SSM COLLEGE OF ENGINEERING AND TECHNOLOGY

LABORATORY MANUAL FOR STRENGTH OF MATERIALS

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SSM College of Engineering and Technology

THE VISION OF THE DEPARTMENT OF CIVIL ENGINEERING DEPARTMENT IS

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- To be a central hub for industry outreach services for creating sustainable infrastructure and enhancing quality of life.
- Strive continuously in pursuit of excellence in every field of civil engineering.

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- Understand the impact of the professional engineering solutions in societal and

SSM COLLEGE OF ENGINEERING AND TECHNOLOGY

STRENGTH OF MATERIALS LAB

DEPARTMENT OF CIVIL ENGINEERING

THIS IS TO CERTIFY THAT THIS BOOK IS A BONAFIDE RECORD PRACTICAL WORK DONE IN THE STRENGTH OF MATERIALS LABORATARY IN _______________ SEMESTER OF _________________YEAR DURING THE YEAR ____________________

NAME :.......................................

ROLL.NO :....................................

SECTION :....................................

SIGNATURE OF LAB INCHARGE:

SSM COLLEGE OF ENGINEERING AND TECHNOLOGY

MANDATORY INSTRUCTIONS

1. Students should report to the labs concerned as per the timetable.

2. Record should be updated from time to time and the previous experiment must be signed by the faculty in charge concerned before attending the lab.

3. Students who turn up late to the labs will in no case be permitted to perform the experiment scheduled for the day.

4. After completion of the experiment, certification of the staff in-charge concerned in the observation book is necessary.

5. Students should bring a notebook of about 100 pages and should enter the readings/observations/results into the notebook while performing the experiment.

6. The record of observations along with the detailed experimental procedure of the experiment performed in the immediate previous session should be submitted and certified by the staff member in-charge.

7. Not more than FIVE students in a group are permitted to perform the experiment on a set up.

8. The group-wise division made in the beginning should be adhered to, and no mix up of student among different groups will be permitted later.

9. The components required pertaining to the experiment should be collected from Lab- in-charge after duly filling in the requisition form.

10. When the experiment is completed, students should disconnect the setup made by them, and should return all the components/instruments taken for the purpose.

11. Any damage of the equipment or burnout of components will be viewed seriously either by putting penalty or by dismissing the total group of students from the lab for the semester/year.

12. Students should be present in the labs for the total scheduled duration.

13. Students are expected to prepare thoroughly to perform the experiment before coming to Laboratory.

14. Procedure sheets/data sheets provided to the students groups should be maintained neatly and are to be returned after the experiment.

15. **DRESS CODE:**

i. Boys - Formal dress with tuck in and shoes.

ii. Girls - Formal dress (salwar kameez).

Iii. Apron in blue color for both boys and girls.

