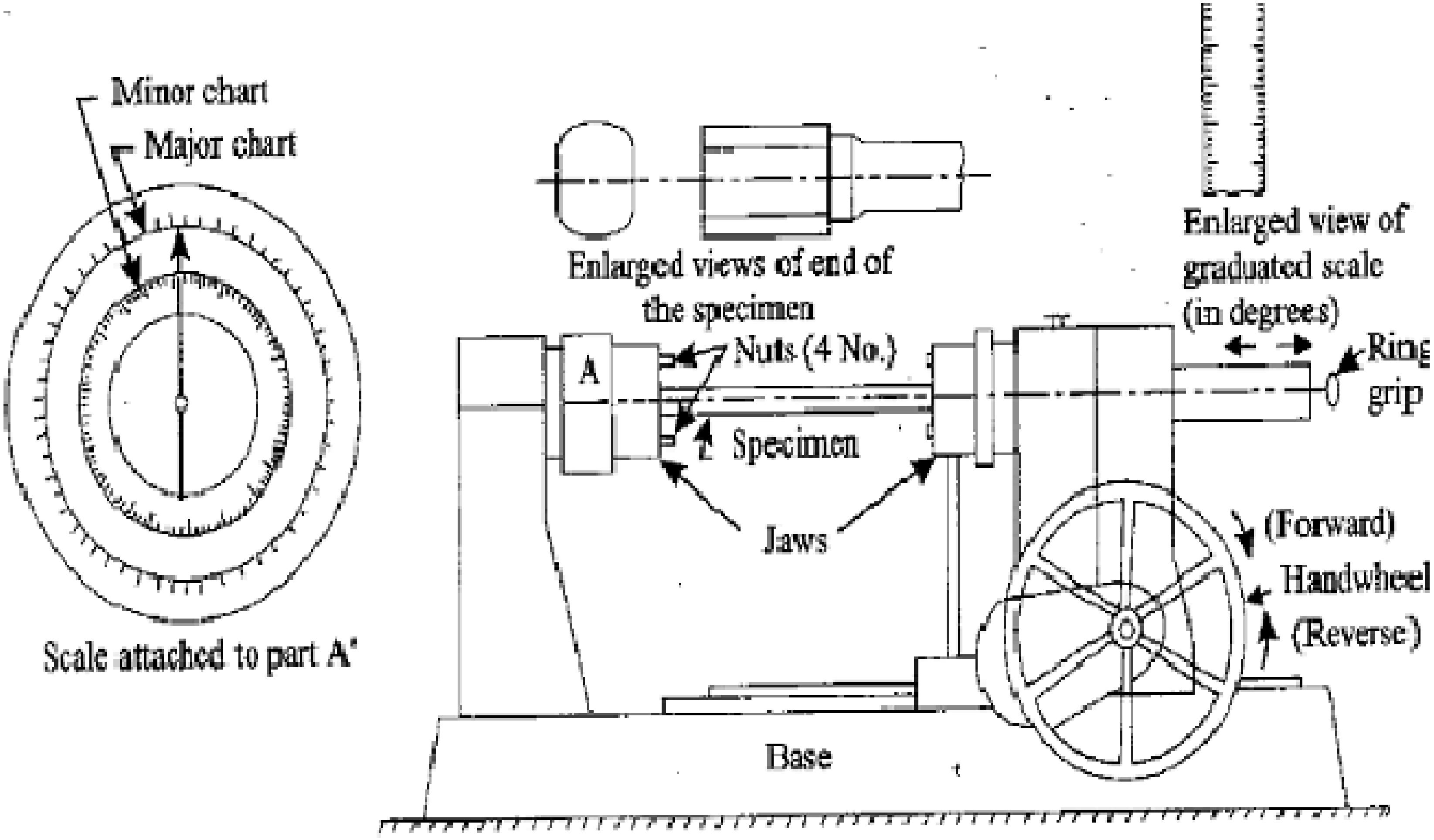


Fig.3.1 **Torsion Testing Machine**

Procedure

1. Measure the diameter at about three places and find the average value.
2. Select suitable grips to suite the size of the specimen and clamp it in the machine by adjusting the sliding jaw.
3. Choose the appropriate loading range depending upon specimen.
4. Set maximum load pointer to zero.
5. Continue till failure of the specimen.
6. Calculate the value of modules of rigidity C by using Torsion equation.
7. Plot a torque – Twist graph (T V/s θ).

Observation

Diameter of the Specimen, d = ……………………….mm

Gauge length of the Specimen, l =……………………...mm

Polar Moment of Inertia, $\frac{\pi d^4}{32}$ =………………………mm^4

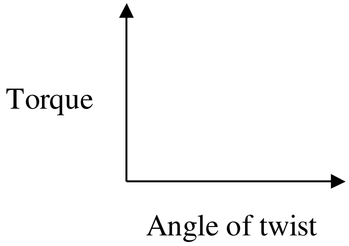
Tabulation

Table 3.1 Torsion test observations

S.No.	Angle of Twist (Deg.)	Angle of Twist (Radians)	Torque		Modulus of Rigidity (N/ mm^2)	Shear stress (N/ mm^2)
			N-m	N-mm		
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

Graph

1. Torque vs. Angle of Twist.



Result

Thus the torsion test on given mild steel specimen is done and the value of modulus of rigidity is calculated.

