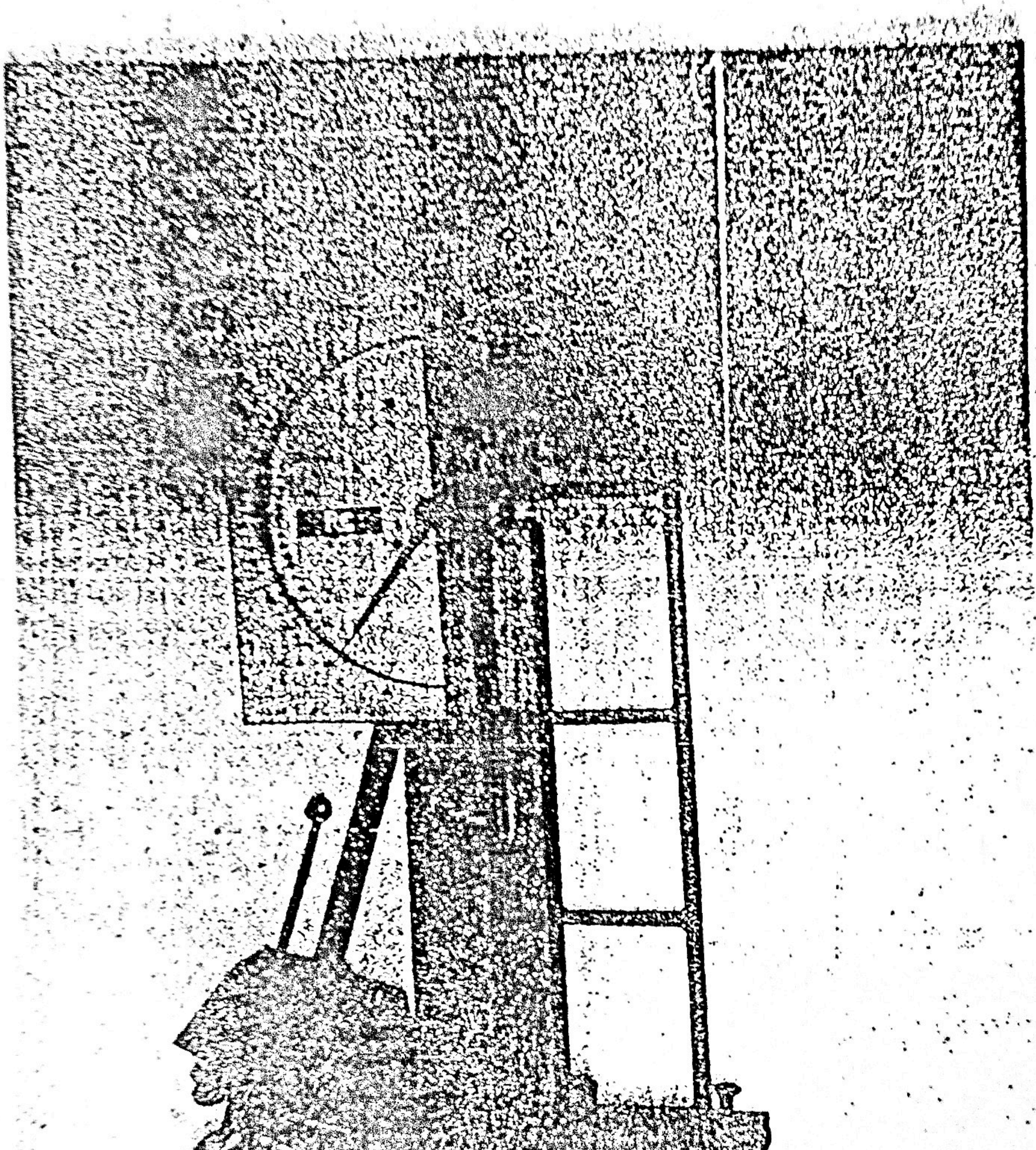
DEPARTMENT OF CIVIL ENGINEERING

M. A. Mannan

STRUCTURAL ENGINEERING LABORATORY

COURSE : STRENGTH OF MATERIALS LAB



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Structural Engineering Laboratory

EXPERIMENT NO. 1

DEFLECTION TEST ON SIMPLY SUPPORTED BEAM

AIM: To find Young's Modulus of elasticity of a given material of beam by conducting deflection test on simply supported setup.

APPARATUS: Simply supported Beam, scale, dial gauges, weights, vernier calipers .