iii. Wearing of jeans is strictly prohibited

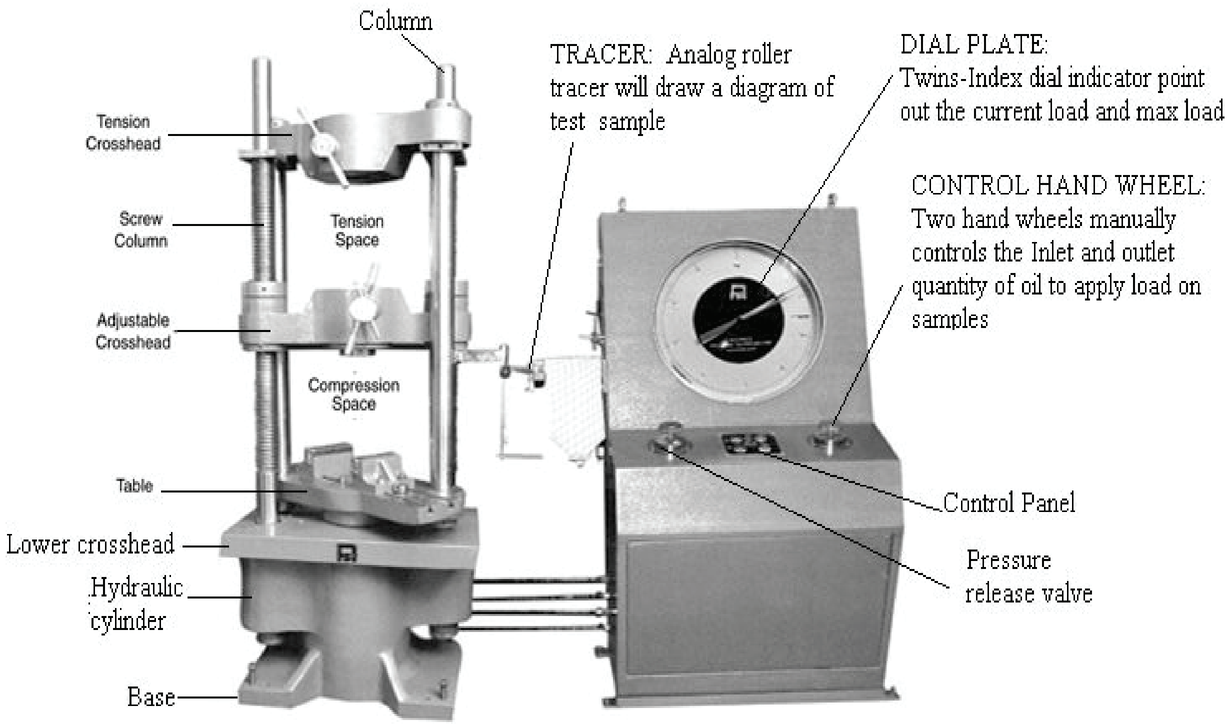
CONTENTS

1. DIRECT TENSION TEST

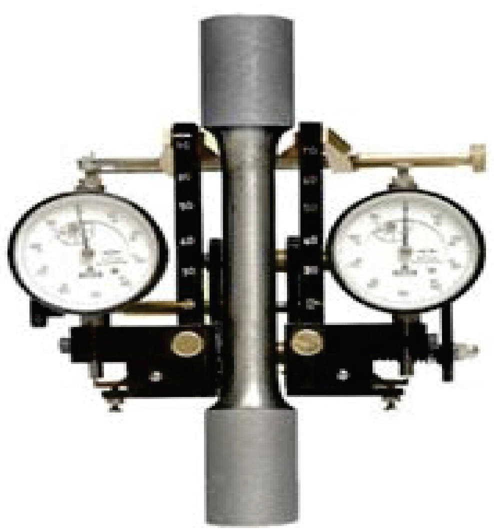
1. **AIM:** To studythe behavior of a mild steel specimen under a gradually increasing tensile load and to determine the following mechanical properties.

   a) Tensile strength. b) Yield strength. c) Ultimate stress
   d)young's modulus. e) Percentage of Elongation. f) Percentage of reduction of area

2. **APPARATUS REQUIRED:** Universal testing machine (UTM), Extensometer.
3. **SPECIMENS REQUIRED**: Mild steel rod of 10 mm dia , steel rule, vernier calipers.
4. **SKETCH-UTM Machine:**



Mechanical Extensometer



Mechanical Extensometer is an attachment to Universal /Tensile Testing Machines. It measures the elongation of a test piece on load for the set gauge length. The least count of measurement is 0.01 mm and maximum elongation measured is up to 3mm.This elongation measurement helps in finding out the proof stress at the required elongation percentage.

5. DESCRIPTION OF APPARATUS:

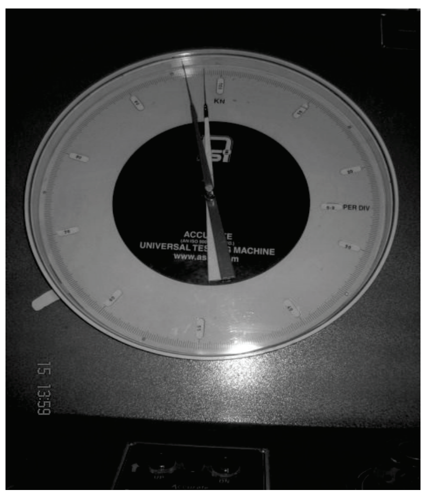
The machine serves the purpose of conducting tension, compression and bending test. The testing machine is operated hydraulically. Driving is performed by the help of electric motor. The machine is equipped with pendulum dynamometer. A recording device is used for registering load deformation diagram.