Rigidity modulus of the specimen calculated= …………………… N/mm^2

Rigidity modulus of the specimen from graph= …………………… N/mm^2

Inference

Reference

IS 1717: 2012 Metallic Materials — Wire — Simple Torsion Test

Significance of the test

When a shaft is subjected to torsion, pure shear stresses are developed in the shaft material. Hence Modulus of rigidity of the material can be determined.

Viva-voce Questions

1. State the assumptions made in the ‘simple torsion theory’.
2. Sketch the shear stress distribution across the cross section.
3. Why are hollow shafts preferred to solid shafts?
4. Sketch the shear stress distribution across the hollow section.
5. Define Torsional Rigidity.
6. Hollow shaft or solid shaft of the same material Which has the higher Modulus of Rigidity?

Space for calculations

Graph paper to be added

Date:

EXPERIMENT – 05

BRINELL HARDNESS TEST

Aim

To find the Brinell Hardness number for the given metal specimen.

Apparatus

Brinell hardness machine, test specimen and Brinell microscope.

Theory

Hardness represents the resistance of material surface to abrasion, scratching and indentation. In all hardness tests, a definite force is mechanically applied on the test piece for about 15 seconds. The indenter, which transmits the load to the test piece, varies in size and shape for different tests. Common indenters are made of hardened steel or diamond.

In Brinell hardness testing, steel balls are used as indenter. Diameter of the indenter and the applied force depend upon the thickness of the test specimen. For accurate results, depth of indentation should be less than 1/8th of the thickness of the test pieces.

System description

The machine consists of a lever of a dial indicator an elevating screw, a hand wheel, load changing lever, load lever, hanging weights, etc. there are two scales on the dial B scale marked in red color and C scale marked in black color. Each scale is graduated with hundred divisions. Zero reading in C scale is opposite to 30 numbers in B scale, so that there is a difference between C and B scales at any point. There are flat and V shape anvils available and they can be used for plane and cylindrical surface respectively. Anvil is placed on the elevating screw so that the specimen can be placed. Indenter can be hold in the indenter holder which is just above the elevating screw.

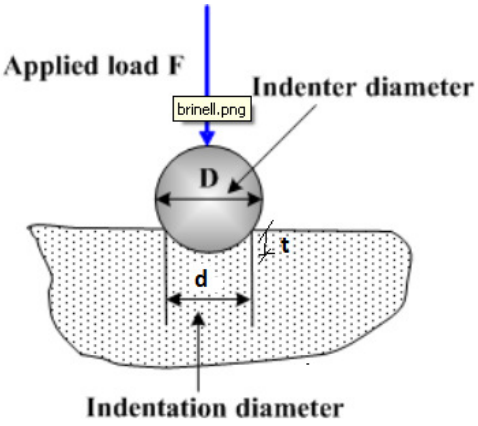


Fig 4(a)-1 **Brinell Indenter**

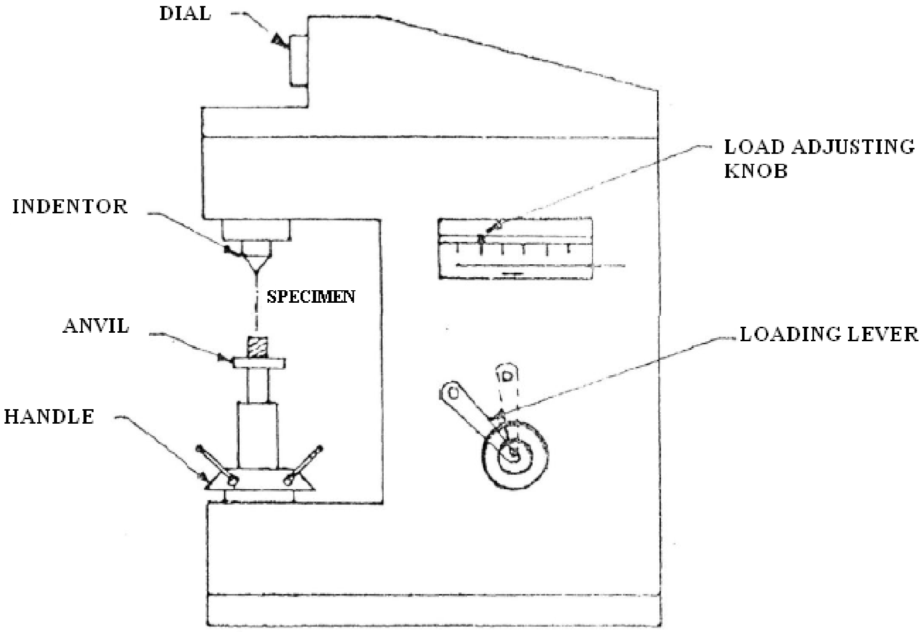


Fig. 4(a)-2 **Brinell Hardness Testing Machine**

Formulae

The depth of indentation, $t = \frac{D}{2} - \sqrt{\left(\frac{D^2}{4} - \frac{d^2}{4}\right)}$

The surface area of indentation = $\pi D t$

Brinell hardness number = Test load / Surface area of indentation

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

Where

D – Diameter of indenter in millimeters
d – Diameter of indentation in millimeters
P – Applied test load

