(20A01201P) STRENGTH OF MATERIALS LAB

- **PREPARED BY**

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Experiments List as per affiliated University

1. Tension test.
2. Bending test on (Steel/Wood) Cantilever beam.
3. Bending test on simply supported beam.
4. Torsion test.
5. Hardness test.
6. Compression test on Open coiled springs
7. Tension test on Closely coiled springs
8. Compression test on wood/ concrete
9. Izod / Charpy Impact test on metals
10. Shear test on metals
11. Use of electrical resistance strain gauges.
12. Continuous beam – deflection test.

Introduction to strength of materials

-INTRODUCTION

Strength of materials, is concerned with methods for finding internal forces, stresses, and deflections/deformations in deformable bodies when subjected to loads.

This branch of science helps to understand the behavior of a material under load, and determines its range of useful applications, Moreover, explains properties of a material by manufacturing processes or the composition of the material itself.

-TYPES OF MATERIALS:

1Ductile Materials: Materials that can be plastically twisted with no crack. They have the tendency to hold the deformation that occurs in the plastic region.

Examples: Aluminum, Copper, and Steel.

2Brittle Materials: Materials when subjected to stress, it breaks without significant plastic deformation. Brittle materials absorb relatively little energy prior to fracture, even those of high strength.

Examples: Chalk, Concrete, ceramics and glass.

-IMPORTANT DEFINITIONS

1 Strength: Is the ability of the material to resist the influence of the external forces acting upon.

2Stress: When a force is applied to a certain cross-sectional area of an object, stress can be defined as the internal distribution of forces within the object that balance and react to the force applied to it.

3Strain: Is defined as the amount of deformation in the direction of the applied force divided by the initial length of the material.

4Stiffness: Is the ability of the object to resist the strains caused by the external forces acting upon it

5-Stability: Is the property of the object to keep its initial position of equilibrium.

6-Durability: is the property of the object to save its strength, stiffness and stability during its life time.

7- Toughness is the ability of a material to absorb energy and plastically deform without fracturing.

-Types of loadings

Transverse loadings : Forces applied perpendicular to the longitudinal axis of a member. Transverse loading causes the member to bend and deflect from its original position, with internal tensile and compressive strains accompanying the change in curvature of the member. Transverse loading also induces shear forces that cause shear deformation of the material and increase the transverse deflection of the member.

Axial loading : The applied forces are collinear with the longitudinal axis of the member. The forces cause the member to either stretch or shorten. Torsional loading: Twisting action caused by a pair of externally applied equal and oppositely directed force couples acting on parallel planes or by a single external couple applied to a member that has one end fixed against rotation.

-TYPES OF BEAMS AND LOADS

Beam can be defined as a structural element that primarily resists loads applied laterally to the beam's axis

1-Cantilever Beam: Is a beam whose one end is fixed and the other end is free.

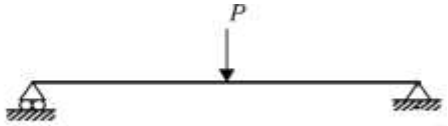
2Simply Supported Beam: is a beam that has pinned support at one end and roller support at the other end.

3Overhanging Beam: Is a type of Simply Supported Beams, which overhangs from its supports. 4-Continous Beam: Is a beam that has more than two supports along its length, commonly used in bridges.

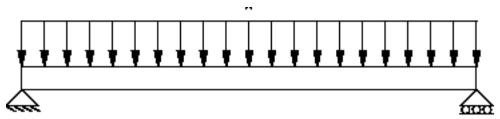
TYPES OF LOADS ON BEAMS

Structural loads are forces applied to a structure or its components. A load is the amount of weight a structure has to carry. Loads cause stresses, deformations, and displacements in structures.

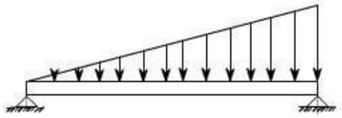
1-Concentrated or Point load: is a load applied to a single, specific point on a structural member.



2-Uniformly Distributed Load: A type of load, which is distributed uniformly over certain length of the beam.



3-Uniformly Varying Load: Are loads varying uniformly from zero to a particular value and spread over a certain length of the beam.



UNITS SYSTEMS

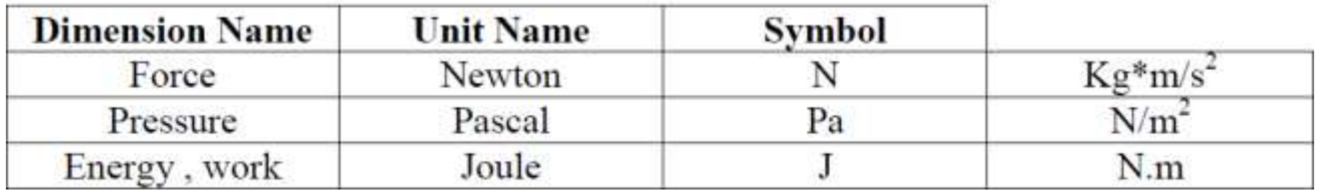
A system of units is a set of related units that are used for calculations. The system includes base units, which represent base dimensions, and derived units, which represent products of powers of base dimensions. Some units exist in more than one system of units.

-International System of Units (**SI)**

Base Units

Dimension Name	Unit Name	Symbol
Length	Meter	m
Mass	Kilogram	kg
Time	Second	s

Derived Units



Dimension Name	Unit Name	Symbol	
Force	Newton	N	$Kg*m/s^2$
Pressure	Pascal	Pa	N/m^2
Energy , work	Joule	J	N.m

EXPERIMENT NO. – 01

TENSION TEST ON MILD STEEL

AIM: To determine tensile test on a metal.

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

(i) Limit of proportionality (ii) Elastic limit

(iii) Yield strength (IV) Ultimate strength

(v) Young's modulus of elasticity (VI) Percentage elongation

(vii) Percentage reduction in area.

APPARATUS: -

(i) Universal Testing Machine (UTM)

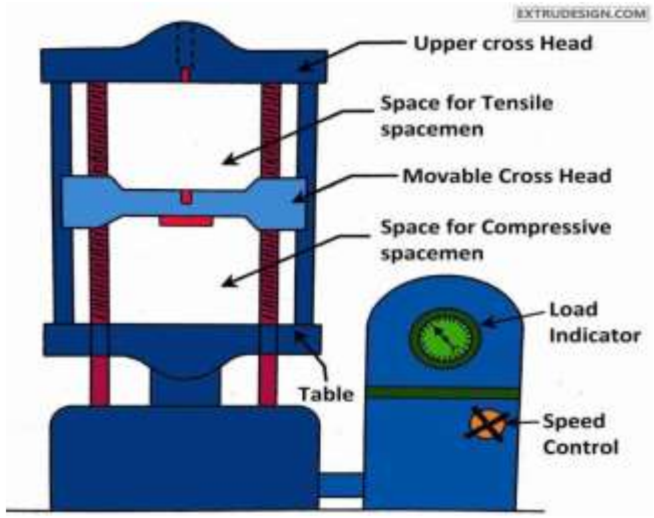
(ii) Mild steel specimens

(iii) Graph paper

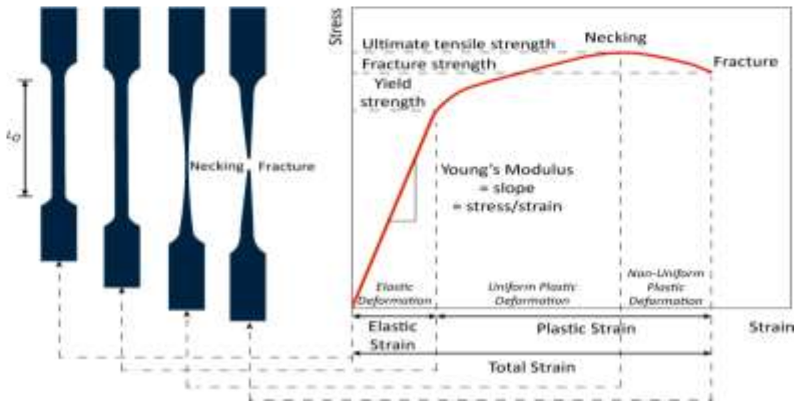
(iv) Scale

(v) Vernier Caliper

DIAGRAM:-



THEORY: The tensile test is most applied one, of all mechanical tests. In this test ends of test piece are fixed into grips connected to a straining device and to a load measuring device. If the applied load is small enough, the deformation of any solid body is entirely elastic. An elastically deformed solid will return to its original form as soon as load is removed. However, if the load is too large, the material can be deformed permanently. The initial part of the tension curve which is recoverable immediately after unloading is termed. As elastic and the rest of the curve which represents the manner in which solid undergoes plastic deformation is termed plastic. The stress below which the deformations essentially entirely elastic is known as the yield strength of material. In some material the onset of plastic deformation is denoted by a sudden drop in load indicating both an upper and a lower yield point. However, some materials do not exhibit a sharp yield point. During plastic deformation, at larger extensions strain hardening cannot compensate for the decrease in section and thus the load passes through a maximum and then begins to decrease. This stage the "ultimate strength"' which is defined as the ratio of the load on the specimen to original cross-sectional area, reaches a maximum value. Further loading will eventually cause ‘neck’ formation and rupture.