6. DESCRIPTION OF PARTS:

CONTROL PANEL: The control panel consists of a complete power pack with drive motor, oil tank, control valves, a pendulum dynamometer, a load indicator system and an autographic recorder.

POWER PACK: The power pack generates the maximum pressure of 200kgf/cm^2. The hydraulic pump provides continuously non-pulsating oil flow. Hence the load application is very smooth.

LOAD INDICATOR SYSTEM:



This system consists of a large dial and a pointer. A dummy pointer is provided to register the maximum load reached during the test. Different measuring ranges can be selected by operating the range selecting knob. An overload trip switch is incorporated, which automatically cuts out the pump motor when the load range is exceeded.

The load ranges has 4 positions.

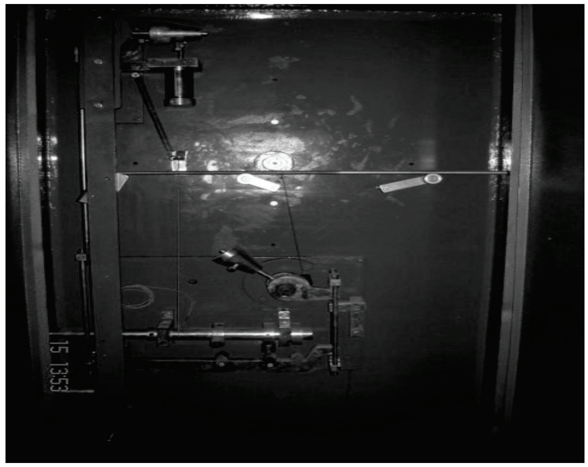
i.e., 0 to 100 KN

0to 250KN

0 to 500 KN

0 to 1000 KN

PENDULUMDYNAMOMETER:



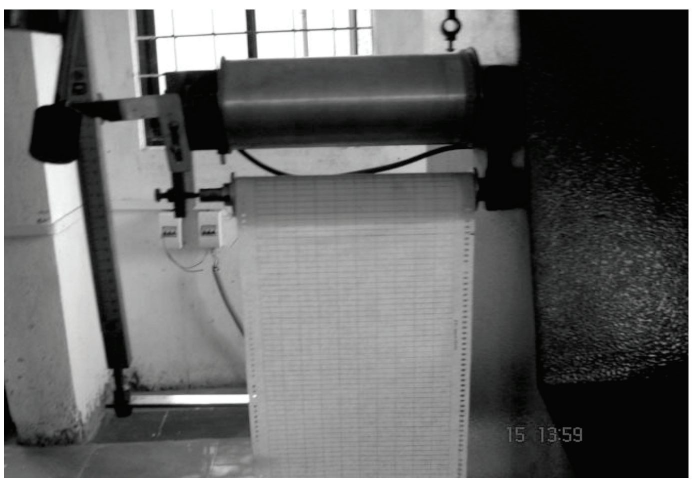
This unit permits selection of favorable hydraulic ratios producing relatively small directional forces. Pressurized oil in the loading cylinder pushes up the measuring piston proportionately and actuates the special dynamometer system. The piston is constantly rotated to eliminate friction. The dynamometer system is also provided with an integral damper and ensures high reliability of operation. The load transmitted to the dynamometer is transferred through a pendulum to the load indicator.

Autographic continuous roll load -Elongation recorder:

This unit is of the open and drums type and is supplied as standard.

Graph paper:The graph paper which is there in the UTM machine is used to draw the stress-strain diagram for the given material.

Graph Drum:



Graph drums on which the graph paper is rolled. It is used to draw the stress Vs strain diagram for the given material

ELONGATION SCALE:

On this scale we measure the elongation or compression of the specimen. This is marked from 0 to 20 cm.