THEORY:

a) A simply supported beam is supported by hinge at one end and roller support at the other end

The second moment of area or moment of inertia of an area is defined as

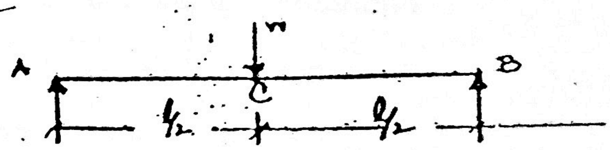
$$I = \int p^2 \, dA$$

Where I is the second moment of area and 'p is the perpendicular distance from the axis to the elemental area. In case of rectangular section, I about the centroidal axis is given by:

$$I = \frac{bd^3}{12}$$

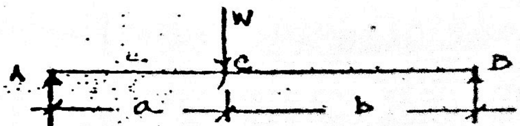
The maximum deflection of a simply supported beam subjected to central load is given by

$$\Delta_{max} = \frac{WL^3}{48EI}$$

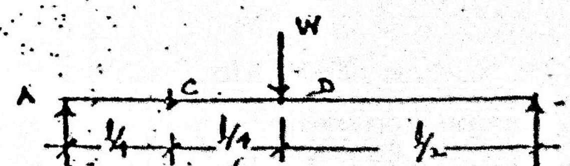


Eccentric load

$$\Delta_c = \frac{Wab\,(L^2 - a^2 - b^2)}{6EIL}$$



b) the Maxwell-Betti Law is mathematically expressed as : $\Delta ij = \Delta ji$



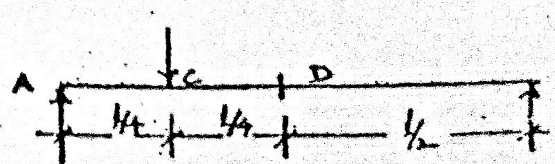
i) Let the load be applied at center:

To find deflection at c:

$$\Delta_c = \frac{11}{768} \frac{WL^3}{EI}$$

ii) Let the load be applied at C

To find deflection at D



$$\Delta_D = \frac{11}{768} \frac{WL^3}{EI}$$

DESCRIPTION OF APPARATUS:

The beam set up consists of a mild steel rectangular frame as shown in figure with a horizontal slit made out of two horizontal square tubes to mount the beam supports. The supports can be mounted at any desired position by means of knobs and support plates. In order to rest the beam on sharp edges, knife edge blocks are fixed to the support blocks by means of bolts and nuts.

To measure the deflection at any section a dial gauge is mounted on dial gauge stand fixed to the frame near that particular point

PROCEDURE:

1) Measure width (b) and depth (d) of the beam with the help of a caliper.and record them.

2) Mount the supports according to the length of beam

3) Place the beam on supports and see that the beam is horizontal. Measure and note the span of beam (distance of supports)

4) Fix up dial gauge stand to the frame near mid point of the beam. Care should be taken to see that the dial gauge pin is in contact with the beam at the central point of the beam, note initial reading of the dial gauge.

5) Apply load W at mid span of beam by hanging weights at that point. The beam will deflect under the load. Note the final reading of the dial gauge. The difference between initial and final reading will give deflection of beam under the load.

6) Take number of similar readings with different weights

7) Repeat procedure for different cases.

OBSERVATIONS:

a) Central load

Material of beam =

Span (L) =

Width (b) =

Depth (d) =

Moment of inerita $I = \dfrac{bd^3}{12}$

$E = \frac{WL}{48 \Delta I}$

Sl.No	Load W kgs	Dial Guage Reading			$E = WL^3/(48\Delta I)$
		Initial mm	Final mm	Difference mm	
1					
2					
3					
4					
5					

RESULT:

a)

b)

c)

Note : In each case plot load vs deflection graph.

DISCUSSIONS:-

1. What is bending formula. Explain each term ?
2. What is meant by section modulus?
3. Draw bending stress distribution for a rectangular beam supported on:
   i) simple supports.
   ii) one end is fixed & the other end is free. ?
4. What is neutral axis ?
5. What is meant by modulus of rupture?
6. What are the points of contraflexure? Where do they occur?

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EXPERIMENT NO. 2

DEFLECTION TEST ON CANTILEVER BEAM

AIM: To find the Young's Modulus of Elasticity of the given material of beam by conducting deflection test on a cantilever beam setup.

APPARTUS: Cantilever beam, scale, dial gauges, weights, vernier calipers.

THEORY: A cantilever beam is fixed at one end and free at the other end.

The second moment of area or moment of inertia of an area is defined as

$$I = \int P^2 \, dA$$

Where I is the second moment of area and 'p' is the perpendicular distance from the axis to the elemental area. In case of rectangular section, I about the centroidal axis is given by

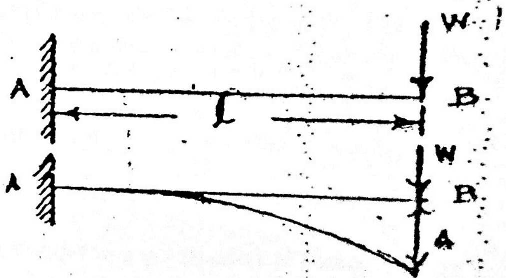
$$I = \frac{bd^3}{12}$$

The maximum deflection of a cantilever beam for different cases is as follows.

a) Load at free end.