PROCEDURE: -

1. Measure the original length and diameter of the specimen. The length may either be length of gauge section which is marked on the specimen with a preset punch or the total length of the specimen.
2. Insert the specimen into grips of the test machine and attach strain-measuring device to it.
3. Begin the load application and record load versus elongation data.
4. Take readings more frequently as yield point is approached.
5. Measure elongation values with the help of dividers and a ruler.
6. Continue the test till Fracture occurs.
7. By joining the two broken halves of the specimen together, measure the final length and diameter of specimen.

OBESERVATION: -

(a) Initial diameter of specimen d1 = (b) Initial gauge length of specimen L1 =

(c) Initial cross-section area of specimen A1 = (d) Load of yield point Ft =

(e) Ultimate load after specimen breaking F = (f) Final length after specimen breaking L2 =

(g) Diameter of specimen at breaking place d2 = (h) Cross section area at breaking place A2 =

Tabulation For Measurement of Diameter:

Trail No	Main scale reading in cm M.S.R	Vernier scale coincidence in div V.S.C	Diameter = M.S.R + L.C x V.S.C in cm

OBESERVATION TABLE:

S.No	Load(N)	Original Gauge length	Extension (mm)	Stress= load/ area (N/mm^2)	Strain= Change in length/ original length
1					
2					
3					
4					
5					

CALCULATION:

- Ultimate tensile strength =……………$\frac{N}{mm^2}$
- Elastic limit = $\frac{Load\ at\ elastic\ limit}{original\ area\ of\ cros\ s\ section}$ = ……………$\frac{N}{mm^2}$
- (iii) Modulus of Elasticity (E) = $\frac{stress\ below\ proportional\ limit}{corrsponding\ strain}$ =……………$\frac{N}{mm^2}$
- (iv) Yield Strength = $\frac{yield\ load}{original\ cross\ sectional\ area}$ =……………$\frac{N}{mm^2}$
- % Reduction in area = $\frac{A_f-A_i}{A_i}\times 100$ = ……………%
- Percentage of elongation = $\frac{l_i-l_f}{l_f}\times 100$ =……………..%
- Limit of Propagation = $\frac{Load\ at\ limit\ of\ proprtionality}{original\ cross\ sectional\ area}$
- Stress = $\sigma = \frac{Load}{Area} = \frac{P}{A}$ …………………… $\frac{N}{mm^2}$
- Strain = $\epsilon = \frac{change\ in\ length}{original\ length}$ = …………..
- Young's modulus= E = $\frac{strss}{strain}$ …………$\frac{N}{mm^2}$

RESULT:-

1. Yield stress= …………………. N/mm2

2. Ultimate stress=………………. N/mm2

3. Nominal breaking stress = ………………N/mm2

4. Actual breaking stress=……………… N/mm2

5. Percentage elongation in length=……………… %

6. Percentage reduction in area=………………… %

PRECAUTIONS:

1. The specimen should be prepared in proper dimensions.
2. The specimen should be properly to get between the jaws.
3. Take reading carefully.
4. After breaking specimen stop to m/c.

VIVA-QUESTIONS

1) Define Hooke's law

2) What do you understand by proof stress?

3) Define ductility and brittleness.

4) What kind of fracture has occurred in the tensile specimen and why?

5) Differentiate between Upper and Lower yield points.

6) What general information is obtained from tensile test regarding the properties of a material?

7) How does Mild Steel differ structurally from Cast Iron?

EXPERIMENT NO-02

BENDING TEST ON (STEEL/WOOD) CANTILEVER BEAM.

AIM: - This experiment is to demonstrate the effect of distance at which the load acting from the fixed end on deflection of the beam.

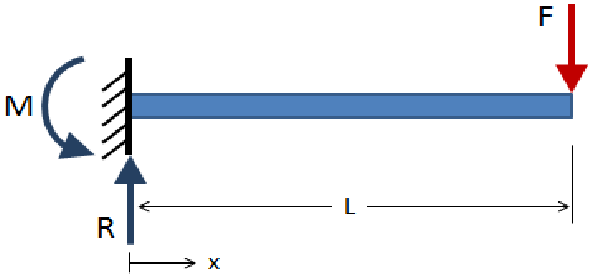
- The effects of young‟s modulus of the material of the beam using different materials bars.
- Determine the bending stress

OBJECTIVE

To determine the bending stress of the Cantilever Beam

APPARATUS: - Cantilever beam, hanger with weights deflection gauge, vernier calipers and meter scale.

DIAGRAM:-



THEORY: - A Cantilever is a Beam one end of which is clamped and other end is free. A beam with a length L and is fixed at one end and the other end is free. Let the moment of inertia of the Beam is „I‟ about it‟s neutral axis and the Young‟s Modulus be ‟E‟.

Moment of inertia about the neutral axis $I = \frac{bh^3}{12}$

Deflection at the end where point load is acting = = δ

The deflection at the end (Max deflection) δ is related to the load 'W', length 'L' moment of Inertia 'I' and Young's Modulus 'E' through the equation

$$\delta = \frac{Wl^3}{3EI}$$

PROCEDURE:

1. Clamp the Beam horizontally on the clamping support at one end.
2. Measure the length of cantilever L (distance from clamp end to loading point)
3. Fix the dial gauge under the beam at the loading point to Read down-ward moment and set to zero.
4. Hang the loading Pan at the free end of the cantilever.
5. Load the cantilever with different loads (W) and note the dial gauge readings
6. Change the length of cantilever for two more different lengths repeat the experiment.
7. Change the position of cantilever and repeat the experiment for the other value of I for rectangular cross-section.

OBSERVATIONS:

Breadth of Beam (b):

Least count of Vernier callipers =

S.No.	M.S.D.	V.S.D.	M.S.D. + (V.S.D.x L.C.) (mm)

Average breadth of beam (b) = mm.

Depth of the beam (d):

Least count of Vernier calipers =

S.No.	M.S.D.	V.S.D.	M.S.D. + (V.S.D.x L.C.) (mm)

Average depth of the beam (d) = mm

$$\text{Moment of inertia, } \mathbf{I} = \frac{\mathbf{bd}^3}{12} = \qquad \mathbf{mm}^4$$

TABULATION

S NO	LOAD IN KGS	LOAD IN NEWTONS	DAIL GAUGE READING	DEFLECTION			YOUNGS MODULUS
				LOADING	UNLOADING	MEAN	

GRAPHS:

Draw a graph between load and deflection. From Graph find the Young’s modulus of the given material.

PRECAUTIONS:

1. Beam should be positioned horizontally
2. The length of the cantilever should be measured properly

3. The dial gauge spindle knob should always touch the beam at the bottom of loading point.

4. Loading hanger should be placed at known distance of cantilever length.

5. All the errors should be eliminated while taking readings.

6. Elastic limit of the Bema should not exceed.

RESULT

Young’s modulus of Elasticity ‘E’ of the material of the beam is_______N/mm2.

VIVA QUESTIONS:

1) What is meant by beam?

2) Draw a neat sketch of experimental set-up and show position of load applied on the beam.

3. Cantilever beam means?

4. What is the deflection formula of cantilever beam?

5. What is the difference between cantilever and simply supported beam?

6. Write types of loads?

EXPERIMENT No:-03

BENDING TEST ON SIMPLY SUPPORTED BEAM.

AIM: **-** To determined young‟s modulus of elasticity of material of beam simply supported at ends.

OBJECTIVE: - To find the values of bending stresses and young‟s modulus of elasticity of the material of a beam simply supported at the ends and carrying a concentrated load at the center.

APPARATUS: -

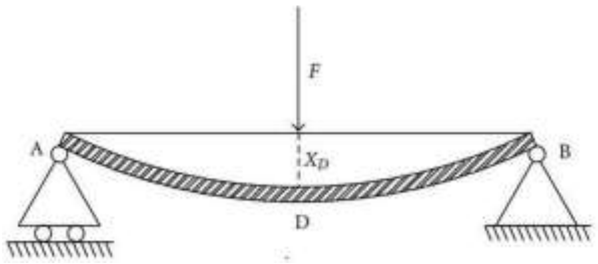
i. Deflection of beam apparatus

ii. Pan

iii. Weights

iv. Beam of different cross-sections and material

DIAGRAM:-



If a beam is simply supported at the ends and carries a concentrated load at its center, the beam bends concave upwards. The distance between the original position of the beams and its position after bending at different points along the length of the beam, being maximum at the center in this case. This difference is known as „deflection‟ In this particular type of loading the maximum amount of deflection (δ) is given by the

$$\delta = \frac{Wl^3}{48EI} \quad \ldots\ldots\ldots\ldots\ldots \text{(i)}$$

$$E = \frac{Wl^3}{48\delta I} \quad \ldots\ldots\ldots\ldots\ldots \text{(ii)}$$

W = Load acting at center, N
L = Length of the beam between the supports mm
E = Young‟s modulus of material of the beam, N/mm2
I = Second moment of area of the cross- section (i.e, moment of Inertia) of the beam, about the neutral axis,

BENDING STRESS

As per bending equation $\frac{M}{I} = \frac{\sigma_b}{Y}$

Where

M = Bending Moment N-mm
I = Moment of inertia mm^4
σ_b = Bending stress, N/mm^2 , and

Y = Distance of the top fibre of beam from the neutral axis

PROCEDURE:

1. Adjust cast- iron block along the bed so that they are symmetrical with respect to the length of the bed.

2.Place the beam on the knife edges on the block so as to project equally beyond each knife edge. See that the load is applied at the center of the beam

3. Note the initial reading of Vernier scale.

4. Add a weight of 20N (say) and again note the reading of the Vernier scale.

5. Go on taking readings adding 20N (say) each time till you have minimum six readings.

6. Find the deflection (δ) in each case by subtracting the initial reading of Vernier scale.

7.Draw a graph between load (W) and deflection (δ). On the graph choose any two convenient points and between these points find the corresponding values of W and δ. Putting these Values in the relation

$$\delta = \frac{Wl^3}{48EI}$$

8. Calculate the bending stresses for different loads using relation

$$\delta_b = \frac{MY}{I}$$

OBSERVATIONS:

Breadth of Beam (b):

Least count of Vernier callipers =

S.No.	M.S.D.	V.S.D.	M.S.D. + (V.S.D.x L.C.) (mm)

Average breadth of beam (b) = mm.