PEN HOLDER:

This is placed above the graph drum, which is to be used for holding the pen. While the needle of the pendulum dynamometer is rotating, this is to be moved. By using this pen holder we can draw the stress-strain diagram.

LOADING PLATFORM:

Loading platform is one on which we keep the specimen for doing the compression test. This loading platform is to be moved in to upward direction by switching on the upward switch of the driving motor. And it is moved downwards by pressing the down switch of the driving motor.

3 · **ELECTRIC MOTOR:** The electric motor gives the power supply to the system by which we can operate the driving motor properly. This power supply is given to the threading device of the UTM.

THEORY:

The Universal Testing Machine (UTM) mainly consists of two units

1. loading unit and
2. control panel

The loading unit consists of

- Lower cross head
- Middle cross head
- Upper cross head

The specimen is tested on the loading unit and the corresponding readings are taken from the fixed dial on the control panel. The main hydraulic cylinders fitted in the centre of the base and the piston slides over the cylinder when the machine is under operation. A lower table is rigidly connected to an upper cross head by two straight columns. This assembly moves up and down with the main piston. The test is conducted by fixing the specimen in between the lower and upper crossheads by jaws inserts. An elongation scale is also kept sliding which is fitted between lower table and upper crosshead.

The two valves on the control panel one on the right side and the other one on the left side are used to control the oil flow in the hydraulic system. The right side valve is a pressure flow control valve and the left side valve is a return valve to allow the oil from the cylinder to go back to the tank. Control panel also consists of dynamometer which measures and indicates the load on the specimen.

BEHAVIOUR OF STEEL UNDER STRESS:-

Steel is an important material used in structure as well as machines. While designing a steel member the designer should have an idea of properties mentioned above. The knowledge of behavior of steel under stress is very essential upto a certain stress limit the steel behaves as an elastic material but beyond that the steel behaves differently. The designer should have an idea of young's modulus of elasticity, the elastic limit and the maximum tensile strength. Also the percentage elongation at failure is a measure of ductility of steel. We get all this information from one single test i.e. Tensile test on steel , (or for the matter on other metals also) in which specimen is subjected to tensile load gradually till it fails.