Deflection at free end 'B'

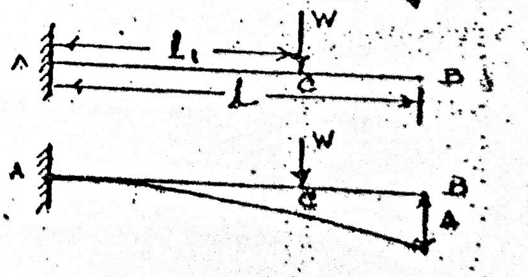
$$= \frac{WL^3}{3EI}$$



b) Load at Intermediate pt. 'C'

Deflection at free end

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



PROCEDURE:

1. Measure width b and depth d of the beam with the help of caliper and record them.
2. See the beam is horizontal. Measure and note the span (L) of the beam from center of the fixed end to free end.
3. Fix up the dial gauge stand to the frame near free end of the beam. Care should be taken to see that the dial gauge pin is in contact with the beam at the central point of the beam. Note initial reading of the dial gauge.

4. Apply load 'W' at free end of the beam by hanging weights to it at that point. The beam will deflect under the load. Note the final reading of the dial gauge. The difference between initial and final reading will give deflection of the beam under the load.
5. Take number of similar readings with different weights.
6. Repeat the procedure for different cases.

OBSERVATION:-

Material of the beam =
Span 'L' =

Width 'b' =
Depth 'd' =

Moment of Inertia I $= \frac{bd^3}{12}$

a) **Load at free end:**

Sl. No	Load in kgs	Dial guage reading		Difference 'Δ' cm	$E = \frac{WL^3}{3\Delta I}$
		Initial mm	Final mm		
1					
2					
3					
4					
5					

b) **Load at Intermediate point:**
(L_1 from the fixed end)

L_1 =

Sl. No	Load in kgs	Dial guage reading		Difference 'Δ' cm	$E = \frac{WL^3}{3EI} + \frac{WL_1^2}{2EI}$ (L-l
		Initial mm.	Final mm.		
1					
2					
3					

4					
5					

RESULT

Note:- In each case draw the graph of load vs. deflection.

DISCUSSION QUESTIONS:-

1 What is meant by second moment of area ?

2 which is preferable term, second moment of area or moment of inertia. Explain?

3 what is meant by flexural rigidity?

4 Differentiate between flexural rigidity and modulus of rigidity

5 What is a propped cantilever?

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EXPERIMENT NO. 3

DEFLECTION TEST ON SPRING

AIM: To find Modulus of Rigidity of the given material and stiffness of the spring.

APPARATUS: Avery's spring testing machine, Vernier calipers and specimens.

THEORY : A Spring is a device to store energy or to absorb energy. The student must describe the following :

i) Types of springs

ii) Types of helical springs & difference between closed coil & open coil springs and the nature of stresses between the two.

Axial deflection of closed coil spring is found from the expression:

$$\Delta = \frac{8 W D^3 n}{G d^4} \quad \text{or} \quad = \frac{64 W R^3 n}{G d^4}$$

Reading the values of Δ and W , on respective scales, the value of G can be found.

The notations used are:

d = dia of wire in cm.

R = mean radius of coil in cm. $= \frac{Di - d}{2}$

n = No. of turns.

G = Modulus of Rigidity kg / cm^2

Δ = deflection in cm.

The stiffness of spring (S) is defined as load per unit deflection.

$$S = \frac{W}{\Delta}$$

Description of apparatus: The machine consists of a straining unit and a weighing unit.

The straining unit consists of a plunger with rack and pinion carried in an adjustable cross head. The lower tension pin & the upper compression platen are located at opposite ends of the plunger. The cross head unit is clamped on two steel tubes secured in a flange bolted to the base and free from the weighing mechanism. The deflection scale is attached to one of the columns and arranged with an indicator so that readings form 1 mm to 100 mm may be taken.

The weighing unit consists of a pressed steel load table on a set of weighing levers communicating with the indicating mechanism. The load is automatically indicated on a dial having 584 mm dia reading line. The max. capacity of machine is 100 kg. The load is applied to the spring under test by means of a plunger operated by a lever. The extent of deflection is read on deflection scale and the load applied is automatically registered on the dial.

PROCEDURE:

1) Count no. of turns (n).
2) Measure dia . of wire (d) & external dia. of coil (D). Hence find mean radius R.
3) Place spring on the machine. Adjust the deflection scale such that it reads zero just before application of load by the hand lever..
4) Apply load. read its value on dial and note the deflection on deflection scale.
5) Repeat the experiment to take atleast six readings.
6) Calculate Rigidity Modulus (G) and plot graph with load versus deflection. Find stiffness of the spring.