Depth of the beam (d):

Least count of Vernier calipers =

S.No.	M.S.D.	V.S.D.	M.S.D. + (V.S.D.x L.C.) (mm)

Average depth of the beam (d) = mm

Moment of inertia, $\mathbf{I} = \frac{\mathbf{bd}^3}{12} =$ $\mathbf{mm}^4$

FORMULA:

Bending moment $M = \frac{Wl}{4}$

Bending stress $\sigma_Y = \frac{\overline{my}}{I}$

Young's modulus of elasticity $E = \frac{\overline{wl^3}}{48\delta I}$

TABULATION

S NO	LOAD IN KGS	LOAD IN NEWTONS	DAIL GAUGE READING	DEFLECTION			BENGING MOMENT	BENDING STRESS	YOUNGS MODULUS
				LOADING	UNLOADING	MEAN			

GRAPHS:

Draw a graph between load and deflection. From Graph find the Young’s modulus of the given material.

PRECAUTIONS:

1. Beam should be positioned horizontally
2. The length of the cantilever should be measured properly
3. The dial gauge spindle knob should always touch the beam at the bottom of loading point.
4. Loading hanger should be placed at known distance of cantilever length.
5. All the errors should be eliminated while taking readings.
6. Elastic limit of the Bema should not exceed.

RESULT

Young’s modulus of Elasticity ‘E’ of the material of the beam is_______N/mm2.

The Bending strength of given specimen = -------$\boldsymbol{Nmm2}$

PRECAUTION

1. Make sure that beam and load are placed a proper position.
2. The cross- section of the beam should be large.
3. Note down the readings of the Vernier scale carefully

VIVA QUESTIONS

1. Types of beams

2) How deflection is measured?

3) How will you determine modulus of Elasticity of a beam material from load deflection curve?

4) Compare your result with the standard modulus of elasticity.

5) What is meant by simple supported beam?

6) Name the type of internal stresses for which a transversely loaded beam is subjected.

EXPERIMENT No: - 04

TORSION TEST

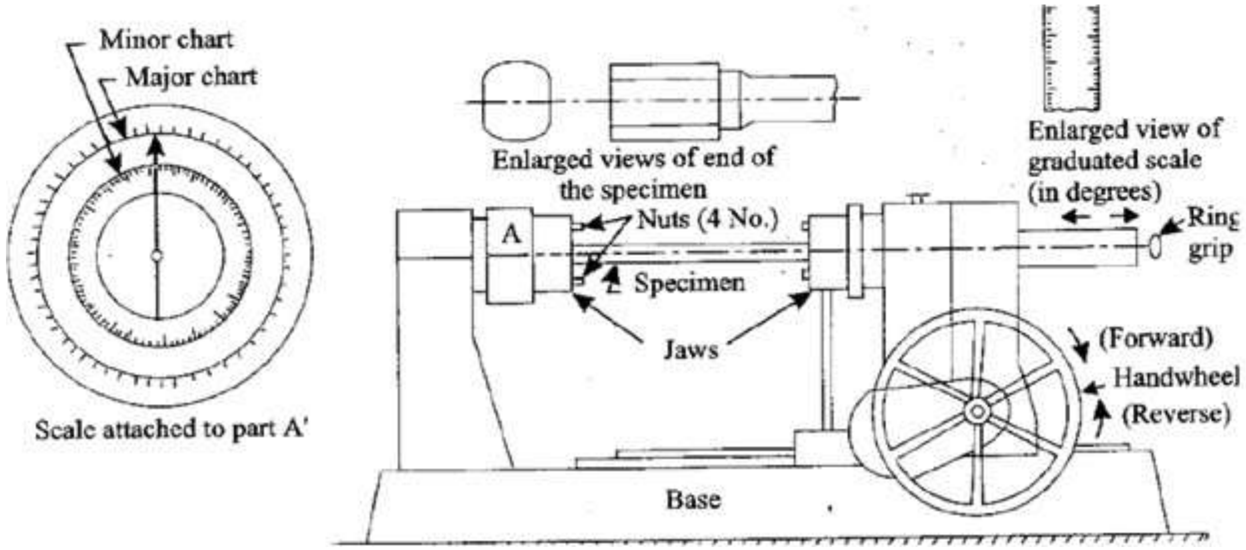
AIM: - To Identify the Torsional Strength on given Mild Steel rod specimen.

OBJECTIVE: - To conduct torsion test on mild steel or cast iron specimen to determine modulus of rigidity.

APPARATUS: -

1. A torsion test machine along with angle of twist measuring attachment.
2. Standard specimen of mild steel or cast iron.
3. Steel rule.
4. Vernier caliper or a micrometer.

DIAGRAM:-



THEORY:-

For transmitting power through a rotating shaft it is necessary to apply a turning force. The force is applied tangentially and in the plane of transverse cross section. The torque or twisting moment may be calculated by multiplying two opposite turning moments. It is said to be in pure torsion and it will exhibit the tendency of shearing off at every cross section which is perpendicular to the longitudinal axis.

Torsion equation is given by below $T/J = \tau/R = G\theta/L$

$G = T\,L/J\,\theta$ N/mm^2

T= maximum twisting torque (N mm)

J = polar moment of inertia (mm^4) = $\pi\, d^4/32$

τ = shear stress (N/mm^2) G = modulus of rigidity (N/mm^2)

θ = angle of twist in radians

L= length of shaft under torsion (mm)

PRINCIPLE: When a straight circular bar of a given material is subjected to a torque 'T', the angle of twist 'θ' in radians over a length 'L' of the bar is given by

$$\theta = (T \times L) / (G \times J)$$

Where J = Polar moment of inertia = $(\Pi\, d^4)/ 32$

PROCEDURE: -

1.Select the driving dogs to suit the size of the specimen and clamp it in the machine by adjusting the length of the specimen by means of a sliding spindle.

2. Measure the diameter at about three places and take the average value.

3. Choose the appropriate range by capacity change lever

4. Set the maximum load pointer to zero.

5. Set the protractor to zero for convenience and clamp it by means of knurled screw.

6. Carry out straining by rotating the hand wheel in either direction.

7. Load the machine in suitable increments.

8. Then load out to failure as to cause equal increments of strain reading.

9. Plot a torque- twist (T- θ) graph.

10.Read off co-ordinates of a convenient point from the straight-line portion of the torque twist (T-θ) graph and calculate the value of G by using relation.

OBESERVATIONS: - Gauge length of the specimen,

L = ……… Diameter of the specimen,

d = ……… Polar moment of inertia,

J = π $d^4/32$ = ...

S NO	TORQUE		ANGLE OF TWIST		MODULUS OF RIGIDITY	AVERAGE MODULUS OF RIGIDITY
	KG-CM	N-MM	DEGREES	RADIAN		

RESULT: -

The modulus of rigidity of the given test specimen material is

GRAPH: Torque Vs Angle of Twist

PRECAUTIONS: -

1) Measure the dimensions of the specimen carefully

2) Measure the Angle of twist accurately for the corresponding value of Torque.

3) The specimen should be properly to get between the jaws.

4) After breaking specimen stop to m/c.

VIVA-QUESTIONS:

1. What is torque?

2. What is torsion equation?

3. What is flexural rigidity?

4. Give the values of G for different materials..

5. What is modulus of rigidity?

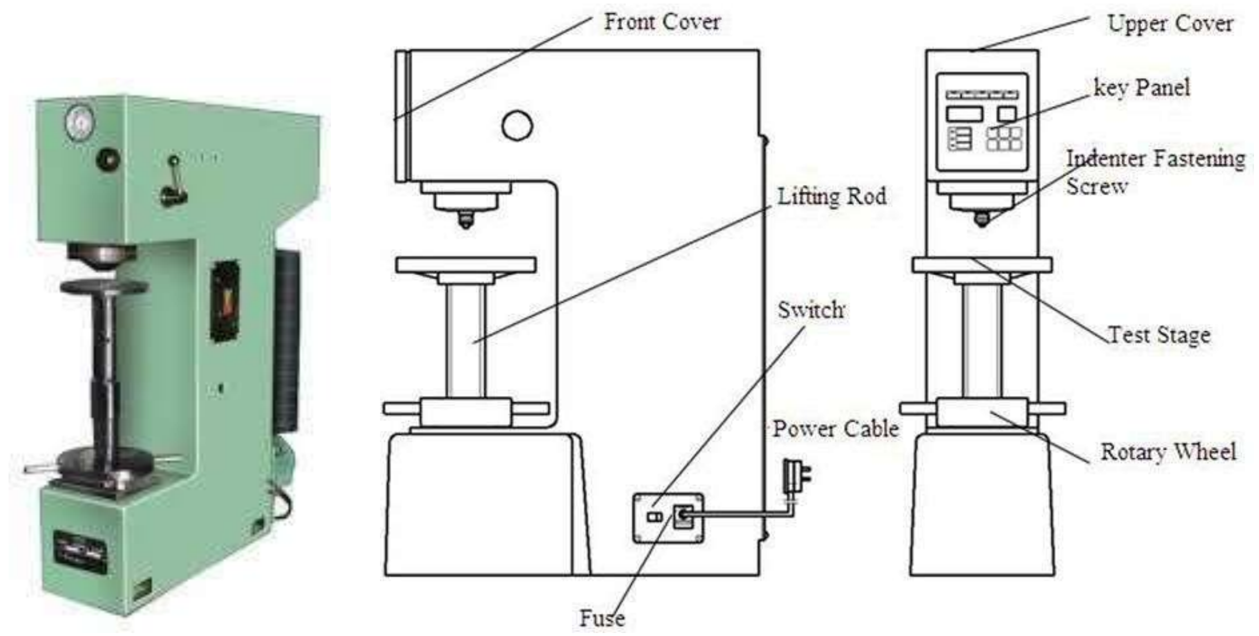
EXPERIMENT No: - 05(A)

