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Strength of Material-I Lab (ME-214-F)

LIST OF EXPERIMENTS

1.To study the Brinell Hardness testing machine and the Brinell hardness test.

2. To study the Rockwell Hardness testing machine and perform the Rockwell hardness test.
3. To study the Impact Testing machine and Perform Izod impact test.
4. To study the Impact Testing machine and Perform charpy impact test.
5. To study the UTM and perform the tensile test.
6. To Perform compression test on UTM.
7. To perform the bending test on UTM.
8. To perform the shear test on UTM.
9. Torsion test on mild steel rod.

EXPERIMENT NO.-1

Objective :- To study the Brinell Hardness testing machine and the Brinell hardness test.

APPARATUS: - Brinell Hardness testing machine, specimen of mild steel / cast iron/ nonferrous metals and Brinell microscope.

THEORY: - Hardness represents the resistance of material surface to abrasion, scratching and cutting, hardness after gives clear identification of strength. In all hardness testes, a define force is mechanically applied on the test piece for about 15 seconds. The indentor,which transmits the load to the test piece, varies in size and shape for different tstes.Common indenters are made of hardened steel or diamond.

In Brinell hardness testing, steel balls are used as indentor. Diameter of the indentor and the applied force depend upon the thickness of the test specimen, because for accurate results, depth of indentation should be less than 1/8th of the thickness of the test pieces. According to the thickness of the test piece increase, the diameter of the indentor and force are changed.

SPECIFICATION OF HARDNESS TESTING OF HARDNESS TESTING M/C AND INDENTORS

A hardness test can be conducted on Brinell testing m/c, Rockwell hardness m/c or vicker testing m/c. the specimen may be a cylinder, cube, think or thin metallic sheet. A Brinell-cum-Rockwell hardness testing m/c along with the specimen is shown in figure. Its specification are as follows:

1. Ability to determine hardness upto 500BHN.
2. Diameter of ball (as indentor) used D = 2.5mm, 5mm, 10mm.
3. Maximum application load = 3000kgf.
4. Method of load application = Lever type
5. Capability of testing the lower hardness range = 1 BHN on application of 0.5D2 load.

PROCEDURE:-

1. Insert ball of dia ‘D’ in ball holder of the m/c.
2. Make the specimen surface clean by removing dust, dirt, oil and grease etc.
3. Make contact between the specimen surface and the ball by rotating the jack adjusting wheel.
4. Push the required button for loading.
5. Pull the load release level and wait for minimum 15 second. The load will automatically apply gradually.
6. Remove the specimen from support table and locate the indentation so made.
7. View the indentation through microscope and measure the diameter ‘d’ by micrometer fitted on microscope.
8. Repeat the entire operation, 3-times.

OBSERVATION AND CALCULATION : -

Following observation are recorded from a test on steel specimen using a hardened steel ball as indentor.

Test piece material = ---------------

Sr. No.	Ball diameter ‘D’ in mm	LoadDiameter of P/D2 applied P in indentation kgf.‘d’ (mm)	BHN

BHN = Load Applied (kgf.)/ Spherical surface area indentation (in mm.)

$$= 2P/\pi D(D-\sqrt{D2 - d2})$$

PRECAUTIONS:-

1. The specimen should be clean properly.
2. Take reading more carefully and correct.
3. Place the specimen properly.
4. Jack adjusting wheel move slowly
5. After applying load remove the load.

RESULT:-

EXPERIMENT NO.-2

Objective : To study the Rockwell Hardness testing machine and perform the Rockwell hardness test.

APPARUTS :- Rockwell Hardness testing machine, specimen of mild steel or other material.

THEORY: - Hardness represents the resistance of material surface to abrasion, scratching and cutting, hardness after gives clear indication of strength. In all hardness tests, a define force is mechanically applied on the piece, varies in size and shape for different tests. Common indentors are made of hardened steel or diamond.