Observations and calculations

1. Test piece material
2. Diameter of Ball
3. Load application time
4. Least count of Brinell Microscope

Tabulation

Table 4(a)-1

S. No.	Material of specimen	Load (P) Kg	Ball dia (D) in mm	Load applied 'P' in Kg_f.	Trial No	Dia of Indentation 'D_i or d' (mm)	Brinell Hardness Number	Mean Brinell Hardness Number
1	Mild steel				1			
					2			
					3			
2	Al				1			
					2			
					3			
3	High Carbon Steel				1			
					2			
					3			
4	Brass				1			
					2			
					3			
5.	Copper				1			
					2			
					3			

Procedure

1. Select the proper size of ball and insert ball of dia “D” in the ball holder of the m/c
2. Make the test specimen surface clean by removing dust, dirt, oil and grease etc.
3. Mount the test specimen surface at right angles to the axis of the ball indenter plunger.
4. Make contact between the specimen surface and the ball by rotating the jack adjusting wheel.
5. Apply the load by shifting the “load-lever” and wait for minimum 15 seconds. The load will be applied gradually.
6. Release the load by shifting the “load-lever”.
7. Remove the specimen from support table and mark the indentation so made.
8. View the indentation through microscope and measure the diameter‘d’ by micrometer fitted on microscope.
9. Repeat the entire operation, three times at other positions of test piece.
10. Calculate the value of BHN.

Precautions

1. The surface of the test specimen should be clean.
2. The testing machine should be protected throughout the test from shock and vibration.
3. The test should be carried out at room temperature.
4. The diameter of each indentation should be measured in two directions at right angles and mean of the diameter should be taken for calculation.

Result The given materials were tested and their Brinell hardness numbers are

1. Mild steel =……………………………BHN
2. High carbon steel =……………………BHN
3. Brass =…………………………………BHN
4. Copper =……………………………….BHN
5. Aluminum =……………………………BHN

Inference

Significance of the test

Brinell hardness test is best for measuring hardness of grey iron castings consisting of soft flake graphite, iron and hard iron carbide. Brinell hardness tests are conducted on structural steel, other rolled sections, steel cast iron, and aluminum castings and in most of forgings.

Reference

IS 1789-1961 Method for Brinell Hardness test for grey cast iron.
IS 3054-1965 Method for Brinell Hardness test for Copper and Copper alloys.
IS 15002005 method for Brinell hardness test for metallic materials

Viva-voce Questions

1. Derive the expression for Brinell Hardness Number.
2. Mention the classification of Hardness tests and mention the scales used.

Date:

EXPERIMENT – 6

ROCKWELL HARDNESS TEST

Aim

To determine the Rockwell hardness number of the given specimen.

Apparatus

Rockwell hardness testing machine, penetrator and test specimen.

Theory

The hardness of a material is resistance to penetration under a localized pressure or resistance to abrasion. The general method of judging the hardness is measuring the resistance of a material to indentation. Hardened steel, sintered tungsten carbide or diamond indenters are generally used for indentation. In this tests, a load is applied by pressing the indenter at right angles to the surface being tested. The hardness of the material depends on the resistance which it exerts during a small amount of yielding or deformation. The resistance depends on friction, elasticity, viscosity and the intensity and distribution of plastic strain produced by a given tool during indentation. Various scales in Rockwell hardness test are given below-

Table 4(b)-1.

Scale	Type of indenter (Dimensions)	Color	Initial load (Kgf)	Major load (Kgf).	Pointer position on dial.	Kind of material.
A	Cone, 120^0	Black	10	50	0	Much harder such as carburized steels, cemented carbides.
B	Ball, 1.588 mm	Red	10	90	30	Soft steels, copper, brass, grey cast iron.
C	Cone, 120^0	Black	10	140	0	Hard steels, Ti, W, Va, etc.