OBSERVATIONS:

Material of spring =

Type of spring =

Dia. of wire (d) of =

External dia. spring (D) of =

Mean radius of coil (R) =

Constant K = $\frac{64 R^3 n}{d^4}$

SI No	Load W kg.	Deflection Cm	Shear Modulus $G = \frac{64WR^3n}{\Delta d^4}$	Stiffness of spring $S = \frac{w}{\Delta}$ kg/cm	Remarks

CALCULATIONS:

RESULT: Stiffness of the given spring =
Rigidity Modulus of the spring =

DISCUSSIONS:-

1 What are the various types of springs?

2 What is the nature of stress in:

i) Helical springs.
ii) Leaf springs.

3 What is the difference between open and closed coil springs?

4 what is meant by spring constant?

5 What is mean radius? How do you calculate it?

6 Define expression for finding deflection in

i) Closed coil spring
ii) Open coil spring

7 What is the difference between leaf spring and laminated spring?

8 What is the relation between Modulus of rigidity and modulus of elasticity?

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EXPERIMENT NO. 4

TORSION TEST ON SHAFT

AIM: To find the modulus of rigidity (shear modulus) of a given material by conducting torsion test.

THEORY:- When one end of a rod is fixed on the other end is subjected to a couple the rod gets twisted, in this condition the rod is said to be in torsion.

The angle through which the rod gets twisted is called angle of twist. (θ)

The couple applied is called torque (T.) Let a rod of diameter (d) and length (L) be subjected to a torque (T.) The general formula for torsion is as follows:

$$G = \frac{TL}{\theta \times J} = \frac{L}{J} \times \frac{T}{\theta}$$

Where T = Torque in (Kg. Cm.)

J = Polar second moment of area in cm^4

$J = \Pi d^4 / 32$

G = Modulus of rigidity in $kg./cm^2$.

θ = Angle of twist in radians.

q = Shear stress in $kg./cm^2$

R = Radius of rod in cm.

The value of L/J is a constant for a particular specimen by applying torque T., and observing the value of θ., G can be found.

APPARATUS:-

1. Torsion testing machine.
2. Vernier calipers
3. Scale.

DESCRIPTION OF APPARATUS:-

Torsion testing machine consists of a triangular frame made out of MS channels and plates. At the top end of the frame main gear is provided which is connected to rod (Specimen) holder by means of a circular shaft. At the other end of the frame a pendulum is provided which can move freely in any direction. Arrangements are made at the top end of the pendulum to fix up the other end of the specimen. The specimen can easily be fixed in the specimen holders provided in the pendulum and main gear. A pointer is fixed to a rod connected to the pendulum to measure the angle of twist and torque.

The main gear is connected to the pinion at one end of which a handle is provided. By rotating the handle, the rod (specimen) is made to twist and correspondingly the pendulum gets lifted up.

The self-wt. of the pendulum is constant. Let the c.g of the pendulum is (D) cm away from the hinge (0) In the vertical position the line of action of force (self wt. of pendulum) passes through the hinge. Therefore, the moments in that position is zero. As the pendulum moves up the perpendicular distance of the line of action of the force (self-wt. of pendulum) increases and it is max. in the horizontal position. Therefore, the moment also increase as the pendulum moves up since the moment is the product of force and perpendicular distance of line of action of force from the hinge. To measure the torque (moment) a calibrated scale is provided which directly gives the torque in kg.cms. On the scale, divisions are marked to measure the angle of twist in degrees. This machine can also be operated electrically

PROCEURE:-

1. Measure the length and diameter of rod (test specimen) and record.
2. Insert the specimen in the specimen holders properly and see that it is securely held in position.
3. Apply an initial torque by rotating the handle in any direction to have a firm grip on the specimen. Note the initial readings of torque and angle of twist..
4. Rotate the handle in the same direction to apply torque. Note the final reading of torque and the corresponding reading of angle of twist and record them in the tabular form.
5. Take number of readings by increasing torque and noting angle of twist.

OBSERVATION:-

Material of specimen =
Length of rod = L =
Dia. of rod. = d =
Polar second moment of inertia = J = $\Pi \times d^4/32$

DISCUSSIONS:-

1 Define polar second moment of area?

2 State the torsion formula & explain all the terms?

3 What is meant by torsional rigidity?

4 What are the assumptions in theory of deriving torsion formula?

5 What is meant by the assumption that plane section remain plane before and after torque?

6 What is the difference between bending & torsion? How the couples are applied in each case?

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EXPERIMENT NO. 5

BRINELL HARDNESS TEST

AIM: To find the Brinell Hardness No. of the given specimen.

EQUIPMENT:- Justy's Brinell hardness testing machine, microscope, and specimen.

THEORY:- Hardness of a material is defined the resistance it offers to Indentation by another body. The purpose of determining hardness no. is

1) To grade materials
2) To have quality control over materials.
3) To have rough idea of tensile strength of material which has some relationship with hardness no.