Rockwell hardness tester presents direct reading of hardness number on a dial provided with the m/c. principally this testing is similar to Brinell hardness testing. It differs only in diameter and material of the indentor and the applied force. Although there are many scales having different combinations of load and size of indentor but commonly 'C' scale is used and hardness is presented as HRC. Here the indentor has a diamond cone at the tip and applied force is of 150 kgf. Soft materials are often tested in 'B' scale with a 1.6mm dia. Steel indentor at 60kgf.

SPECIFICATION OF HARDNESS TESTING M/C AND INDENTORS:-

A hardness test can be conducted can be conducted on Brinell testing m/c, Rockwell hardness m/c or vicker testing m/c. the specimen may be a cylinder, cube, thick or thin metallic sheet. A Brinell-cum-Rocwell hardness testing m/c along with the specimen is shown in figure. Refer to Fig. 6.

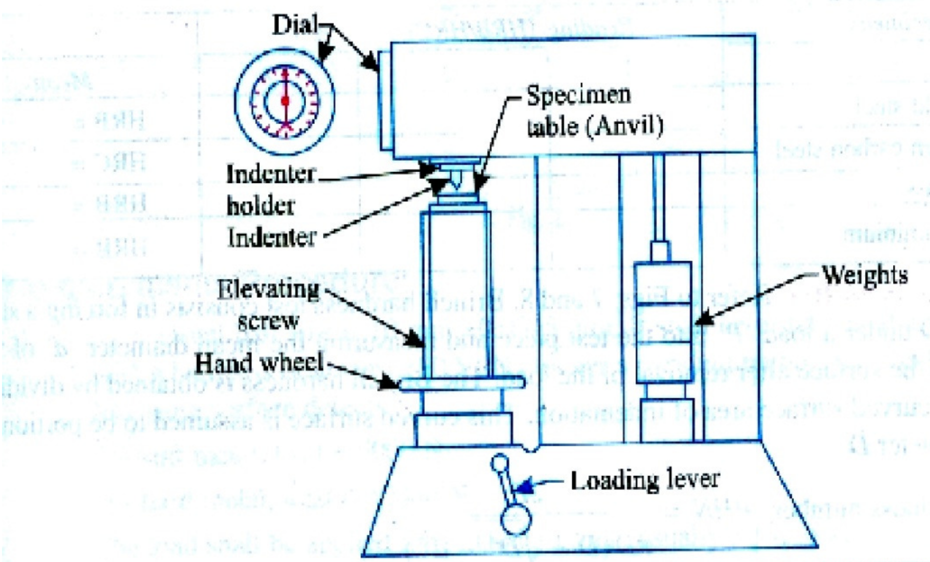

Fig. 6. Rockwell hardness tester.

Various scales in Rockwell hardness test are given below:-

Scale	Type of indentor (Dimension)	Initial load (kgf)	Major load (kgf)	Pointer Position on dial	Kind of material

PROCEDURE:-

1. Insert ball of dia. 'D' in ball holder of the m/c.
2. Make the specimen surface clean by removing dust, dirt, oil and grease etc.
3. Make contact between the specimen surface and the ball by rotating the jack adjusting wheel.

4. Push the required button for loading.
5. Pull the load release lever wait for minimum 15 second. The load will automatically apply gradually.
6. Remove the specimen from support table and locate the indentation so made.
7. Repeat the entire operation, 3-times.

OBSERVATION AND CALCULATION : -

Following observation are recorded are from a test on steel specimen using a hardened steel ball as indentor.

Test piece material =-----------

HRA = 100-(t/0.002)
HRB = 130-(t/0.002)
HRC = 100-(t/0.002)

PRECAUTIONS:-

1. The specimen should be clean properly.
2. Take reading more carefully .

EXPERIMENT No.-3

Objective:- To study the Impact Testing m/c and Perform Izod impact test.

APPARATUS :- Impact testing m/c, Izod test specimens of mild steel, Aluminium, Vernier caliper, specimen setting fixture.