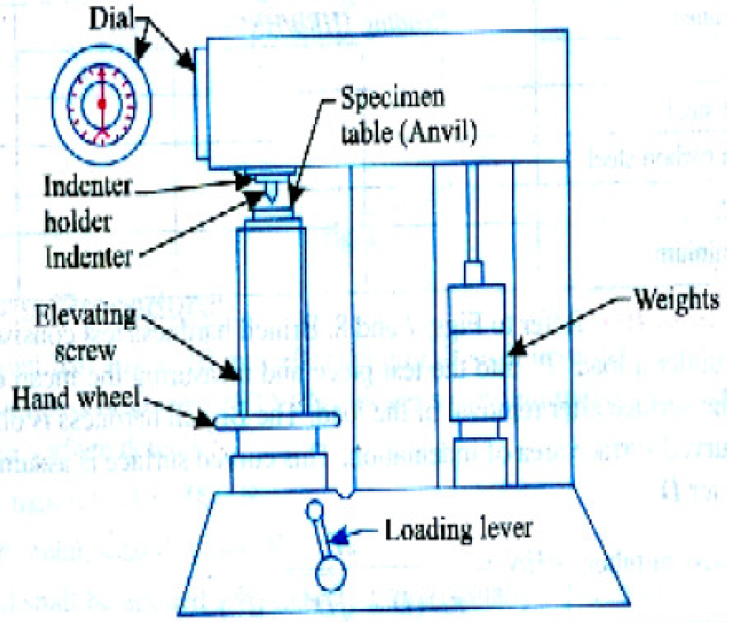


Fig.4(b)-1 **Rockwell Hardness Testing Machine**

Procedure

1. Select the proper size of ball and insert ball of diameter “D” in the ball holder of the m/c
2. Make the test specimen surface clean by removing dust, dirt, oil and grease etc.
3. Mount the test specimen surface at right angles to the axis of the ball indenter plunger.
4. Place the specimen on platform of a machine. Using the elevating screw raise the platform and bring the specimen just in contact with the ball. Apply an initial load until the small pointer shows red mark.
5. Release the operating valve to apply additional load. Immediately after the additional load applied, bring back operating valve to its position.
6. Read the position of the pointer on the relevant scale of graduation, which gives the Rockwell hardness number.
7. Repeat the procedure three times on the specimen selecting different points for indentation.

Precautions

1. Indentation should not be made nearer to the edge of a specimen to avoid unnecessary concentration of stresses. In such case distance from the edge to the center of indentation should be greater than 2.5 times diameter of indentation.
2. Rapid rate of applying load should be avoided. Load applied on the ball may rise a little because of its sudden action. Also rapidly applied load will restrict plastic flow of a material, which produces effect on size of indentation.
3. After applying major load, wait for some time to allow the needle to come to rest.
4. Test specimen should not be subjected to any heating or cold working.
5. Thickness of the specimen should not be less than 8 times the depth of indentation to avoid the deformation to be extended to the opposite surface of a specimen.

Tabulation

Table 4(b)-2

Sl No.	**Material**	**Load in Kgf**	**Indenter Scale**	**Trial Number**			**Rockwell Hardness Number (HRC)**
				1	**2**	**3**	
1							
2							
3							

Observations

1. Material of test piece
2. Hardness of scale used
3. Minor load
4. Major load

Result

Rockwell Hardness number of the specimen was found for the given material as follows

1. Copper = ……………………….. HRC
2. Brass = ……………………….. HRC
3. Aluminum = ……………………….. HRC

Inference

Significance of the test

The Rockwell test is rapid and simple in operation and may be used on thinner specimens, and very soft to very hard materials. It is essentially used to determine the hardness of finished parts (bearings, valves, nuts, bolts, gears, etc.) cutting tools and forming tools, small castings and forging, sheet metal, large diameter wire, electrical contacts, plastic sheets or parts and case hardened parts etc.

Reference

IS 5652-1 (1993) Rockwell (A scale) hardness test for Hard Metals.

IS 1586-2000 Method for Rockwell Hardness Test for Metallic material (Scales A,B,C,D,E,F,G,H,K scales).

Viva-voce Questions

1) What is Hardness?
2) State the difference between Rockwell and Brinell Hardness tests. Can they be related to any other property of the material?

Space for calculations

Date:

EXPERIMENT 07

SPRING TESTING

Aim

To determine the modulus of rigidity of the material of given close coiled helical the spring.

Apparatus

1. Spring testing machine
2. Screw gauge
3. Vernier caliper
4. Close coil helical spring.

Theory

Spring is an elastic member, which deflects, or distorts under the action of load and regains its original shape after the load is removed. Springs May be made of carbon steel, silicon steel, manganese steel or completely alloyed steels. It is essential to know the rigidity modulus of the springs because it is used as energy absorbing device. The helical spring are made up of a wire coiled in the form of a helix and is primarily intended to store strain energy due to axial tensile or compressive load.

Formulae

$$\text{Modulus of rigidity (C or G or N)} = \frac{8\,W\,D^3\,n}{d^4\delta}$$

Where

W – Applied load in Newton's
δ Deflection of spring in millimeters
C – Rigidity modulus or shear modulus of spring in N/mm^2
D – Mean Diameter of spring in millimeters
n – Number of turns of coil in the spring.
d – Diameter of spring wire in millimeters.

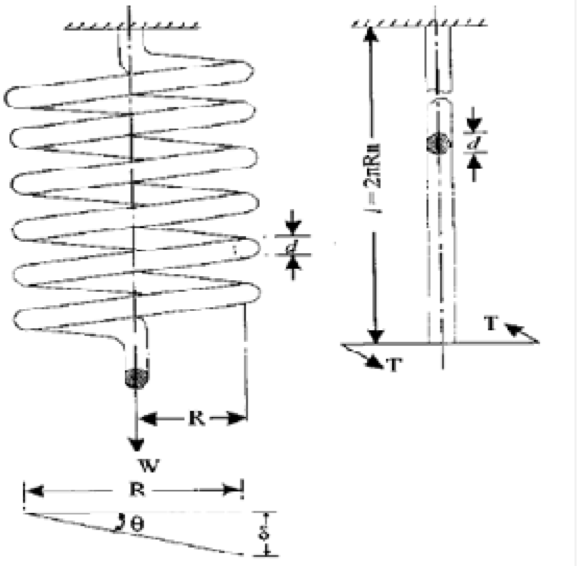


Fig 5.1 **Closely coiled helical spring**

Tabulation

Table 5.1

Sl No	Applied Load W(N)	Deflection of the Spring in mm			Stiffness of the Spring (K=W/δ) (N/mm)	Rigidity Modulus G (N/mm^2)
		loading	unloading	Avg (δ)		
1						
2						
3						
4						
5						

Procedure

1. By using Vernier caliper measure the diameter of the wire of the spring and also the diameter of spring coil.
2. Count the number of turns.