BRINELL HARDNESS TEST

AIM: - To determine the hardness of the given specimen using Brinell hardness test.

APPARATUS: - Brinell hardness testing machine, Aluminum specimen, Ball indenter.

DIAGRAM: -



General theory for hardness test:

Hardness may be defined as resistance of the metal plastic deformation by indentation. However, the term may also refer to stiffness or temper or to resistance to scratching, abrasion or cutting. Mainly there are three types of hardness tests.

1) Indentation test
2) Abrasion or wear test
3) Scratch test.

Of these the most important tests are based upon the principles of indentations and are the Brinell's, Rockwell and Vickers's hardness tests. In each case the material under test is indented by another body to which a static load is applied.

Theory for Brinell hardness test:

Hardness of a material is generally defined as Resistance to permanent indentation under static or dynamic loads. However, it also refers to stiffness or to resistance to scratching, abrasion or cutting. Indentation hardness maybe measured by various hardness tests, such as Rockwell, Vickers, Brinnells hardness etc. In Brinell‟s hardness test, a hard steel ball, under specified conditions of load and time, is forced into the surface of the material under test and the diameter of the impression is measured. Hardness number is defined as the load in kilograms per square millimeters of the surface area of indentation. This number depends on the magnitude of the load applied, material and geometry of the indentor. For the Brinell‟s hardness number, the diameter of the indentor and load shall be taken from the following table:

Ball diameter	Load in Kg			
	Ferrous materials	Non Ferrous materials		
	Steel & Iron 30 D^2	Brass 10 D^2	Aluminum 5 D^2	Soft bearing metals 2.5 D^2
10 mm	3000	1000	500	250
5 mm	750	250	---	---
2.5 mm	187.5	----	---	---

FORMULA:

Brinell hardness number (BHN) = load/area of indentation of steel ball

$$\boxed{\text{BHN}=\frac{P}{\pi D/\ 2(D-\sqrt{B}\ -d^2)}}$$

Where,

P-load applied on the indenter, Kg.

D-Diameter of steel ball indenter, mm.

d- Diameter of ball impression, mm

PROCEDURE:-

1. Insert ball of diameter ‘D’ in the ball holder of machine.
2. Make the specimen surface clean by oil, grease, dust etc.
3. Make contact between the specimen surface and ball using jack adjusting wheel.
4. Push the required button for loading.
5. Pull the load release level and wait for 15 seconds.
6. Remove the specimen from the support table and locate the Indentation.
7. View the indentation through microscope and measure the diameter ‘d’ of the indentation using micrometer fixed on the microscope.
8. Repeat the procedure and take three readings.

OBESERVATION TABLE:-

Specimen material	Diameter of ball intender mm	Load (P) *Kg*	Diameter of ball impression			Average Diameter *mm*	Brinell hardness number
			d1 *mm*	d2 *mm*	d3 *mm*		

RESULT: - The hardness of the metal is found to be

i) Hard steel =

ii) Unhardened Steel =

PRECAUTION:-

1. Brielle test should be performed on smooth, flat specimens from which dirt and scale have been cleaned.
2. The test should not be made on specimens so thin that the impression shows through the metal, nor should impression be made too close to the edge of a specimen.

VIVA QUESTIONS:

1. How to measure the hardness

2. What are the formulae of BHN?

3. Which ball size is recommended for Brinell test?

4. What is the difference between the brinell and Rockwell hardness test?

5. For steel ultimate tensile strength =------------BHN?

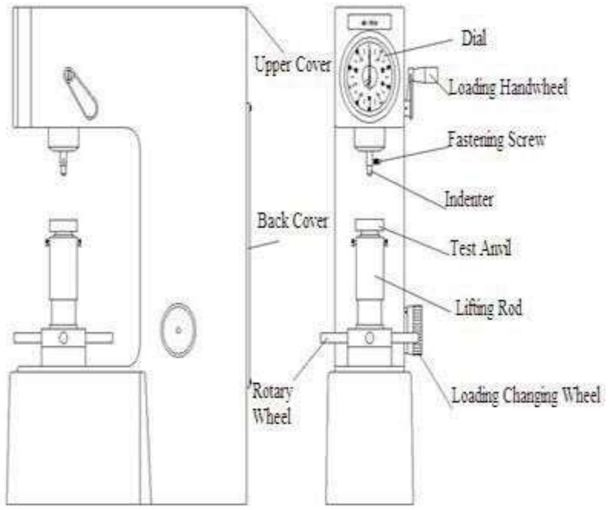
EXPERIMENT No: - 05(B)

AIM: To determine the hardness of the given Specimen using Rockwell hardness test.

APPARATUS: Rockwell hardness testing machine

MATERIAL: soft and hard mild steel specimens, brass, Aluminum etc., Black diamond cone indenter.

DIAGRAM:



THEORY:

Rockwell test is developed by the Wilson instrument co U.S.A in 1920. This test is an indentation test used for smaller specimens and harder materials. The test is subject of IS: 1586. The hardness of a material is resistance to penetration under a localized pressure or resistance to abrasion. Hardness tests provide an accurate, rapid and economical way of determining the resistance of materials to deformation.

There are three general types of hardness measurements depending upon the manner in which the test is conducted:

Choice of Loads and Indentor for various hardness tests:

Total load	588.4N	980.7N	1471N	1839N	2452N
indentor	Diamond 120^0	Ball 1.558mm dia.	Diamond 120^0	Ball 2.5mm dia	Ball 5mm dia
scale	A	B	C	Brinnel 30 D^2	Brinnel 10D^2
Dial to be read	Black	Red	black	……….	…………..
Typical applications	Thin steel & shallow case Hardened steel	Soft steel, malleable, copper& Aluminum alloys.	Steel, hard, cast steel, deep case hardened steel, other metals, harder than HRB-100	Steel and cast iron	Copper and aluminum alloys

PROCEDURE:

1. Examine hardness testing machine (fig.1)

2.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.

3. Release the operating valve to apply additional load. Immediately after the additional load applied, bring back operating valve to its position.

4. Read the position of the pointer on the C scale, which gives the hardness number.

5. Repeat the procedure five times on the specimen selecting different points for indentation.

OBSERVATION TABLE:

S.NO	**Specimens**	**Reading (HRC/)**			**Mean**	
		1	2	3		
1	Mild Steel				HRB =	
2	High Carbon steel				HRC =	
3	Brass				HRB =	
4	Aluminum				HRB =	

PRECAUTIONS:

1. The specimen should be clean properly

2. Take reading more carefully and

3.The test should not be made on specimens so thin that the impression shows through the metal, nor should impression be made too close to the edge of a specimen.

VIVA QUESTIONS:

1. Define Hardness

2. Size of the Ball to be used in Ball Indenter of Rockwell Hardness Test.

3. Different Types of Hardness Testing Methods.

4. Applications of Rockwell Hardness A – Scale, B-Scale, C-Scale 5. In Rockwell hardness test the hardness is measuredby?

EXPERIMENT No: - 06

COMPRESSION TEST ON OPEN COILED SPRINGS

AIM:

To determine the modulus of rigidity and stiffness of the given compression spring specimen.

APPARATUS:

i. Spring testing machine.
ii. A spring
iii. Vernier caliper, Scale.
iv. Micrometer.

THEORY: Springs are elastic member which distort under load and regain their original shape when load is removed. They are used in railway carriages, motor cars, scooters, motorcycles, rickshaws, governors etc. According to their uses the springs perform the following Functions:

1) To absorb shock or impact loading as in carriage springs.
2) To store energy as in clock springs.
3) To apply forces to and to control motions as in brakes and clutches.
4) To measure forces as in spring balances.

To change the variations characteristic of a member as in flexible mounting of motors. The spring is usually made of either high carbon steel (0.7 to 1.0%) or medium carbon alloy steels. Phosphor bronze, brass, 18/8 stainless steel and Monel and other metal alloys are used for corrosion resistance spring. Several types of spring are available for different application. Springs may classified as helical springs, leaf springs and flat spring depending upon their shape. They are fabricated of high shear strength materials such as high carbon alloy steels spring form elements of not only mechanical system but also structural system. In several cases it is essential to idealize complex structural systems by suitable spring.