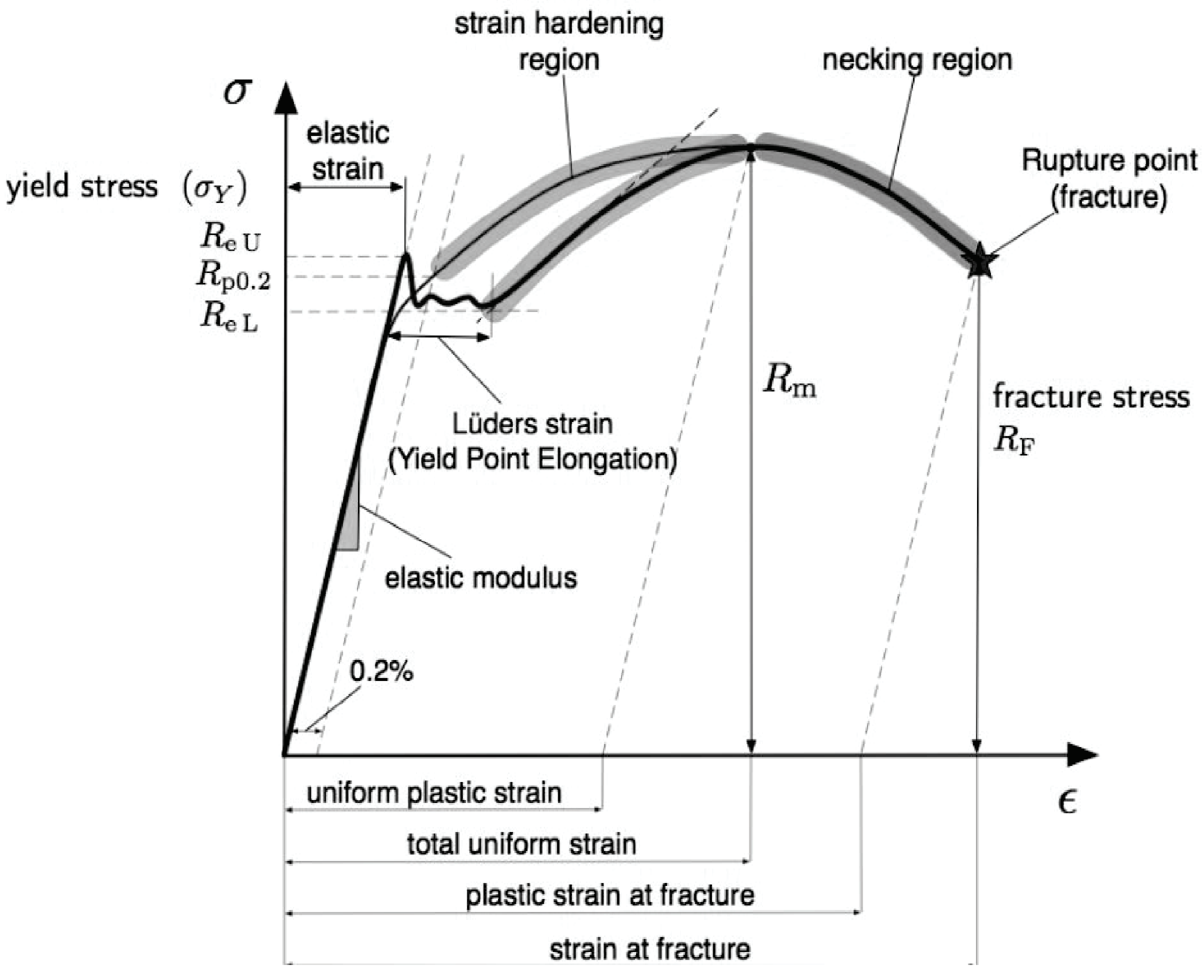
BEHAVIOUR OF VARIOUS MATERIALS:

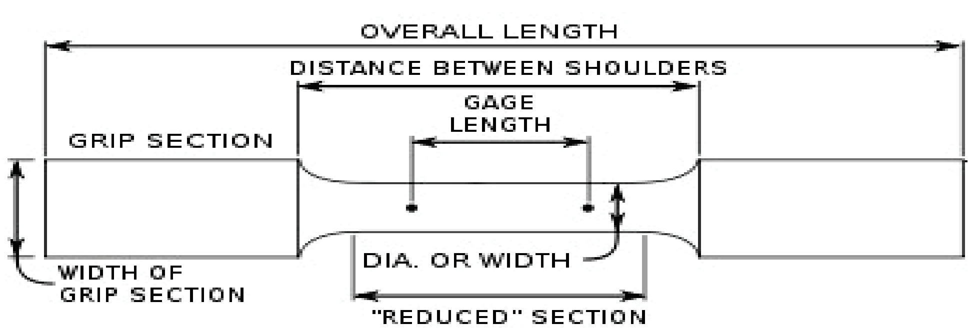
a) Mild steel has got definite yield point. It contains carbon content less than 0.3%. Medium carbon steel contains carbon 0.3% to 0.8%. High carbon steel contains carbon 0.8% to 1.5%. As the carbon content increases the strength also increases, but the ductility is reduced. High carbon steel does not show clear yield point.

b) Cast iron is brittle, it does not exhibit any yield point, and it has a low limit of proportionality Its ductility is low.