3. Insert the spring in the spring testing machine and load the spring by a suitable weight and note the corresponding axial deflection in compression.
4. Increase the load and take the corresponding axial deflection readings.
5. Plot a graph between load and deflection. The slope of the graph gives the stiffness of the spring.

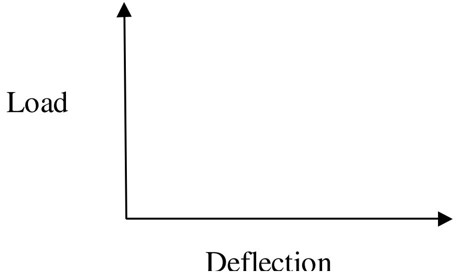
Observations

1. Least count of the screw gauge =..................
2. Diameter of the spring wire (d) =..........................mm
3. Least count of the Vernier calipers =..................
4. Outer to Outer Diameter of the spring coil (D_0)=............................mm
5. Mean coil diameter (D) =. $D_0 – 0.5\ d – 0.5\ d$ = ...mm
6. Mean coil radius (R) =.......................................mm
7. Number of turns in the coil (n) =...................

Graph

The following graph is drawn by taking load along Y-axis and deflection along X-axis.

· Load Vs Deflection



Result

Rigidity modulus of the spring from calculation= ………………………… N/mm^2
Rigidity modulus of the spring from graph = …………………………… N/mm^2

Inference

Significance of the test

If the value of Rigidity Modulus found using the test is in agreement with the standard value, then the test conducted is correct. Rigidity modulus is the property of material representing the torsional characteristics of the spring material.

Viva-voce Questions

1. Mention the classification of types of springs and give at least one example for each.
2. What are the assumptions made in the derivation of deflection equation for a close coiled helical spring?
3. Distinguish between close coiled and open coiled springs.
4. Define Modulus of Rigidity and state the relationship between E, K, G and μ.
5. Derive the formula used in the test procedure.

Space for calculations

Graph paper to be added

Date:

EXPERIMENT 08

COMPRESSION TEST

Aim

To determine the compressive strength of a given brick.

Apparatus

Vernier calipers Scale, Compression testing machine.

Theory

Bricks are used in construction of either load bearing walls or in partition walls of framed structure as shown in the Fig.6-1. In load bearing walls total weight from slab and upper floor comes directly through brick wall and then it is transferred to the foundation. In this case the bricks are loaded with compressive nature of force on other hand in framed structure bricks are used only for construction of partition walls, in which layer comes directly on the lower layers of wall. However in any case the bricks in actual practice are to be tested for their compressive strength.

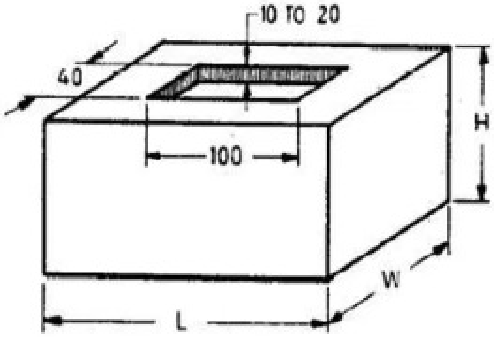


Fig 6.1 **Burnt clay brick**

Procedure

A. Preparation of test specimen

1) Remove unevenness observed in the bed faces to provide two smooth and parallel faces by grinding.
2) Immerse in water at room temperature for 24 hours.
3) Remove the specimen and drain out any surplus moisture at room temperature.
4) Fill the frog (if provided) and all voids in the bed face with cement mortar (1 cement, 1 clean course sand of grade 3mm and down).

5) Store under the damp jute bags for 24 hours followed by immersion in clean water for 3 days.
6) Remove, and wipe out any traces of moisture.

B. Test Procedure

1) Measure the length and breadth of the specimen at the center of the brick.
2) Place the specimen with flat faces horizontal, and mortar filled face facing upwards between two 3-plywood sheets each of 3mm thickness and carefully centered between plates of the testing machine.
3) Apply load axially at a uniform rate of 14 N/mm^2 ($140 kgf/cm^2$) per minute till failure occurs and note the maximum load at failure.
4) The load at failure shall be maximum load at which the specimen fails to produce any further increase in the indicator reading on the testing machine.
5) Calculate the compressive strength.
6) Repeat the test procedure for minimum of 3 bricks and report the average.

Formula

$$\text{Compressive Strength} = \frac{\text{Max.Load at failure}}{\text{Loaded Area of brick}}$$

Tabulation

S.N	Identification Mark	Area A=L X B	Height (H)	Load (N) (P)	Compressive Strength (stress) P/A (N/mm^2)	Average Compressive Strength N/mm^2
1						
2						
3						

Precautions

1. Measure the dimensions of Brick accurately. .
2. The range of the gauge fitted on the machine should not be more than double the breaking load of specimen for reliable results.