Hardness tests are mainly of three types.

a) Brinell test.
b) Rockwell test.
c) Vickers test.

Brinell hardness test is based upon pressing a steel sphere of known dimensions into material under test. The hardness can be determined from the size of indentation made for a known load.

Brinell Hardness No. (B.H.No.)

$$B.H.No = \frac{\text{Load}}{\text{Spherical area of indentation.}}$$

$$= \frac{F}{\pi \frac{D}{2} (D - \mathrm{sqrt}(D^2 - d^2))} = \frac{2F}{\pi D(D - \sqrt{D^2 - d^2})}$$

F = Load in Kg.
D = Dia of steel ball in mm
d = dia of indentation in mm.

BALL DIA & LOADS:- The standard ball diameter is 10 mm, but ball of sizes 1,2,5 mm, are also available. The ideal value for the ratio of indentation diameter to ball diameter is 0.375 for a realistic hardness no. to be obtained and should not be outside the range (0.25 to 0.50). To achieve an acceptable value of d/D the relationship between load F/D^2 for various metals are:

hand wheel in counter clockwise direction. Measure the diameter of impression indentation by bringing the specimen under the microscope.

4) Repeat the same procedure to take a number of readings and tabulate them as follows:

OBSERVATIONS:-

Test piece A:

Material of test piece =
Dia of ball in mm (D) =
F / D^2 =
Load to be applied F =
Load application time =

Test No.	Impression d mm		Average d = ½ (d1 + d2)	$HB = \frac{2F}{\Pi D / (D - \sqrt{D^2 - d^2})}$
	d1	d2		
1.				
2.				
3.				

Test piece B:-

(Same as above)

RESULT:-

1) Test piece A Brinell Hardness No.
2) Test piece B Brinell Hardness No.
3) Tensile strength of steel

DISCUSSIONS :-

1. What are the precautions in hardness test ?
2 Define hardness ?
3 How many tests are there to find hardness ?
4 What is the difference between Rockwell's & Brinell's test?
5 Derive the expression for spherical area of indentation ?
6 What is the significance of F/D^2 ratio?
7 What is the max hardness which can be tested by B.H testing machine ?
7 What is the relationship between B.H.N & Tensile strength of a material ?

Material	SPECIFIED F/D²
Steel	30
Copper & Aluminum alloys	10
Copper & Aluminum	5
Lead	1

Porras

PRECAUTIONS :

1) Load applied should be within specified range. For example load applied to a copper specimen using 10 mm dia ball, should be $5 \times D^2 = 5 \times 10 \times 10 = 500$ kgs

2) The material must have reasonable thickness. In general thickness should be above 15 mm, using10 mm dia ball and 5 – 15 mm using 5 mm dia ball.

3) The material must have reasonable width. The counter of indentation must be not less than 2 ½ times the dia of indentation from any edge.

4) The test surface should be flat and polished.

5) The load should be held for 15 seconds.

Tensile Strength:

There is an approximate direct relationship between tensile strength and hardness no.

Tensile Strength		= K x HB
Carbon Steel	K	= 33.5 kg/cm² (3.35 Mpa)
Nickel chrome Steel	K	= 35.7 kg/cm² (3.57 Mpa)

PROCEDURE:

1) Select an anvil most suitable for supporting a particular specimen. Fix up the required penetrator after cleaning it properly ,2.5 mm ball penetrator for hard materials such as steels and cast iron undera load of 187.5 kgs, and 5 mm ball penetrator for Copper, Copper alloys Aluminum and its alloys etc.under a load of 250kgs.

2) Select a major load depending upon the material under testwith the help of load selecting disc. Before starting the test keep the loading handle towards the operator. Place the specimen on the anvil and raise it by rotating the hand wheel clockwise, until contact is made with the penetrator. Continue carefully rotating the hand wheel till the main pointer is at set position, i.e. at zero of 'c' scale and 30 of B- scale. The main pointer of the dial will automatically stop at this set position and will not move further even if the specimen is raised a little further. However the hand wheel should not be rotated when once the pointer stops at set position, otherwise it may cause damage to the penetrator. This way a minor load of 10 kgs is automatically applied.

3) For applying the remaining major part of the selected load, push away the loading handle and keep it there for 15 seconds, within 15 seconds. Completion of impression takes place and then the major load is removed by pulling the loading handle towards the operator. Take out the specimen lowering it by rotating the

EXPERIMENT NO. 6

ROCKWELL HARDNESS TEST

AIM: To find the hardness of the given material by Rockwell hardness test.

EQUIPMENT: Rockwell hardness testing machine, microscope and specimen.

THEORY: Hardness of a material is defined as the resistance it offers to indentation by another body. The purpose of determining hardness number is to

i)Grade the materials : ii) Have quality control over material; iii) To have rough idea of tensile strength of material which has some relationship with hardness number. The rockwell hardness test is based on the indentation of a hard tip, or indentor, into the test piece under the action of two consecutively applied loads minor (initial) and major (final).