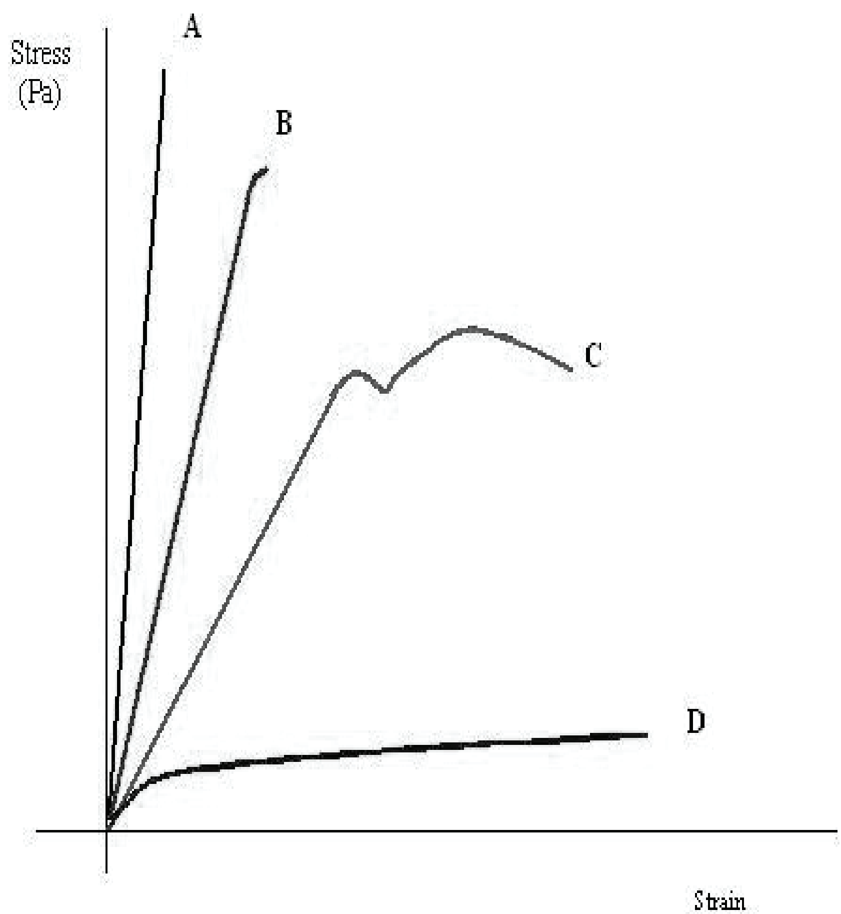
c) Non ferrous metals and their alloys:- These also do not show a definite yield point and their limit of proportionality is low. But they are ductile.

Stress strain curves and derived properties for Mildsteel





Stress-strain graphs of different materials.



Curve **A** shows a **brittle** material. This material is also strong because there is little strain for a high stress. The fracture of a brittle material is sudden and catastrophic, with little or no plastic deformation. Brittle materials crack under tension and the stress increases around the cracks. Cracks propagate less under compression.

- Curve **B** is a **strong** material which is not ductile. Steel wires stretch very little, and break suddenly. There can be a lot of elastic strain energy in a steel wire under tension and it will "whiplash" if it breaks. The ends are razor sharp and such a failure is very dangerous indeed.
- Curve **C** is a **ductile** material
- Curve **D** is a **plastic** material. Notice a very large strain for a small stress. The material will not go back to its original length.

Overall Length=

Length of Reduced section =

Distance between shoulders =

Diameter of reduced section=

Width or dia of grip section =

PROCEDURE:

1) Measure the length and diameter of given specimen.
2) Fix the load range by placing counter weights on the balancing pendulum at the back of the machine.
3) With the pressure release valve open adjust the middle cross head to fix the specimen between upper and middle cross head by operating the up and down switches. Also adjust the machine to read zero.
4) Fix the specimen between upper and middle cross head properly so that load is applied axially.
5) Before operating the UTM ensure that the oil delivery valve (left) is open and the pressure release valve (right) is closed.
6) After switching on the UTM open the pressure release valve and close the oil delivery valve.
7) Now, push the 'ON' button on the control panel and there will be tension acting on the specimen due to fluid pressure.
8) Before applying the pressure adjust the pencil to the graph roll.
9) Position the Extensometer on the specimen. Position Upper clamp to press upper knife on the specimen.
10) The extensometer will now be fixed to the specimen by spring pressure. Set zero on both the dial gauges.
11) Start loading the test specimen and take the reading Of load on the machine at required elongation or the elongation at required load.
12) For better accuracies mean of both dial gauge readings should be taken as elongation.
13) The yield point is observed when the line needle is suddenly stops for a second and continues to move.
14) At one stage the line needle begins to return, leaving the dummy needle there itself. At this point the ultimate strength of the specimen is observed.
15) After some time the specimen breaks making a huge sound.
16) As the specimen breaks the graph is metallically plotted according to the behavior of specimen under tension due to applied load.
17) Note and record the required reading and the graph plotted.
18) Remove the broken pieces of the specimen from the machine and safely switch off the machine.
19) Measure the gauge length of the test specimen and diameter of the neck.