Result

The average compressive strength of brick sample is found to be…………..

Inference

Reference

IS 3495 Method of tests of burnt clay building bricks
Part I – Determination of compressive strength

Significance of the test

For load bearing walls, compressive strength of brick is the criterion to decide the thickness of the wall.

Viva-voce Questions

1. Why Bricks tested for compressive strength?
2. Define frog?
3. Why do you sprinkle water on bricks before actual use?
4. Write the maximum and minimum limits of compressive strength of bricks?
5. What are the classifications of bricks as per IS 1077? And classify the brick you tested as per the code.
6. Compression tests are generally performed on brittles materials-why?
7. Which will have a higher strength a small specimen or a full size member made of the same material?
8. What is column action? How does the h/d ratio of specimen affect the test result?
9. How do ductile and brittle materials differ in their behavior in compression test?
10. What are bi-modulus materials? Give examples.
11. Are the compressive strength and the specific gravity related? If so, what trends do the data indicate.

Space for calculation

Date:

EXPERIMENT 9

IZOD IMPACT TEST

Aim

To determine the Impact toughness (strain energy) of a given specimen through Izod Impact test.

Apparatus

Izod impact testing machine, test specimen of mild steel, Aluminum, Vernier calipers, steel rule and specimen setting fixture.

Theory

In manufacturing locomotive wheels, connecting rods etc. the components are subjected to impact (shock) loads. These loads are applied suddenly. The stress induced in these components is more than stress produced due to gradually applied loads. Therefore, impact tests are performed to assess shock absorbing capacity of materials subjected to suddenly applied loads. These capabilities are expressed as (i) rupture energy (ii) Modulus of rupture (iii) Notch impact strength.

Two types of notch impact tests are used

1. Charpy test
2. Izod test

In Charpy test, the specimen is placed as ‘cantilever beam’. The specimens have V-shaped notch of 45^0 or a U-shaped notch. The notch is located on tension side of specimen during impact loading. Depth of notch is generally taken as t/5 to t/3, where ‘t’ is thickness of the specimen.

Impact Strength The resistance of material to fracture under suddenly applied loads is known as Impact Strength.

Specification of M/c and Specimen details

- Impact capacity 300joule
- Least count of capacity (dial) scale = 2 joule
- Weight of striking hammer = 18.7 kg
- Swing diameter of hammer = 1600mm
- Angle of hammer before striking = $90^0/135^0$
- Distance between supports = 40mm.
- Striking velocity of hammer = 5.6m/sec.
- Specimen size = 75 X10 X 10 mm

- Type of notch = V-notch
- Angle of notch = 45^0
- Depth of notch = 2mm.