In order to eliminate zero error and possible surface effects to roughness of scale, the initial or minor load is first applied and produces an initial indentation.

A conical shaped diamond cone with a 120° apex angle and 0.2 mm radius is used as the indentor or penetrator in the rockwell test for hard material. For softer materials a hardness steel ball 1.5 mm in diameter is generally used.

PROCEDURE : First a minor load of 10 kg. is applied by turning hand wheel , till the pointer comes to rest at set position. Then a major load as required is applied by pulling the lever towards the operator for 15 seconds. The rockwell hardness number is the difference in degree of the indentation made by applying major and minor loads. It is directly read on B or C scales as appropriation after removing the major load.

OBSERVATIONS:

Material of test piece =
Load applied =
Time of application =
Thickness of specimen =
Indentor used =

S.No	Rockwell No.	Scale Used

Thickness of specimen ball penetrator

RESULTS: Average Rockwell hardness number for carbon steel =

Average Rockwell hardness number for mild steel =

Scale	Indentor	Load	Materials to be tested
1	2	3	4
B	1/16	100 kgs.	Aluminum, copper, Brass, Mild Steel
C	Diamond cone penetrator	150 kgs.	Stainless Steel, Hard carbon steel

DISCUSSIONS

1. What is the significance of this test ?
2. What is the size of the maximum indentor?
3. To what specimens this test is carried out?

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EXPERIMENT NO. 7

COMPRESSIVE STRENGTH OF BRICKS

AIM :- To determine cracking and crushing strength of given bricks.

APPARATUS REQUIRED: 100 tons compression testing machine, scale.

THEORY: Bricks are important building unit subjected to compressive loads, hence it is important to determine their load carrying capacity.

The cracking strength is defined as the ratio of compressive load at which first crack is observed in brick to the surface area of brick under test.

$$\text{Cracking strength} = \frac{\text{Load at which first crack appears}}{\text{Surface area of brick}}$$

The crushing strength is the ratio between the load at which the brick gets crushed completely and the surface area of brick.

$$\text{Crushing strength} = \frac{\text{Load at which the brick gets crushed}}{\text{Surface area of brick}}$$

DESCRIPTION OF APPARATUS:-

The compression testing machine is of 100 tons capacity. It consists of a cast iron base and steel cross head fixed by two rods. The hydraulic jack of 100 ton capacity is fixed on the base. The lower plate can be removed and spear may be placed on hydraulic jack to reduce the gap between upper and lower platen for smaller specimens.

A screw passes through cross head which can be raised or lowered to adjust the clearance between two platens. The upper platen is attached to the head screw. The upper platen has got spherical seat for the self aligning action.

The recording unit consists of three pressure gauges 100 tons, 50 tons and 25 tons. The pump is placed into this unit. The on-off buttons and pressure release valve are provided on front panel. A hand operation is also fixed inside this unit, which is operated by inserting handle in the bracket through the slot.

PROCEDURE:-

1. Measure dimensions of brick with the help of a scale and record.
2. Make the surfaces of the brick coming in contact with the plates smooth by rubbing it on hard surface., Even after rubbing if there are some cavities, fill them up with fine sand so that the load is applied on the entire surface evenly.
3. Lower the upper platen by lowering screw with the help of hand wheel to bring it in contact with brick. Close the return valve and keep the supply valve open.

To test the specimen on single shear pass the specimen through the shear tool such that it passes through a hole of hollow block and then half the width of solid block. In this case the specimen fails by breaking at one section. Apply load till the specimen breaks and note down the load at failure in Kg or KN.

DISCUSSIONS :-

1) Explain the terms

i) Single Shear
ii) Double Shear
iii) Punching Shear
Give examples of each.

2) How many types of stresses are there ? What are the types of stresses in the following situations

i) Rivets in a lap joint.
ii) Rivets in a butt joint.

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EXPERIMENT NO. 9

TENSILE TEST ON UNIVERSAL TESTING MACHINE

AIM: To study the working of a universal testing machine and to determine the tensile strength of specimen

DESCRIPTION OF MACHINE:

Universal Testing Machine is primarily intended for tensile tests. It can also be used to carry out with suitable accessories a wide variety of other tests such as bending, shear, compression and hardness.

It has two essential parts :
i) Straining mechanism or loading unit (on left).
ii)Recording mechanism or control console (on righThe straining unit consists of a cast iron base, supporting four vertical rods. There are three cross-heads rigidly connected to the columns. The lowest one functions as a compression cross head. The middle one is adjustable cross head. It can move vertically up and down . The tension specimen is fixed between adjustable cross-head and the upper tension cross head.

For compression, bending and shear test , the specimen is fixed between the adjustable cross head and the bottom compression cross head.

The lower part houses the working cylinder and it is fitted with pipes for pressure application , measurement and oil leakage. These pipes are connected to the console and the rotating beam dynamometer.