S.NO OBSERVATION	Load (P)in "N"	Specimen Dia. as per applied load(d) in mm	Area of the specimen as per applied load(A) in mm^2	Original gauge length of specimen(l) in mm	Extension (δl) in mm	Stress"f"(P/A) N/mm^2	Strain" e"(δl/l)	Modulus of elasticity(E)=f/e - N/mm^2
1								
2								
3								
4								
5								

SAMPLE CALCULATIONS:

1. Diameter of the specimen, d =
2. Length of the specimen, L=
3. Lower Yield point found at =
4. Upper Yield point found at=
5. Ultimate strength found at =
6. Break point found at =

Stress: The resistance offered by a body against the deformation is called stress. Stress (f) = Load (p)/area of cross section (A)

= P/A N / mm^2

Strain: The ratio of change in length to the original length is called strain

Strain (e) = Change in length / Original length (l)

Young's modulus: The ratio of stress to strain within the elastic limit is called modulus of elasticity (or) young's modulus.

E = Stress (f)/ Strain (e)

Tensile Strength: The tensile strength or ultimate tensile strength is the maximum load obtained in a tensile test divided by the original area of the cross-section of the specimen. It is used for the quality control of the product. It can be co-related to other properties such as hardness and fatigue strength.

$$P_u = P_{max}/A_0$$

Where P_u = ultimate tensile strength in kg/mm^2

P_{max}= Maximum load obtained in tensile test in Kgs

A_0 = original cross-sectional area of load specimen in mm^2.

Yield Strength: It is defined as the stress which will produce a small amount of permanent deformation. Yield strength $P_y = P_e / A_0$

P_e= load obtained at yield point

A_0 = original area of cross-section in mm^2.

Percentage Elongation:

$$\%E = (L-L_0)/ L_0 \times 100$$

E = percentage elongation L = Increased length or gauge length at fracture. L_0 = original length.

Total % elongation up to fracture point is an indication of ductility (ability of a material to with stand plastic deformation).

Reduction of Area: It is the ratio of decrease in cross-sectional area to the original area expressed percentage.

$$\% R_A = (A_0-A)/ A_0 \times 100$$

R_A = percentage reduction in area.

A_0 = original cross-sectional area

A = final cross-sectional area after fracture.

PRECAUTIONS:

1. Carefully switch 'ON' the machine
2. Hold the loads carefully, so that it doesn't fall on your feet and gets you injured.
3. Set the dial corresponding to the load applied.
4. While operating the machine do not touch the rod column along which the piston moves
5. Be careful while fixing the specimen between the jaws of the UTM
6. Keep your hands away from the parts of the UTM, after the specimen is fixed between the jaws of the machine

RESULTS:

a) Tensile strength: N/mm^2
b) Yield strength: N/mm^2
c) Ultimate stress: N/mm^2
d) Young's modulus: N/mm^2
e) Percentage of Elongation: %
f) Percentage of reduction of area: %

VIVA QUESTIONS:

1) Loading accuracy of the machine is?

A. $\pm$ 1%

2) Which type of motor used in the UTM?

A. 3· Phase

3) Define stress?

A. Force / area

4) Define strain?

A. e = change is dimensions/ original dimensions

5) What is the unit of stress?

A. N/m^2

6) What is the unit of strain?