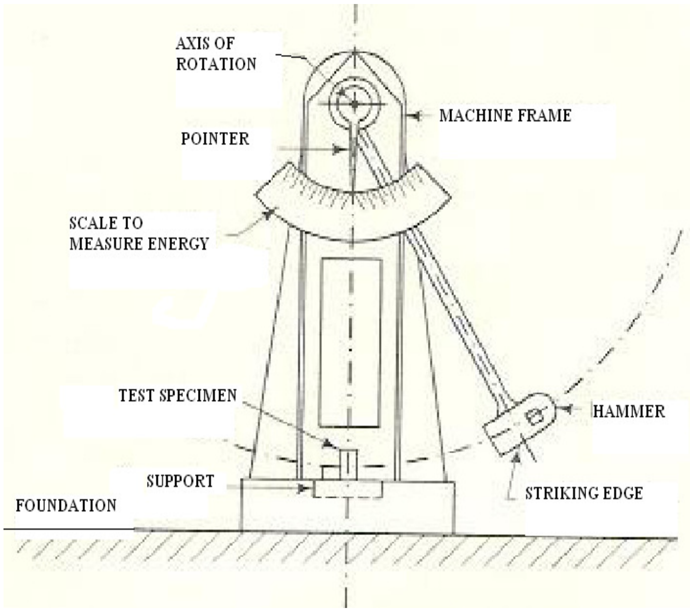


Fig 7(a)-1 **Izod Impact testing machine**

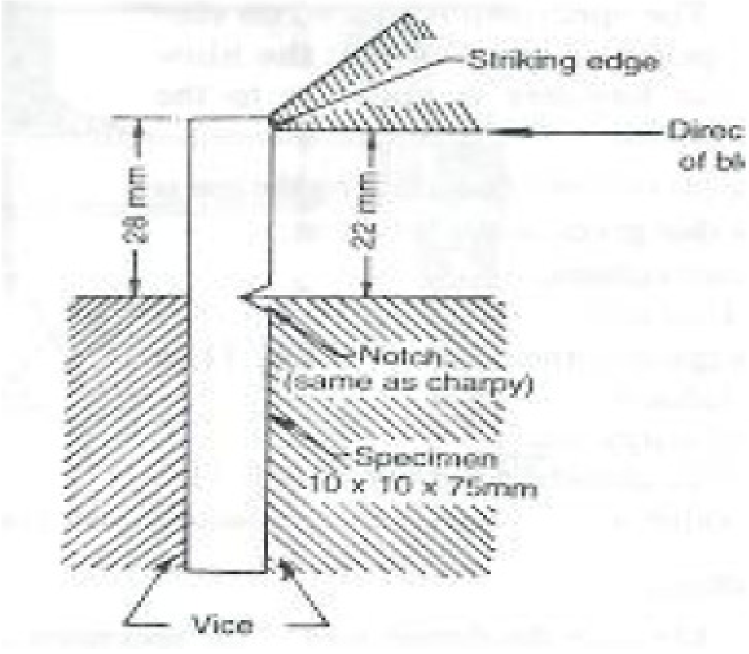


Fig 7(a)-2 **Specimen position in Izod Impact testing**

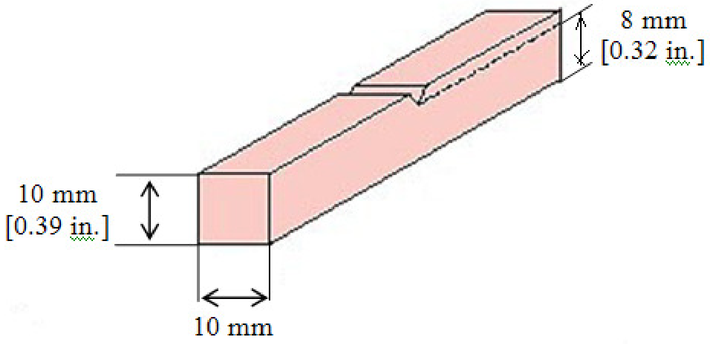


Fig 7(a)-3 **Specimen dimensions in Izod Impact testing**

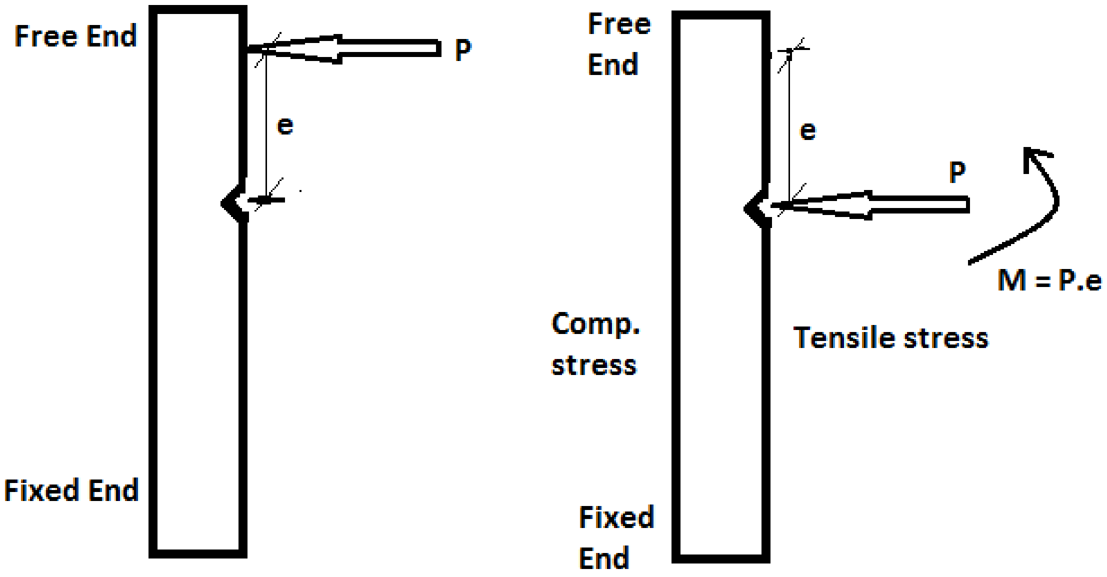


Figure showing the specimen with the equivalent load (P) accompanied by the moment (M)

Fig 7(a)-4 **Specimen showing the equivalent load in Izod Impact testing**

The accompanying moment as shown in the Fig. 7(a)-4 will produce bending stress. Tensile stress on the striking face and compressive stress on the non-striking face.

Procedure

1. With the striking hammer (pendulum) in safe test position, place the test specimen in impact testing machine's anvil in such a way that the notch face the hammer and is half inside and half above the top surface of the anvil. The notch is on the tension face. For a standard test, the energy is set to 168 J.
2. Bring the striking hammer to position of Initial energy, and lock it at this position.
3. Note down the initial energy.

4. Release the hammer by trigger, it will fall due to gravity and break the specimen through its momentum, the total energy is not absorbed by the specimen. Then it continues to swing. At its topmost height after breaking the specimen, the indicator stops moving, while the pendulum falls back. Note the indicator reading at the top most final position.
5. Again bring back the hammer to its initial position and lock it.
6. Remove the broken specimen by loosening the clamping screw.

Tabulation

Area of cross- section of specimen (A) __________

S.No.	**Material**	**Initial Energy (E_1) In Joule**	**Absorbed Energy (E_2) In Joule**	**Residual Energy $E_3=(E_1-E_2)$ in Joule**	**Impact Energy $I = E_2/A$ In Joule/mm^2**

Calculations

1. Modulus of rupture = Rupture/Effective volume of specimen
2. Notch impact strength = Absorbed energy/ Effective cross section area.