THEORY :- In manufacturing locomotive wheels, coins, connecting rods etc. the components are subjected to impact (shock) loads. These loads are applied suddenly. The stress induced in these components are many times more than the stress produced by gradual loading. Therefore, impact tests are performed to asses shock absorbing capacity of materials subjected to suddenly applied loads. These capabilities are expressed as (i) Rupture energy (ii) Modulus of rupture and (iii) Notch impact strength.

Two types of notch impact tests are commonly-

1.Charpy test
2.Izod test

In Izod test, the specimen is placed as 'cantilever beam'. The specimens have V-shaped notch of 45°. U- shaped notch is also common. The notch is located on tension side of specimen during impact loading.
Depth of notch is generally taken as t.5 to t/3 where 't' is thickness of the specimen.

SPECIFICATION OF M/C AND SPECIMEN DETAILS :

Its specifications along-with their typical values are as follows:

Impact capacity = 164joule
Least count of capacity (dial) scale = 2joule
Weight of striking hammer = 18.7 kg
Swing diameter of hammer = 1600mm
Angle of hammer before striking = 90
Distance between supports = 40mm.

Striking velocity of hammer = 5.6m/sec
Specimen size = 75x10x10 mm
Type of notch = V-notch
Angle of notch = 45°
Depth of notch = 2 mm