PROCEDURE:

1. Measure the outer diameter (D) and diameter of the spring coil for the given compression spring.
2. Count the number of turns. i.e. Coil in the given compression specimen.
3. Place the compression spring at the centre of the bottom beam of the spring testing machine.
4. Rise the bottom beam by rotating right side wheel till the spring top roaches the middle cross beam.
5. Note down the initial reading from the scale in the machine.
6. Apply a load of 25kg and note down the scale reading. Increase the load at the rate of 25kg up to a maximum of 100kg and note down the corresponding scale reading.
7. Find the actual deflection of the spring for each load by deducting the initial scale reading from the corresponding scale reading.

OBESERVATION:

Least count of micrometer = ……mm
Diameter of the spring wire, d =………mm (Mean of three readings)
Least count of Vernier caliper = ……mm
Diameter of the spring coil D = ……mm (mean of three readings)
Number of turns N =

S NO	LOAD		SCALE ON READING		DEFLECTION	RIGIDITY MODULUS	STIFFNESS
	KG	N					

CALCULATION

(i) Inner diameter of spring di = ………………mm
(ii) Outer diameter of spring do= …………..mm
(iii) Length of the spring L = …………………mm
(iv) Number of turns n =
(v)Material of spring =
(vi)Young’s modulus E = 2 ×10^5

1. Deflection **α:** 64 WR 3 N Sec α [cos 2 α / N + 2Sin 2 α /E] N/mm2

Where, W=Load applied in Newton
R=Mean radius of spring coil = (D-d) / 2
N= Number of turns
a=Helix angle of spring
N=Modulus of rigidity of spring Material
E=Young’s modulus of the spring material

2. Tanα = pitch / 2πR

3. Pitch = (L-d) / n

Where, d= Diameter of spring wire in mm
L= Length of spring in mm
N= No of turns in spring

4. Stiffness of spring (K) = w / d

Where,
d=Deflection of spring in mm
W=Load applied in Newton’s

5. Maximum Energy Stored = 0.5 x W_{Max}

Where, W_{Max} = Maximum load applied
δ_{Max} = Maximum deflection

PRECAUTIONS

1.Place the specimen at center of compression pads,
2. Stop the machine as soon as the specimen fails.
3.Cross sectional area of specimen for compression test should be kept large as compared to the specimen for tension test: to obtain the proper degree of stability

RESULT

Under compression test on open coil helical spring
1. Rigidity Modulus (N) = N/mm
2. Stiffness of spring (K) = N/mm
3. Maximum energy stored =

VIVA QUESTIONS:

1. What is meant by stiffness

2. Define deflection

3. What are different types of springs

4. Define helical spring

5. What is the strain energy stored in the springs

EXPERIMENT No: - 07

TENSION TEST ON CLOSELY COILED SPRINGS

AIM: To determine the stiffness of the spring and modulus of rigidity of the spring

APPARATUS:

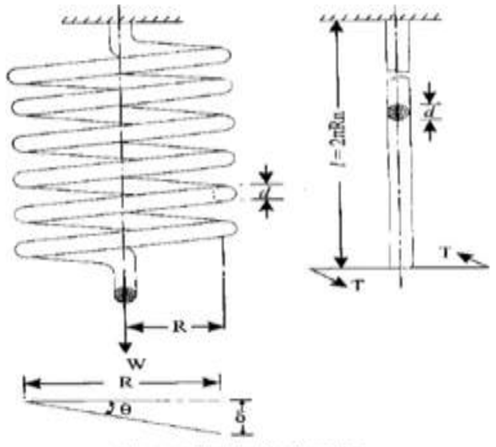
i) Spring testing machine.

ii) A spring iii) Vernier caliper,

iii) Scale.

iv) Micrometer

DIAGRAM:



Close-coiled helical spring.

THEORY

Springs are elastic members, which distort under load and regain their original shape when load is removed. They are used in railway carriages, motorcars, scooters, motorcycles, rickshaws, governors etc.

Different Types Of Springs:

1. Closely - coiled springs &Tension helical springs
2. Open-coiled springs & Compression springs
3. Full- elliptical leaf springs.
4. Semi - elliptical leaf springs.
5. Cantilever leaf springs
6. Circular springs.

Depending on their use, springs perform the following functions:

1. Absorb shock or impact loading as in carriage springs.
2. Store energy as in Clock springs.
3. Supply forces to and to control motions as in brakes and clutches
4. Measure forces as in spring balance.
5. Absorb the vibrations.

Springs are usually made of either High carbon steel (0.7% to 1.0%) or Medium carbon alloy steels, Phosphor bronze, Brass and 18/8 Stainless steel. Other metal alloys are also used for corrosion resistance.

FORMULAE USED:

$$\boxed{\text{Modulus of rigidity } C = \frac{64PR^3n}{d^4\delta}}$$

Where,

P=load in, N

R=mean radius of the spring, mm (D-d/2)

d= diameter of the spring coil, mm

δ=deflection of the spring, mm

D=outer diameter of the springs, mm

$$\text{Stiffness, } k = \frac{p}{\delta}$$

P=load in N

δ=Deflection on spring in mm

PROCEDURE:

1. Measure the outer diameter (D) and diameter of the spring coil (d) for the given compression spring.
2. Count the number of turns i.e. coils (n) in the given compression specimen.
3. Place the compression spring at the center of the bottom beam of the spring testing machine.
4. Insert the spring in the spring testing machine and load the spring by a suitable weight and note the corresponding axial deflection in tension or compression.
5. Note down the initial reading from the scale in the machine.
6. Increase the load and take the corresponding axial deflection readings.
7. Find the actual deflection of the spring for each load by deducting the initial scale reading from the corresponding scale reading.
8. Calculate the modulus of rigidity for each load applied.
9. Plot a curve between load and deflection. The shape of the curve gives the stiffness of the spring.

OBESERVATIONS:

1. Material of the spring specimen =
2. Least count of micrometer = ……...mm
3. Diameter of the spring wire, d =………mm (Mean of three readings)
4. Least count of Vernier Caliper = ……...mm
5. Diameter of the spring coil, D = ……...mm (Mean of three readings)
6. Number of turns, n =
7. Initial scale reading = ……...mm

Sl No.	Applied Load		Scale Reading, mm	Actual Deflection, mm	Modulus of Rigidity, GPa	Stiffness, N/mm
	Kg	N				
1						
2						
3						
4						
5						

RESULT:
The modulus of rigidity of the given spring = ------------------- GPa
The stiffness of the given spring = ------------------- N/mm2
GRAPH: Load Vs Deflection
PRECAUTIONS: -
1) Dimensions should be measure accurately with the help of Vernier Calipers.

2) Deflection from the scale should be noted carefully and accurately.

VIVA QUESTIONS:
1. What is meant by tension spring

2. Define stiffness

3. What are different types of springs

4. Differentiate open coiled and closed coiled springs

5. Define strain energy

EXPERIMENT No: - 08

Compression Test On Wood/ Concrete

AIM: - Compressive strength of brick

OBJECTIVE: - The specimen brick is immersed in water for 24 hours. The frog of the Compressive Strength

APPARATUS: Bricks, Oven Venire Caliper, Scale, Etc.

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

THEORY: Bricks are used in construction of either load bearing walls or in portion walls in case of frame structure. In bad bearing walls total weight from slab and upper floor comes directly through brick and then it is transverse to the foundation. In case the bricks are loaded with compressive nature of force on other hand in case of frame structure bricks are used only for construction of portion walls, layers comes directly on the lower layers or wall. In this case bricks are loaded with compressive nature of force. Hence for safely measures before using the bricks in actual practice they have to be tested in laboratory for their compressive strength.

PROCEDURE:

1. Select some brick with uniform shape and size.
2. Measure it's all dimensions. (LXBXH)
3. Now fill the frog of the brick with fine sand. And
4. Place the brick on the lower platform of compression testing machine and lower the spindle till the upper motion of ram is offered by a specimen the oil pressure start increasing the pointer engineering start returning to zero leaving the drug pointer that is maximum reading which can be noted down.

OBSERVATION TABLE:-

S.No.	L X B XH Cm^3	Area L X B Cm^2	Load (N) (P)	Compressive Strength P/A(N/mm^2	Average Compressive Strength
01					
02					
03					
04					
05					

CALCULATION:- -

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

RESULT: - The average compressive strength of new brick sample is found to be ………. Kg/sq.cm.

PRECAUTION: -

1) Measure the dimensions of Brick accurately.
2) Specimen should be placed as for as possible in the lower plate.
3) The range of the gauge fitted on the machine should not be more than double the breaking load of specimen for reliable results.

VIVA-QUESTIONS:

1. Compression tests are generally performed on brittles materials-why?

2. Which will have a higher strength: a small specimen or a full size member made of the same material?

3. What is column action? How does the h/d ratio of specimen affect the test result?

4. How do ductile and brittle materials in their behavior in compression test?

EXPERIMENT No: - 09

IZOD / CHARPY IMPACT TEST ON METALS

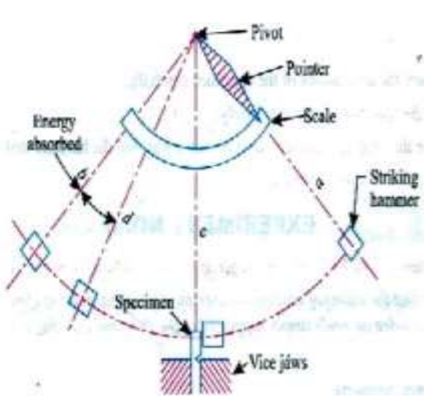
AIM: -To determined impact strength of steel.