The load applied to the specimen is noted on the control console. The control console houses the hydraulic drive, load stabilizer , dynamometer and graph recorder.

There are four ranges of 10 t, 5 t, 21/2 t, and 1 t. and the machine can be set for any of these ranges by adjusting the knobs at the dial gauge and weights in the console unit. The recorder consists of a drum on which the graph roll is mounted.

ACCESSORIES:

Tension Test : Tension test specimens are held at each end by grips of wedge type which are serrated on their inner faces. When the load is applied, the wedging action causes these serrated gripping surfaces to bite into and hold firmly the specimen.

Hardness Test: For Brinell hardness test , a ball holder with 10 mm. ball is provided The specimen rests on the lower pression plate.

Bending Test:

A Pressure foot is provided which bears upon the center of the beam specimen. The span of the specimen can be adjusted by suitable holes provided in the compression cross head. The pressure foot is fixed on the adjustable cross head which moves vertically up and down.

OBSERVATIONS:

TESTING TEST

Material : Mild Steel
Length of specimen : 50 mm.
Dia of specimen : 12 mm.

S.NO	Load applied (kg)	Elongation observed (cm.)
1	270	0
2	540	0.0005
3	810	0.001
4	1080	0.0015
5	1350	0.002
6	1620	0.0025
7	1890	0.003
8	2160	0.0035
9	2430	0.004
10	2700	0.0045
11	2950	0.005
12	3180	0.006
13	3361	0.0065
14	3630	0.0080
15	3760	0.0095
16	3870	0.014
17	3870	0.017
18	3820	0.020
19	3730	0.025
20	3820	0.075
21	4270	0.12
22	5200	0.25
23	5600	0.38
24	5800	0.50
25	5140	0.75
26	6230	0.95
27	6000	1.12
28	5230	1.25

Dia. At fracture = 9.7 mm

CALCULATIONS:

Sample: Stress = $\frac{\text{Load}}{\text{original area}}$

Sl.No.(10)

$= \frac{2700}{\pi/4 \times 12^2} = 2387\ kg/cm^2$

Strain = $\frac{\text{Change in length}}{\text{Original length}} = \frac{0.0045}{5}$

$= 0.000900$

The values of stress and strain are as under

Sl.no	Stress	Strain	Sl.no.	Stress	Strain
1			15		
2			16		
3			17		
4			18		
5			19		
6			20		
7			21		
8			22		
9			23		
10			24		
11			25		
12			26		
13			27		
14			28		

DISCUSSIONS:-

1 Why the machine is called U. T. M?

2 What is the purpose of adjustable cross heads?

3 What are the safety devices provided in U T M?

4 What is the difference between true & nominal stress?

5 Draw typical nominal stress – strain diagram & true stress – strain diagram for mild steel ?

6 Draw typical stress – strain diagram for Aluminum. In what respect it defers from stress – strains diagram of mild steel ?

7 Draw typical stress – strains diagram for cast iron. In what respect this stress – strain diagram differs from that of mild steel ?

8 What property is measured by percentage elongation and reduction in area.? Name some materials for similar property ?

9 Give the value of 'E' for the following materials

a) Wood (b) Mild steel (c) ~~Prestressing wire~~
d) Copper (e) Brass (f) Aluminium

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EXPERIMENT NO. 10

IMPACT TEST

AIM: To determine the impact strength of the given metal specimen

APPARATUS: Izod impact testing machine and metal specimen

THEORY:

The impact strength is usually determined for brittle materials to know the shock or impact resisting capacity of the material

The pendulum impact testing machine serves for conducting impact tests. Charpy and Izod tests are carried out to determine the behavior of metals especially of steel and steel castings under impact stresses.

Impact test specimens for Izod test must be prepared as per the standard test specimen. A mild steel specimen of size 10 mmX10 mm and length 75 mm is provided with a 45° V-notch; 2mm deep with root radius 0.25 at a distance of 28 mm from one end.
Provision of notch (groove) ensures:
a) Conversion of mild steel to brittle material.
b) Failure of specimen at that position.

PROCEDURE:

8) For conducting Izod test, the Izod striker is to be secured firmly to the bottom of the hammer.

9) The specimen for Izod test is firmly secured in the specimen support with the help of clamping screw and notch on the specimen should face the pendulum striker.

10) Set red pointer on 164 reading on the dial, when the pendulum is latched at 90° position.

11) After ascertaining that there is no person in the range of swinging pendulum, operate lever. Now the pendulum is released and the specimen will be smashed.

12) Carefully slow down the swinging pendulum by operating the pendulum brake.

13) Read the position of reading pointer on dial and note down indicated value.

14) Remove the broken specimen by loosening the clamp screw and thus the machine will be ready for carrying out next test.