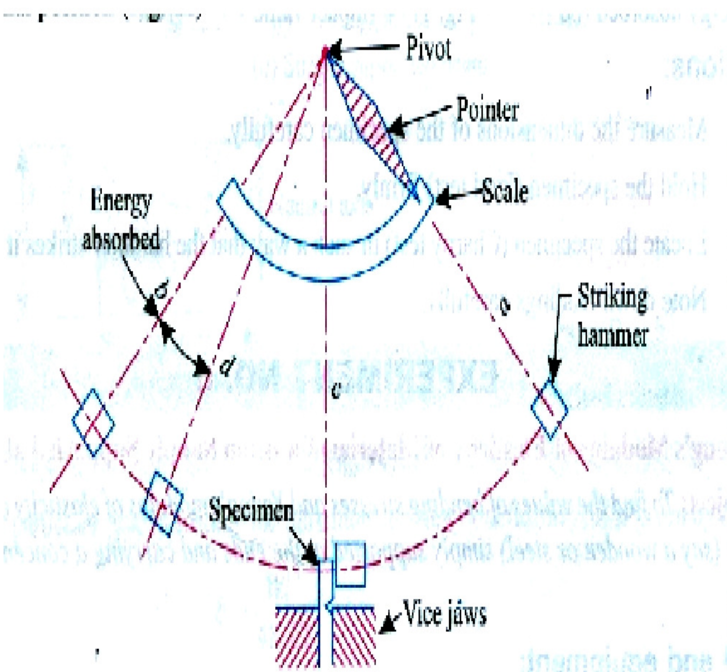

Fig. 11

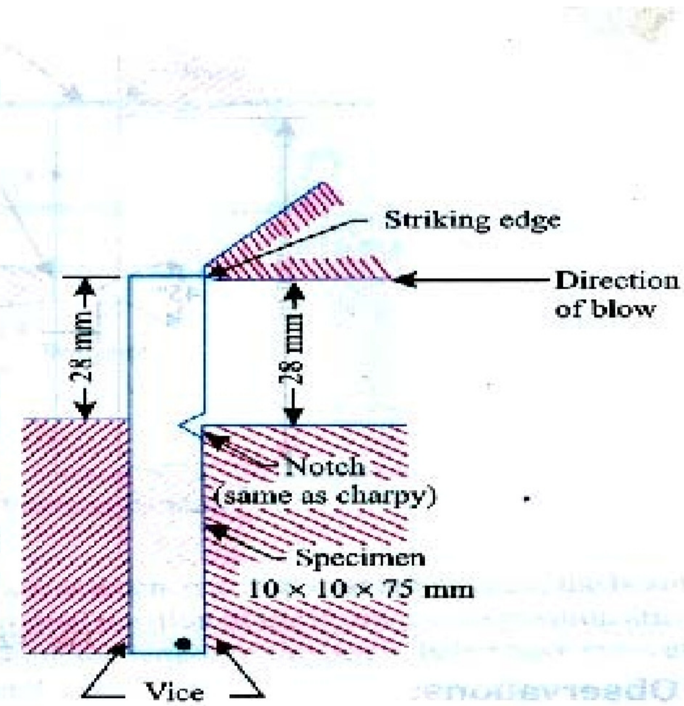

Fig. 10. Izod test.

Procedure:-

1.Lift the hammer to an appropriate knife edge position and notch the energy stored in the hammer. For the standard Izod test the energy stored should be 164j.

2.Locate the test specimen on the m/c supports.

3.Release the hammer. The hammer will break the piece and shoot up the other side of the specimen.

4.Note the residual energy indicated on the scale by the hammer.

5.Impact strength of the test specimen is the difference of the initial energy stored in hammer and the residual energy.

OBSERVATION :-

Sr. No.	Initial Energy (E1) In joule	Residual Energy (E2) In joule	Absorb Energy (E1-E2)

CALCULATION :-

Modulus of rupture = Rupture / Effective volume of specimen

Notch impact strength = Absorb energy / Effective cross section area

PRECAUTIONS :-

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

RESULT :- The impact strength of given specimen = -------joule/mm^2

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ERIMENT NO.-4

Objective:- To study the Impact Testing m/c and Perform charpy impact test.

APPARATUS :- Impact testing m/c, charpy test specimens of mild steel, Aluminium, Vernier caliper, specimen setting fixture.

THEORY :- In manufacturing locomotive wheels, coins, connecting rods etc. the components are subjected to impact (shock) loads. These loads are applied suddenly. The stress induced in these components are many times more than the stress produced by gradual loading. Therefore, impact tests are performed to asses shock absorbing capacity of materials subjected to suddenly applied loads. These capabilities are expressed as (i) Rupture energy (ii) Modulus of rupture and (iii) Notch impact strength.

Two types of notch impact tests are commonly-

1.Charpy test
2.Izod test

In Izod test, the specimen is placed as 'cantilever beam'. The specimens have V-shaped notch of 45°. U- shaped notch is also common. The notch is located on tension side of specimen during impact loading.Depth of notch is generally taken as t.5 to t/3 where 't' is thickness of the specimen.

SPECIFICATION OF M/C AND SPECIMEN DETAILS :

Its specifications along-with their typical values are as follows:

Impact capacity = 300joule
Least count of capacity (dial) scale = 2joule
Weight of striking hammer = 18.7 kg.
Swing diameter of hammer = 1600mm
Angle of hammer before striking = 160°
Distance between supports = 40mm
Striking velocity of hammer = 5.6m/sec

Specimen size = 55x10x10 mm
Type of notch = V-notch
Angle of notch = 45°
Depth of notch = 2 mm