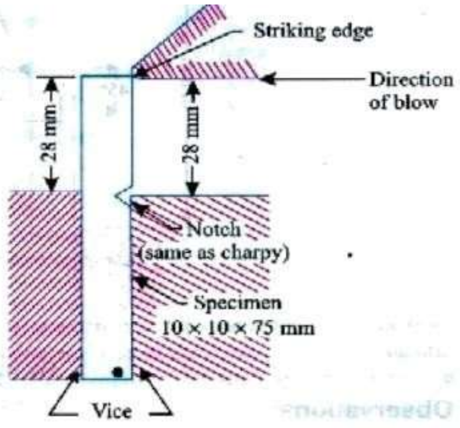
OBJECTIVE: -To determine the impact strength of steel by Izod impact test

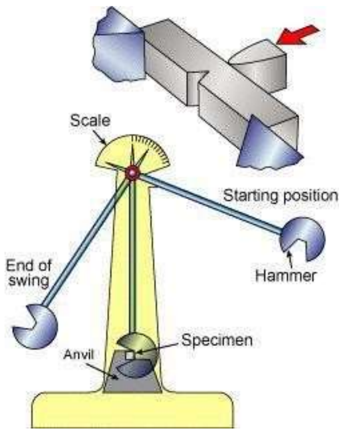
APPARATUS: -

1. Impact testing machine
2. A steel specimen 75 mm X 10mm X 10mm

DIAGRAM:-







THEORY:-

An impact test signifies toughness of material that is ability of material to absorb energy during plastic deformation. Static tension tests of unnotched specimens do not always reveal the susceptibility of a metal to brittle fracture. This important factor is determined by impact test. Toughness takes into account both the strength and ductility of the material. Several engineering materials have to withstand impact or suddenly applied loads while in service. Impact strengths are generally lower as compared to strengths achieved under slowly applied loads. Of all types of impact tests, the notch bar tests are most extensively used. Therefore, the impact test measures the energy necessary to fracture a standard notch bar by applying an impulse load. The test measures the notch toughness of material under shock loading. Values obtained from these tests are not of much utility to design problems directly and are highly arbitrary. Still it is important to note that it provides a good way of comparing toughness of various materials or toughness of the same material under different condition. This test can also be used to assess the ductile brittle transition temperature of the material occurring due to lowering of temperature.

	Charpy Impact Testing	Izod Impact Testing
Materials Tested	Metals	Plastics & Metals
Types of Notches	U-notch and V-notch	V-notch only
Position of the Specimen	Horizontally, notch facing away from the pendulum	Vertically, notch facing toward the pendulum
Striking Point	Middle of the sample	Upper Tip of the sample
Common Specimen Dimensions	55 x 10 x 10 mm	64 x 12.7 x 3.2 mm (plastic) or 127 x 11.43 mm round bar (metal)
Common Specifications	ASTM E23, ISO 148, or EN 10045-1	ASTM D256, ASTM E23, and ISO 180

PROCEDURE:-

(a) lzod test

With the striking hammer (pendulum) in safe test position, firmly hold the steel specimen in impact testing machine's vice in such a way that the notch face the hammer and is half inside and half above the top surface of the vice.

Bring the striking hammer to its top most striking position unless it is already there, and lock it at that position.

Bring indicator of the machine to zero, or follow the instructions of the operating manual supplied with the machine.

Release the hammer. 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 at that topmost final position. Again bring back the hammer to its idle position and back.

Charpy Test

1.With the striking hammer (pendulum) in safe test position, firmly hold the steel specimen in impact testing machines vice in such a way that the notch faces s the hammer and is half inside and half above the top surface of the vice.

2.Bring the striking hammer to its top most striking position unless it is already there, and lock it at that position.

3.Bring indicator of the machine to zero, or follow the instructions of the operating manual supplied with the machine.

4. Release the hammer. 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 at that topmost final position.

5. The specimen is placed on supports or anvil so that the blow of hammer is opposite to the notch.

OBESERVATION:-

Izod Test

Impact value of - Mild Steel ------------N-m

Impact value of - Brass ------------N-m

Impact value of - Aluminum ------------N-m

Charpy test

Impact value of - Mild Steel ------------N-m

Impact value of - Brass ------------N-m

Impact value of - Aluminum ------------N-m

RESULT:-

Izod Test

i. The energy absorbed for Mild Steel is found out to be Joules.
j. The energy absorbed for Brass is found out to be Joules.
k. . The energy absorbed for Aluminum is found out to be Joules

Charpy test

l. The energy absorbed for Mild Steel is found out to be Joules.
iv. The energy absorbed for Brass is found out to be Joules.
v. . The energy absorbed for Aluminum is found out to be Joules

PRECAUTION:-

Measure the dimensions of the specimen carefully.

Hold the specimen (lzod test) firmly.

Note down readings carefully.

VIVA QUESTIONS:

1. In what way the values of impact energy will be influenced if the impact tests are conducted on two specimens, one having smooth surface and the other having scratches on the surface

2. What is the effect of temp? On the values of rupture energy and notch impact strength?

3. What is resilience? How is it different from proof resilience and toughness?

4. What is the necessity of making a notch in impact test specimen?

5. If the sharpness of V-notch is more in one specimen than the other, what will be its effect on The test result?

EXPERIMENT No: - 10

SHEAR TEST ON METALS

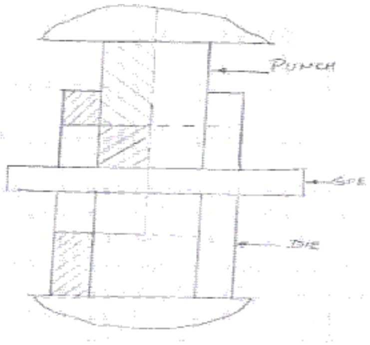
AIM: To determined Shear Test of Steel.

OBJECTIVE: To conduct shear test on specimens under double shear:

APPARATUS: -

1. Universal testing machine (UTM)
2. Mild steel specimen.
3. Device for double shear test.
4. Vernier caliper /screw gauge

THEORY: -Place the shear test attachment on the lower table, this attachment consists of cutter. The specimen is inserted in shear test attachment & lift the lower table so that the zero is adjusted, then apply the load such that the specimen breaks in two or three pieces. If the specimen breaks in two pieces then it will be in single shear & if it breaks in three pieces then it will be in double shear.



PROCEDURE:

- Insert the specimen in position and grip one end of the attachment in the upper portion and one end in the lower portion.
- Switch on the main switch of universal testing machine.
- The drag indicator in contact with the main indicator.
- Select the suitable range of loads and space the corresponding weight in the pendulum and balance it if necessary with the help of small balancing weights.
- Operate (push) buttons for driving the motor to drive the pump.
- Gradually move the head control level in left-hand direction till the specimen shears.
- Down the load at which the specimen shears.
- Stop the machine and remove the specimen

OBESERVATION:-

Diameter of the Rod, D = ….. mm

Cross-section area of the Rod (in double shear) = 2x π/4x d^2 =................ mm^2

Load taken by the Specimen at the time of failure , W = N

Strength of rod against Shearing = f x2x $\pi/4$x d^2

f = W / 2x π/4x d^2 N/mm^2

RESULT:

The Shear strength of mild steel specimen is found to be……………… N/mm^2

PRECAUTION:-

- The measuring range should not be changed at any stage during the test.
- The inner diameter of the hole in the shear stress attachment should be slightly greater than that of the specimen. Measure the diameter of the specimen accurately.

VIVA-QUESTIONS:

1. Does the shear failure in wood occur along the 45° shear plane?

2. What is shear stress?

3. What is single & double shear?

4. What is finding in shear test?

5. What is unit of shear strength?

EXPERIMENT No: - 11

USE OF ELECTRICAL RESISTANCE STRAIN GAUGES.

Aim: To measure the stress & strain using strain gauges mounted on cantilever beam.

Apparatus used:

1 Strain gauge Kit,
2cantilever beam weights,
3 Multimeter.

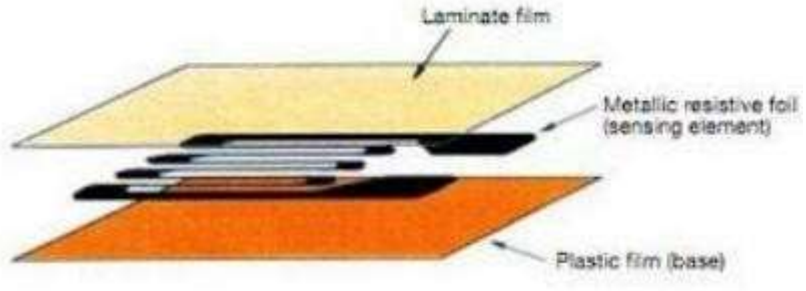


Fig: Strain Gauge

Procedure:

1. Arrange the cantilever beam, ammeter and voltmeter as shown in figure.
2. After this, put the weight on the rod of cantilever beam.
3. Measure the digital display reading for a particular weight.
4. Measure the value of ammeter (along) and voltmeter reading (micro-volt)
5. Increase the strength of weight.
6. Repeat the steps for increased weight.
7. Measure all dimensions of scale of cantilever.
8. Plot a graph between R/R0 and strain (ε).
9. Find Gauge Factor (GF) by finding the inverse of the slope i.e.

$$= \frac{\varepsilon}{\Delta R / R_0}$$

10. Mark on $\frac{\Delta R}{R_o}$ the graph and use Gauge Factor to find strain.

S.No	Loads (gms)	Resistance			$\frac{\Delta R}{R_o}$	Strain Ɛ
		R_o	R_f	$\Delta R = Rf - R_o$		
1.						
2.						
3.						
4.						
5.						
6.						
7.						