RESULT:

The notch impact strength I is calculated according to the following relation:

$I = K/A$

Where I – Impact strength in kg/cm or Joules/in

K – Impact energy absorbed on repute in Kgm or Joules

A – area of cross section of specimen of V- notch before test in Sq.cm (0.2 Sq.cm)

Breadth of "V" notch = 10 mm = 1 cm

Depth of "V" notch = 2 mm = 0.2 cm

PRECAUTIONS:

Extreme care must be taken to see that correct striker / striking fork and correct support / clamping are chosen for a particular test. For example, in order to carry out Izod test, striker and clamping device are only to be used.

After rebuilding, all screws are to be supervised for solid fit.

Before proceeding to the actual test, it is to be confirmed that strikers and supports are correctly selected. If this is not ensured a serious damage to the impact testing machine may result easily.

The pendulum impact testing machine must be installed such that the swinging range of the pendulum does by no means project into spaces which are subject to traffic. Furthermore the working place is to be safeguarded against hitting by straying particle of the broken specimen.

Persons who are not involved in testing shall not be permitted to stay too close to the machine. Every test is to be carried out with utmost care.

DISCUSSIONS:

1. What is meant by impact load?
2. Name the tests carried out to know the impact resistance.
3. What is the significance of the values of impact resistance of materials?

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EXPERIMENT NO. 11

FATIGUE TEST

AIM: To determine the endurance limit of a specimen of material by fatigue test.

APPARATUS: Fatigue testing machine, test specimen, weights.

INTRODUCTION:

Fatigue refers to failure of materials or structural elements under the action of repeated stresses. Fatigue failure is the result of slip occurring along certain crystallographic directions accompanied by local crystal fragmentation rupturing the atomic bonds, and thus leading to the formation of submicroscopic cracks which soon become visible cracks.

Fatigue failure is particularly dangerous since the incipient cracks are often unseen and the failure may finally occur with disastrous suddenness in high speed machines or vehicles. The advance of the cracks is slow initially. With inspection at frequent intervals and rejecting or rectifying parts which have developed cracks, loss of the member may be avoided.

Surface fatigue occurs under high concentrated compressive loads between two rolling surfaces such as ball bearings and gear teeth and results in spalling or flaking of the material on one or both surfaces. This is usually caused by high shearing stresses below the surface.

THEORY:

In fatigue testing, a specimen is subjected to periodically varying stresses by means of mechanical devices. The applied stresses may alternate between equal positive and negative values, from zero to positive maximum or negative values, or between unequal positive and negative values. The most common loading is alternate tension and compression of equal numerical values. A series of fatigue tests are made on a number of specimens of the material at different stress levels. The stress endures is then plotted against the number of cycles sustained. By choosing lower and lower stresses, a value may be found which will not produce failure, regardless of the number of applied cycles. The stress value is called the "fatigue limit".

Some materials (generally those with a well defined yield point) have what is known as an "endurance limit". This is the maximum unit stress that can be repeated through a definite range, an indefinite number of times without causing structural damage.

The fatigue testing machine helps in determining the fact as to how much strong the specimen is against bending where it has to bear continuous rotating stress. The machine is supported in a vertical angle frame. Vertical load is applied by slotted weight assembly. Self aligning bearing permits both vertical loading and rotation of the specimen.

The fatigue testing specimen is rotated by an electric motor. An electronic counter is used to record the no. of revolutions and calculate the number of cycles to failure.

SPECIFICATIONS:

Diameter of test specimen	:	7.5 m
Maximum bending moment	:	200 kgs. cm.
Revolution measurements	:	Electronic 7 digit counter
Motor capacity	:	0.5 H.P., 3000 R.P.M.
Current	:	3 Phase

PROCEDURE:

1. Insert the test specimen (7.5 mm dia) in the bearing housing of the machine.
2. Apply verticle load by slotted weight assembly.
3. Set the electronic revolution counter to zero.
4. Start the motor
5. Record the number of revolutions at which the specimen fails.
6. Calculate the stress using the formula mentioned below. Now the four points loading the bending moment is:-

$$M=(W/2)xa$$

where a= Distance from fulcrum to the nearest support in mm = 48 mm

Also $M= (\pi x d^3 x \sigma)/32$

Therefore $(\sigma b = 16\ W \times a\ /(\pi x d^3)$ Kg./mm^2

where σb = Fatigue Stress (Bending Stress)

The machine is equipped with the counter, then time for failure 't' may be noted:-

$N= t \times n \times 60$

t = time to failure in hours

n = rated no. of revolutions recorded in the counter at the point of failure / time in minutes.

OBSERVATIONS:

Dia. Of test piece

Dia. Of test piece 'd' mm	Load W Kg.	No. of Cycles 'N' endurance limit (106 Cycles)	Stress Kg/(

RESULT:

DISCUSSIONS:

(1) What is meant by fatigue of metals?

(2) State four different components of a motor vehicle which are likely to suffer fatigue failure.

(3) Explain what is endurance of a metal.