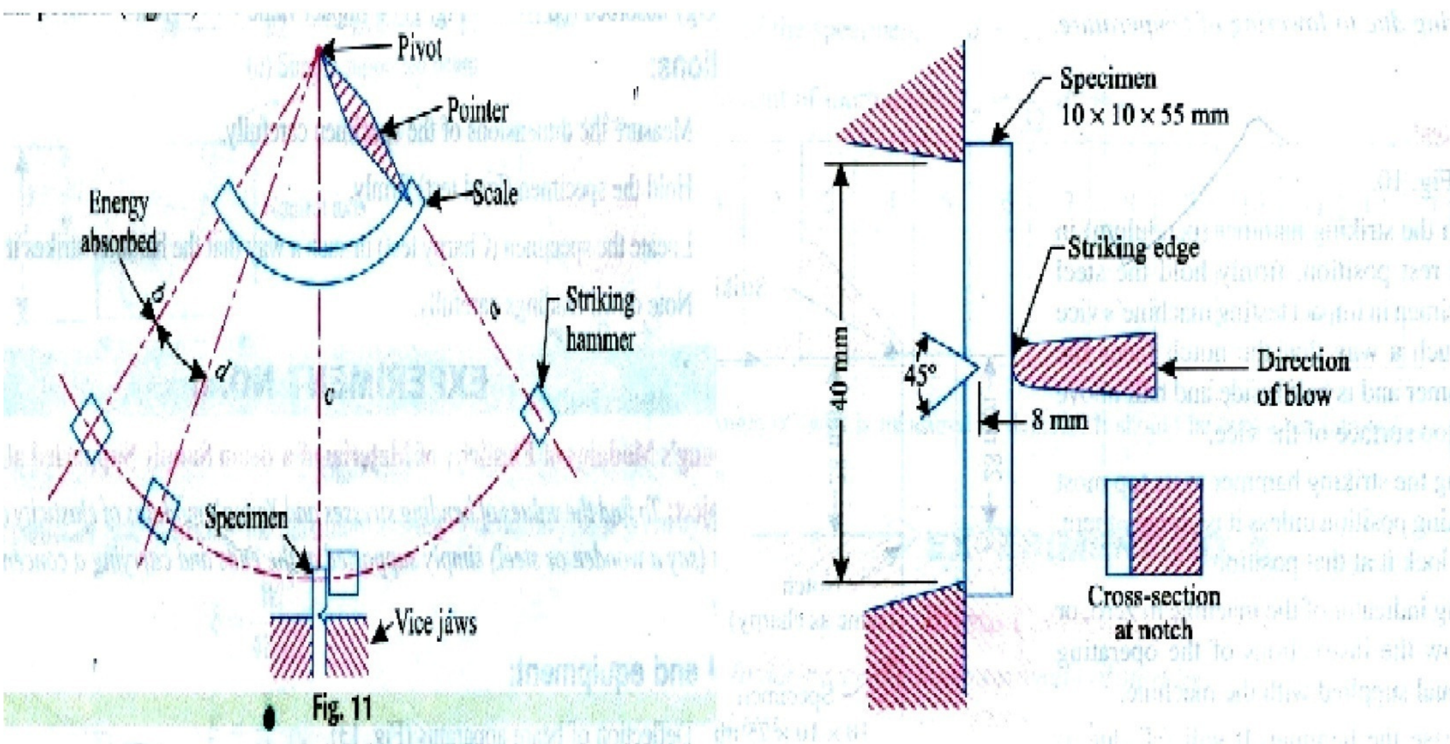


Fig. 11

PROCEDURE:-

1.Lift the hammer to an appropriate knife edge position and notch the energy stored in the hammer. For the standard Charpy test the energy stored should be 164j.

2.Locate the test specimen on the m/c supports.

3.Release the hammer. The hammer will break the piece and shoot up the other side of the specimen.

4.Note the residual energy indicated on the scale by the hammer.

5.Impact strength of the test specimen is the difference of the initial energy stored in hammer and the residual energy.

OBSERVATION :-

Sr. No.	Initial Energy (E1) In joule	Residual Energy (E2) In joule	Absorb Energy (E1-E2)

CALCULATION :-

Modulus of rupture = Rupture / Effective volume of specimen

Notch impact strength = Absorb energy / Effective cross section area

PRECAUTIONS :-

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

RESULT :- The impact strength of given specimen = -------joule/mm^2

EXPERIMENT NO.-5

Objective:- To study the UTM and perform the tensile test.

APPARATUS :- A UTM, mild steel specimen, vernier caliper/micrometer, dial gauge & graph paper.

THEORY :- Various m/c and structure components are subjected to tensile loading in numerous application. For safe design of these components, there ultimate tensile strength and ductility one to be determine before actual use. Tensile test can be conducted on UTM.