Strain Ɛ (Theoretical) = $\frac{\Delta l}{l} = \frac{6PL}{Ebt^2}$ for cantilever type elastic member

Ɛ (Experimental) = $\frac{\frac{\Delta R}{R_o}}{Guage\ Factor\,(GF)}$

Modulus of Elasticity E = Stress/Strain

Strain = E $_x$ strain = E $_x$ e

Depending upon the beam used in apparatus force stress and strain values varies accordingly with simply supported or cantilever beam terminology.

EXPERIMENT No: - 11

CONTINUOUS BEAM – DEFLECTION TEST.

AIM: To find the young‟s modulus of the given structural material (mild steel or wood) by measuring deflection of Continuous beam.

APPARATUS: Beam supports, loading yoke, Slotted weight hanger, Slotted weights, Dial gauge, Dial gauge stand, Scale & Vernier callipers.

THEORY: Consider the following loading case as a two span continuos beam of Uniform flexural rigidity EI. It is loaded at half of each span from end supports and deflection is measured at 1/4th of span from right end support. Deflection (δ) at F= (43/6144)* (WL3/EI)

Where δ = Deflection

W= Load.

L= span

E= Young‟s Modulus

I = Moment of inertia of the beam = (1/12)*(bd3)

PROCEDURE:

A beam of known cross-section (rectangular shape with width “b” and depth “d”) and length “L” is simply supported at two ends and at the center (at A,C &B). Equal loads W are applied at half of each span (at D & E) as shown in the figure

(1) In six increments. The deflection at F is correlated graphically to the load applied and the Young‟s Modulus is determined.

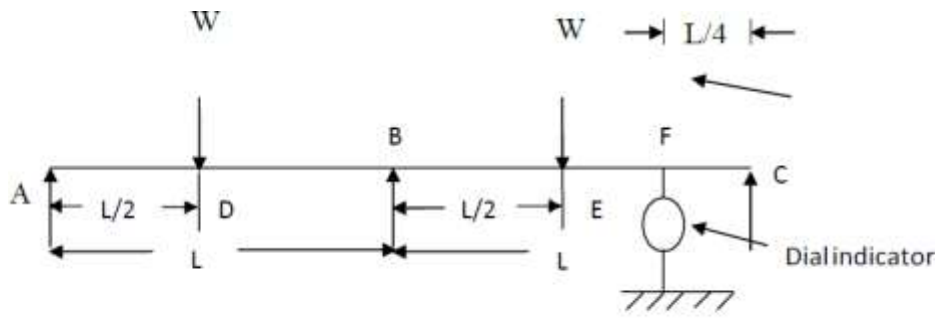


Figure.1: Continuous Beam Deflection.

OBSERVATIONS:

SL.No	**Parameters for set-up-1**	**Value**
1	Width of the beam (rectangular) cross-section, b mm	
2	Depth of the beam (rectangular) cross-section, d mm	
3	Length of the beam between supports , L, mm	
4	Location of the load W from left support (L/2) mm	
5	Location of the deflection point from right support (L/4) mm	

CALCULATION OF CONSTANTS: Moment of inertia (I) =

Young‟s Modulus (E) =

TABULAR COLUMN:

Sl No	Load applied (W)		Deflection in mm		Average	Deflection LC x Avg.	Young’s Modulus (E)
	Kg	N	loading	unloading			N/mm^2
Quarter span(Steel Specimen)							

RESULT:

Young’s Modulus of STEEL from the deflections on a two span continuous beam is:

________________ **N/mm^2**

ADDITIONAL EXPERIMENT No: - 1

VERIFICATION OF MAXWELL’S RECIPROCAL THEOREM ON BEAMS

AIM: To find young‟s modulus of the material of the given beam by conducting bending test on simply supported beam using Maxwell‟s law of reciprocal deflections.

APPARATUS: Beam supports, Loading yoke, Slotted weight hanger, Slotted weights, Dial gauge, Dial gauge stand, Scale & Vernier callipers

FORMULA: For a simply supported beam with concentrated load at mid-span the formulae of deflection is as follows:

$$\Delta = 11\, WL^3 / 768\, EI$$

PROCEDURE:

1. The breadth and depth of the beam along the span is measured and average values are taken.

2.The load is applied in increments and the corresponding deflections with the help of dial gauge are measured.

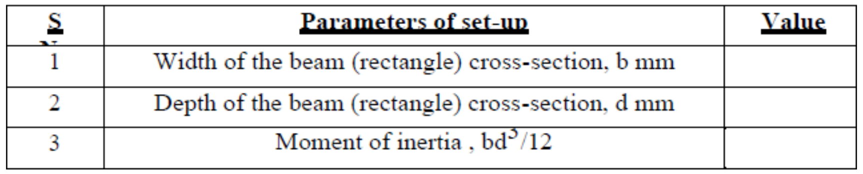
3. Precautions are to be taken to keep the dial gauge in correct position to measure the desired deflection.

4. The deflections corresponding to various loads for each case are tabulated.

5.The beam is placed horizontally and in the first case, the loads are acted in the middle and dial gauge is placed at 1/4th of the beam and loads are added slowly and according to the load, the readings are noted. Similarly note down the deflections while unloading.

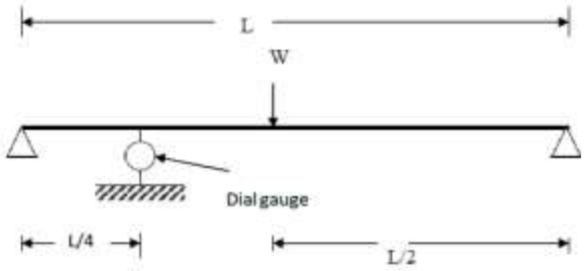
6.In the second case load is placed at 1/4th of the beam and dial gauge at the center and the readings are noted similar to the first case.

Table 1:

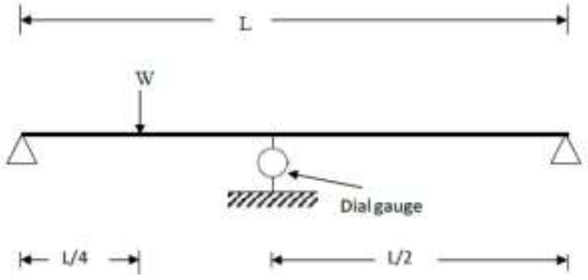


S	Parameters of set-up	Value
1	Width of the beam (rectangle) cross-section, b mm	
2	Depth of the beam (rectangle) cross-section, d mm	
3	Moment of inertia , $bd^3/12$	

Case (i):



Case (ii):



OBSERVATIONS:

Table 2:

S No	Load applied(W)		Deflection in mm		Average	LC x Avg.	Young's Modulus (E) N/mm^2
	Kg	N	Loading	Unloading			
Case (i)							
1							
2							
3							
4							
5							
6							
7							
Case (ii)							
1							
2							
3							
4							
5							
6							
7							

Table 3:

S.No	Load(W) N	Avg. 1	Avg. 2	Average of 1&2(z)	Young's Modulu	% Error (z-(x or
1						
2						
3						
4						
5						
6						

CALCULATIONS:

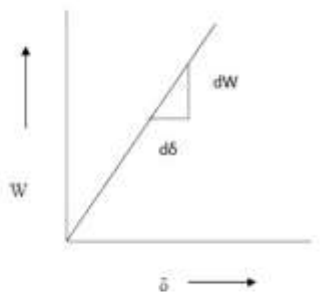
Moment of inertia (I) =________mm^4 Young's

Modulus (E) = (11/768) * (W/δ) * (L^3/I)

RESULT: The Young's modulus of steel by Maxwell's reciprocal theorem is:

The percentage error is:

GRAPHS TO BE DRAWN:



ADDITIONAL EXPERIMENT No: - 2

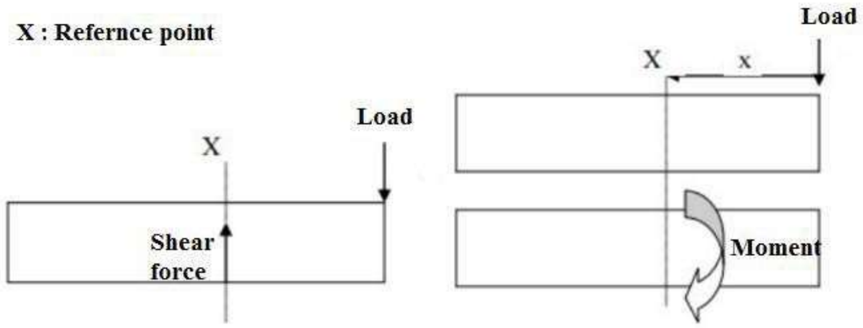
SHEAR FORCE AND BENDING MOMENT

I-Introduction:

Shear force is the internal resistance created in beam's cross section, in order to balance transverse external load acting on it, while bending moment is bending effect due to an applied load at a given distance away from the reference point.