Precaution

1. **Do not stand in front of the swinging hammer or releasing hammer.**
2. The specimen should be prepared in standard dimensions.
3. Bring the loose pointer in contact with the fixed pointer after setting the pendulum.
4. Hold the specimen (lzod test) firmly.

Result

S.No.	Material	Energy Absorbed J/mm^2

Inference

The test is conducted using different material specimens. The softer materials undergo large deformation and hence work done is more. As a result, the energy absorbed is higher for soft materials than other materials.

Significance of the test

Impact test is very useful in testing materials, which have not been properly heat-treated. Heat treatment gives poor impact or Izod values. Wrought iron has very high impact value.

Reference

IS 1598 Method for Izod Impact test (V – Notch) for steel.

Viva-voce Questions

1. Why do we conduct Izod impact test on metals?
2. What the impact test signifies the character of material?
3. What is the difference between Izod, Charpy and Victor's impact tests?

Date:

EXPERIMENT 10

CHARPY IMPACT TEST-

Aim

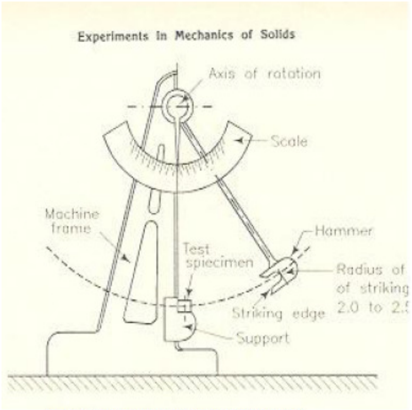
To study the Impact testing M/c, and perform the charpy impact test.

Apparatus Impact testing M/c, charpy test specimens of mild steel, Aluminum, Vernier calipers, specimen setting fixture.

Theory Same as experiment 7(a)

Mounting of specimen

Specimen is tested as a beam supported at each end (Fig.7b). Hammer is allowed to hit then specimen at the opposite face behind the notch.



Charpy impact testing equipment

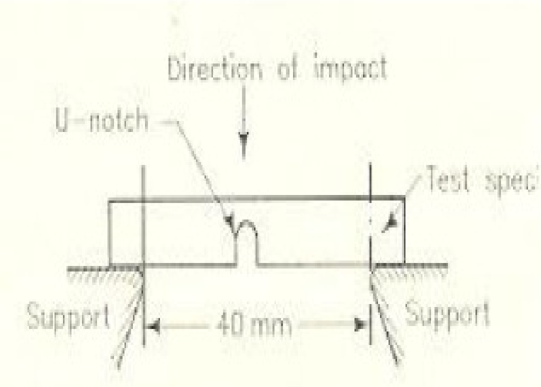
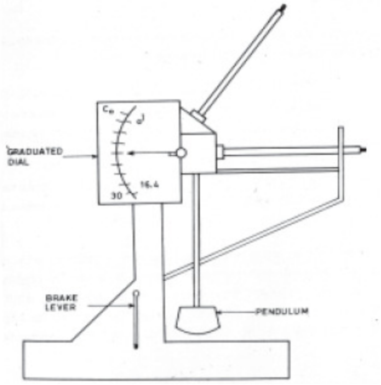


Fig 7(b)-1 **Izod / Charpy testing machine**



Procedure

1. Lift the hammer to an appropriate knife edge position and note the energy stored in the hammer. For the standard charpy test the energy stored should be 300J
2. Place the test specimen on the m/c supports. The notch is on the tension face.

3. Release the hammer. The hammer will break the piece and shoot up the other side of the specimen.
4. Note the energy indicated on the scale by the hammer.
5. Impact strength of the test specimen is the difference of the initial energy stored in hammer and the residual energy.

Tabulation

Area of cross- section of specimen (A) __________

S.No.	**Material**	**Initial Energy (E_1) In Joule**	**Absorbed Energy (E_2) In Joule**	**Residual Energy $E_3=(E_1-E_2)$ in Joule**	**Impact Energy I = E_2/A In Joule/mm^2**

Calculations

1. Modulus of rupture = Rupture/Effective volume of specimen
2. Notch impact strength = Absorbed energy/ Effective cross section area.

Precautions

1. **Do not stand in front of swinging hammer or releasing hammer**.
2. The specimen should be prepared in standard dimensions.
3. Make the loose pointer in contact with the fixed pointer after setting the pendulum.
4. Place the specimen in proper position.

Result

S.No.	Material	Energy Absorbed J/mm^2

Inference

The test is conducted using different material specimens. The softer materials undergo large deformation and hence work done is more. As a result, the energy absorbed is higher for soft materials than other materials.

Significance of the test

Impact test is very useful in testing materials, which have not been properly heat-treated. Heat treatment gives poor impact or Izod values. Wrought iron has very high impact value.

Reference

IS 1499 Method for Charpy Impact test (U – Notch) for steel.

IS 1757 Method for Charpy impact test (V notch) for metallic material

Viva-voce Questions

1. What do you mean by modulus of toughness or “Toughness Index” of a material?
2. Why notch is provided in the specimen for impact test?
3. What is the reason for placing the notch on tension side?
4. Does the specimen break into two parts? If not why?
5. How is impact strength denoted, if test is conducted with a non-standard machine?
6. Can impact test conducted with different dimensions be compared?