A material when subjected to a tensile load resists the applied load by developing internal resisting force . These resistances come due to atomic bonding between atoms of the material. The resisting force for unit normal cross-section area is known as stress.

The value of stress in material goes on increasing with an increase in applied tensile load, but it has a certain maximum (finite) limit too. The minimum stress, at which a material fails, is called ultimate tensile strength. The end of elastic limit is indicated by the yield point (load). This can be sen during experiment as explained later in procedure with increase in loading beyond elastic limit original cross-section area (Ao) goes on decreasing and finally reduces to its minimum value when the specimen breaks.

ABOUT THE UTM & ITS SPECIFICATIONS :-

The tensile test is conducted on UTM. It is hydraulically operates a pump, oil in oil sump, load dial indicator and central buttons. The left has upper, middle and lower cross heads i.e; specimen grips (or jaws). Idle cross head can be moved up and down for adjustment. The pipes connecting the lift and right parts are oil pipes through which the pumped oil under pressure flows on left parts to more the cross-heads.

SPECIFICATIONS :-

Load capacity = 0-40000 kgf

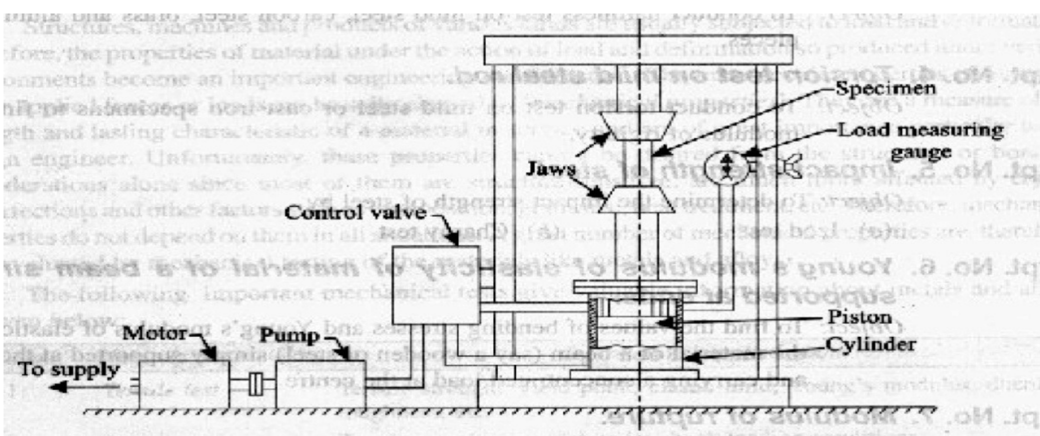
Least count = 8kgf

Overall dimn. =

Power supply = 440V

PROCEDURE :-

1. The load pointer is set at zero by adjusting the initial setting knob.
2. The dial gauge is fixed and the specimen for measuring elongation of small amounts.
3. Measuring the diameter of the test piece by vernier caliper at least at three places and determine the mean value also mark the gauge length.
4. Now the specimen is gripped between upper and middle cross head jaws of the m/c.
5. Set the automatic graph recording system.
6. Start the m/c and take the reading.
7. The specimen is loaded gradually and the elongation is noted until the specimen breaks.



• Fig. 1. Tenstile testing machine.

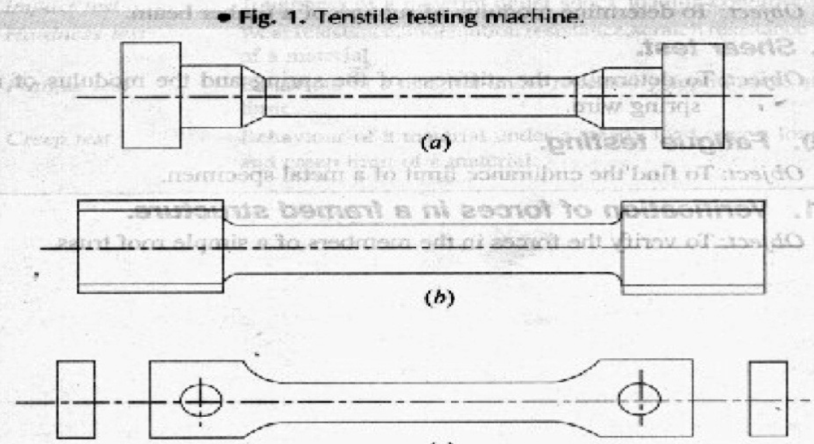


Fig. 2. Mild steel specimens.