There are several types of beams, such as: cantilever beam, simply supported beam, overhanging beam, and continuous beam, the difference between them is explained in the overview section. In this experiment, simply supported beam will be examined.

Having a good understanding of shear force and bending moment, is very important in the engineering field, in civil engineering a good understanding of these two concepts are the key to design structural element.



Objectives:

1To calculate theoretical values for shear force and bending moment, resulting from a load acting on simply supported beam.

2 Draw shear force diagram (SFD) and bending moment diagram (BMD).

3 Compare theoretical values to true values.

System Description

Shear force and bending moment test stand WP 960 G.U.N.T

Simply supported beam length 80 cm.

Procedure:

1- Level the beam by using water level ruler.

2- Set the shear and moment gages to zero.

3 Add a load to hanger A.

4 Record the shear and moment reading from the gages.

5 Repeat steps 1-4 using 2 loads at both A and C.

6 Add uniform load to the beam (by distributing equal loads over the beam length).

7 Record the shear and moment reading from the gages.

Theory and Calculations:

The shear and bending moment throughout a beam are commonly expressed with diagrams. A shear diagram shows the shear along the length of the beam, and a moment diagram shows the bending moment along the length of the beam. These diagrams are typically shown stacked on top of one another, and the combination of these two diagrams is a shear-moment diagram. In order to draw a shear force and bending moment diagrams, first the value of shear force and bending moment must be calculated at supports (reactions) and at points where load varies.

It is important to note that The SFD and BMD curves shape depends on the load type (i.e. point load, Uniformly distributed load..etc.).The following table shows the different curve shapes for SFD and BMD, SF and BM equations, depending on load type and location.

After calculating SF, BM, and drawing SFD and BMD, error percentage between true values and theoretical values must be calculated using the following equation:

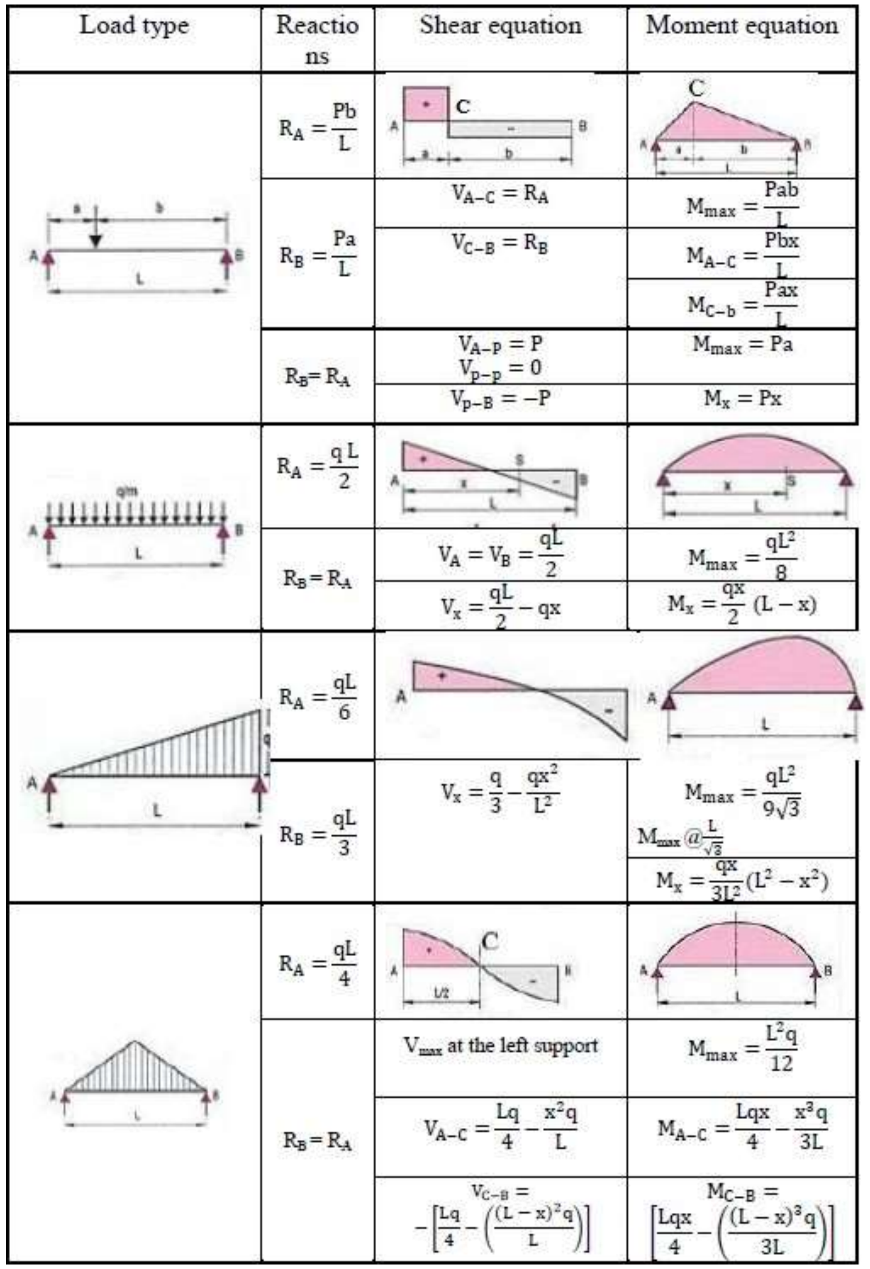
$E\% = |V_E - V_T V_E| * 100\%$ (4.1)

Where:

E% : Error percentage.

V_E: Experimental value (from gage).

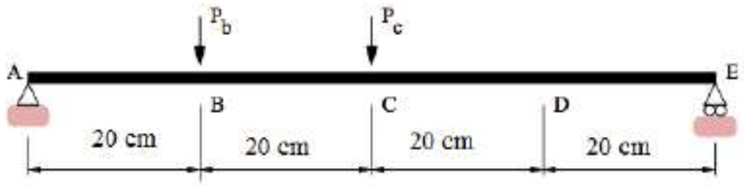
V_T : Theoretical value (calculated).



Load type	Reactions	Shear equation	Moment equation
	$R_A = \frac{Pb}{L}$		
	$R_B = \frac{Pa}{L}$	$V_{A-C} = R_A$ $V_{C-B} = R_B$	$M_{max} = \frac{Pab}{L}$ $M_{A-C} = \frac{Pbx}{L}$ $M_{C-b} = \frac{Pax}{L}$
	$R_B = R_A$	$V_{A-P} = P$ $V_{P-P} = 0$ $V_{P-B} = -P$	$M_{max} = Pa$ $M_x = Px$
	$R_A = \frac{qL}{2}$		
	$R_B = R_A$	$V_A = V_B = \frac{qL}{2}$ $V_x = \frac{qL}{2} - qx$	$M_{max} = \frac{qL^2}{8}$ $M_x = \frac{qx}{2}(L-x)$
	$R_A = \frac{qL}{6}$		
	$R_B = \frac{qL}{3}$	$V_x = \frac{q}{3} - \frac{qx^2}{L^2}$	$M_{max} = \frac{qL^2}{9\sqrt{3}}$ $M_{max} @ \frac{L}{\sqrt{3}}$ $M_x = \frac{qx}{3L^2}(L^2 - x^2)$
	$R_A = \frac{qL}{4}$		
	$R_B = R_A$	V_{max} at the left support $V_{A-C} = \frac{Lq}{4} - \frac{x^2 q}{L}$ $V_{C-B} = -\left[\frac{Lq}{4} - \left(\frac{(L-x)^2 q}{L}\right)\right]$	$M_{max} = \frac{L^2 q}{12}$ $M_{A-C} = \frac{Lqx}{4} - \frac{x^3 q}{3L}$ $M_{C-B} = \left[\frac{Lqx}{4} - \left(\frac{(L-x)^3 q}{3L}\right)\right]$

***VI-Collected Data*:**

Case 1:



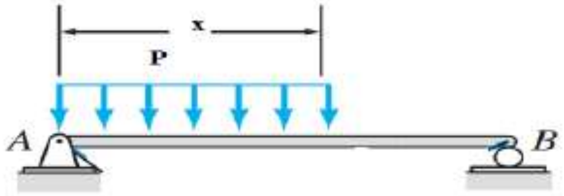
Load P_b = ... N.

Gage reading for shear force= ....N

Load P_c = ...N.

Gage reading for moment= .... N.m

Case 2:



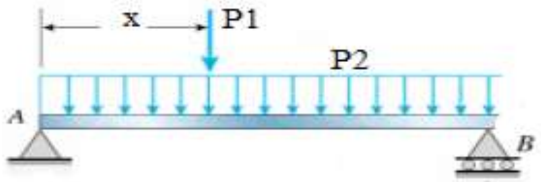
Distance = ... m.

Gage reading for shear force= ....N

Load P= .... N/m.

Gage reading for moment= .... N.m

Case 3:



Distance x = ... m.

Gage reading for shear force= ....N

Load P_1= .... N.

Gage reading for moment= .... N.m

Load P_2=.........N.

***Results*:**

1. -Draw SFD and BMD for each Case.
2. -Find equations for SF and BM at distance x for each case.
3. -Calculate the errors in each case.