OBSEVATION :-

Initial diameter of specimen d_1 = ------

Initial gauge length of specimen L_1 = -----

Initial cross-section area of specimen A_1 = ----

Load of yield point Ft. = -----

Ultimate load after specimen breaking F = -----

Final length after specimen breaking L_2 = ------

Dia. Of specimen at breaking place d_2 = -------

Cross section area at breaking place A_2 = ----

CALCULATION :-

1) Ultimate tensile strength = ------
2) Percentage elongation % = ------
3) Modulus of elasticity E = --------
4) Yield stress = --------
5) % reduction in area = -------

PRECAUTIONS :-

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

RESULT :-

EXPERIMENT NO.- 6

Objective:- To Perform compression test on UTM.

APPARATUS :- A UTM or A compression testing m/c, cylindrical or cube shaped specimen of cast iron, Alumunium or mild steel, vernier caliper, liner scale, dial gauge (or compressometer).

THEORY :- Several m/c and structure components such as columns and struts are subjected to compressive load in applications. These components are made of high compressive strength materials. Not all the materials are strong in compression. Several materials, which are good in tension, are poor in compression. Contrary to this, many materials poor in tension but very strong in compression. Cast iron is one such example. That is why determine of ultimate compressive strength is essential before using a material. This strength is determined by conduct of a compression test.

Compression test is just opposite in nature to tensile test. Nature of deformation and fracture is quite different from that in tensile test. Compressive load tends to squeeze the specimen. Brittle materials are generally weak in tension but strong in compression. Hence this test is normally performed on cast iron, cement concrete etc. But ductile materials like aluminium and mild steel which are strong in tension, are also tested in compression.

TEST SET-UP, SPECIFICATION OF M/C AND SPECIMEN DETAILS :

A compression test can be performed on UTM by keeping the test-piece on base block (see in fig.) and moving down the central grip to apply load. It can also be performed on a compression testing machine. A compression testing machine shown in fig. it has two compression plates/heads. The upper head moveable while the lower head is stationary. One of the two heads is equipped with a hemispherical bearing to obtain. Uniform distribution of load over the test-piece ends. A load gauge is fitted for recording the applied load.

SPECIMEN :- In cylindrical specimen, it is essential to keep $h/d \leq 2$ to avoid lateral instability due to bucking action. Specimen size = $h \leq 2d$.

PROCEDURE :-

1.Dimension of test piece is measured at three different places along its height/length to determine the average cross-section area.

2.Ends of the specimen should be plane . for that the ends are tested on a bearing plate.

3.The specimen is placed centrally between the two compression plates, such that the centre of moving head is vertically above the centre of specimen.

4.Load is applied on the specimen by moving the movable head.

5.The load and corresponding contraction are measured at different intervals. The load interval may be as 500 kg.

6.Load is applied until the specimen fails.

OBSERVATION :-

Initial length or height of specimen h = ------mm.
Initial diameter of specimen do = ------------mm.

Sr. No.	Applied load (P) in Newton	Recorded change in length (mm)

CALCULATION :-

Original cross-section area A_o = -----
Final cross-section area A_f = --------
Stress = -------
Strain = -------

For compression test, we can

i)Draw stress-strain (σ-ε) curve in compression,
ii)Determine Young's modulus in compression,

iii)Determine ultimate (max.) compressive strength, and
iv)Determine percentage reduction in length (or height) to the specimen.

PRECAUTIONS :-

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

RESULT :-

EXPERIMENT NO.- 7

Objective :- To perform the bending test on UTM.

APPARATUS USED :- UTM or Beam apparatus, Bending fixture, vernier caliper, meter rod, test piece & dial gauge.

THEORY :- Bending test is perform on beam by using the three point loading system. The bending fixture is supported on the platform of hydraulic cylinder of the UTM. The loading is held in the middle cross head. At a particular load the deflection at the center of the beam is determined by using a dial gauge. The deflection at the beam center is given by:

$$\delta = WL^3 / 48EI$$

PROCEDURE :-

1.Measure the length, width and thickness of test piece, by vernier caliper.

2.Place the bending fixture on the lower cross head of the testing m/c.

3.Place the test piece on the rollers of the bending fixture.

4.By loading the dial gauge in a stand, make its spindle knob the test piece.

5.Start the m/c and note down the load and dial gauge readings.

6.Plot the graph between load and deflection.

OBSERVATION :-

Least count of vernier caliper = -----
Length of beam (L) = --------
Width of beam (b) = ------

Thickness of beam (t) = ------

Sr. No.	Load 'W' in Newton	Deflection 'δ' in mm	Young's Modulus 'E' N/mm^2

CALCULATION :-

$I = bt^3/12$
$\delta = wL^3/48EI$

PRECAUTIONS :-

1. Test piece should be properly touch the fixture.
2. Test piece should be straight
3. Take reading carefully.
4. Elastic limit of the beam should not be exceeded.

RESULT :-

EXPERIMENT NO.- 8

Objective :- To perform the shear test on UTM.

APPARATUS USED :- A UTM, Specimen, shearing attachment, vernier caliper etc.

THEORY :- A type of force which causes or tends to cause two contiguous parts of the body to slide relative to each other in a direction parallel to their plane of contact is called the shear force. The stress required to produce fracture in the plane of cross-section, acted on by the shear force is called shear strength.

PROCEDURE :-

The method for determining the shear strength consists of subjecting a suitable length of steel specimen in full cross-section to double shear, using a suitable test rig, in a testing m/c under a compressive load or tensile pull and recording the maximum load 'F' to fracture.

OBSERVATION :-

Applied compressive force (F) = ---------kgf.
Diameter of specimen = ---------mm.

CALCULATION :-

The shear strength shall be calculated from the following formulae :

$\tau s = (F/2) / (\pi d2/4) = 2F / \pi d2$

where 'd' is the actual diameter of the specimen

PRECAUTIONS :-

1. The specimen should be all place equal dia.
2. Measure the diameter of specimen carefully.
3. The specimen should be properly grip between the test rig.
4. Take reading more carefully.
5. After shearing specimen stop to m/c.

RESULT :- Shear strength of specimen = -------

EXPERIMENTNo.- 9

Objective:- Torsion test on mild steel rod.

OBJECT: -To conduct torsion test on mild steel or cast iron specimens to find out modulus of rigidity

APPARATUS: -1. A torsion testing machine.

2. Twist meter for measuring angles of twist

3. A steel rule and Vernier Caliper or micrometer.

THEORY: -

A torsion test is quite instrumental in determining the value of modulus of rigidity of a metallic specimen. The value of modulus of rigidity can be found out thought observations made during the experiment by using the torsion equation.

$$T/J = \tau/R = C\theta/L$$

T = Torque applied

J = Polar moment of inertia

τ = shear stress

C = Modulus of rigidity,

θ =Angle of twist (radians), and

L = Length of shaft

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 protector to zero for convenience and clamp it by means of knurled screw.
6. Carry out straining by rotating the handweel 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 C by using relation

$$C= TL/J\theta$$

PRECAUTION:- 1) Measure the dimensions of the specimen carefully

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

Result:-

i)Modulus of rigidity of mild steel rod is ------------- N/mm^2

ii)Modulus of rigidity of Aluminum rod is ------------- N/mm^2