A. Dimension Less

7) Why we are using only rectangular threading in the UTM is

A. Power supply is more in rectangular threading to lift the loading platform.

8) Define young's modulus of elasticity

A. It is the ratio of stress to strain.

9) What is the unit for young's modulus of elasticity

A. KN/mm^2

10) What is the purpose of UTM

A. The machine serves the purpose of conducting tension compression and bending tests.

(11) What is the purpose of dynamometer?
A. The dynamometer measures and indicates the load on the specimen.

12) How many types of positions does load indicator system is having?

A. The loading system will be 4 positions

i.e., 0 to 100 KN

0 to 250 KN

0 to 500 KN

0 to 1000 KN

13) What is the purpose of graph paper

A. The graph paper is used to draw the stress strain dig.

14) Define tensile stress.

A. When a section is subjected to two equal and opposite pulls and the body tends to increase its length, the stress induced is called tensile stress.

15) Define Compressive stress

A. When a section is subjected to two equals and opposite pushes and the body tends to decrease its length, the stress induced is called tensile stress.

16) What is the maximum pressure which generates in the power pack A. 2000 kgf/cm^2

17) What is elastic limit

A. Within this limit stress is directly proportional to strain.

18) Define unit stress

A. Unit stress represents the resistance developed by a unit area of cross section

19) Define volumetric strain

A. It is a ratio between the change in volume and original volume of the body

20) Define modulus of elasticity

A. the ratio between tensile stress and tensile strain or compressive stress to compressive strain is termed as modulus elasticity

21) What is the relation between the modulus of elasticity (E) and modulus of rigidity

A. E = 2C (1+1/m)

22) What is Poisson's ratio

A. The ratio of lateral strain to linear strain is known as poisons ratio

23) What is the relation between E, K & C

A. E = 9KC/3K+C

24) What is linear strain?

A.Linear strain is the deformation of the bar per unit length in the direction of the force.

2. SHEARING TEST ON UTM

AIM: To determine the ultimate shear strength of the given specimen (Mild steel) subjected for shearing under a gradually increasing load.

APPARATUS REQUIRED:

i) Universal testing machine.

ii) Shear test attachment.

iii) Mild steel rod of 8 mm dia, length 140mm.

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.

PURPOSE:-The purpose of the test is to find out the shear strength of steel specimen subjected to single shear as well as to double shear. This test is useful in the design of riveted joints, as the rivets may be either in single shear or may be in double shear.

Shear stress:- It is produced in a body when it is subjected to two equal and opposite forces spaced at an infinite decimal distance or tangentially across the resisting section.

$$\text{Shear stress, fs} = \frac{\text{Shearing force}}{\text{area resisting force}}$$

PROCEDURE:

1. For performing the shear test the space between lower table and the middle cross arm is used. Insert the specimen in position and grip one end of the attachment in the upper portion and one end in the lower portion.

2. There are 5 sets of attachments for testing different sizes that is diameters of rods. These diameters are 5mm, 8mm, 12mm, 16mm and 20mm.

3. The specimen M.S. rod, diameter 8mm is fixed in the attachment/fixture and the fixture is firmly secured at the lower table.

4. 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.

5. Operate (push) buttons for driving the motor to drive the pump.

6. Gradually move the head control level in left-hand direction till the specimen shears.

7. Down the load at which the specimen shears.

8. Stop the machine and remove the specimen

Repeat the experiment with other specimens.

OBESERVATION:-

Diameter of the Rod, D = ….. mm

Cross-section area of the Rod = $\pi/4x\ d^2$ =.. mm2

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

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

$f = W / 2x\ \pi/4x\ d^2$ N/mm2

OBSERVATIONS:-

Sr.No.	Material	Dia.(d)	Area(A)	Load P (N)	Stress=P/A (N/mm^2)
1	Mild steel				

RESULT:

The Shear strength of mild steel specimen is found to be = ……………… N/mm2

PRECAUTION:-

1 The measuring range should not be changed at any stage during the test.

2. The inner diameter of the hole in the shear stress attachment should be slightly greater than that of the specimen.

3. Measure the diameter of the specimen accurately.

EXPERIMENT :-3

TORSIONTEST

Determinethe rigidity modulus of mild steel specimen by performing Torsion Test

AIM: To determine the shear strength and rigidity modulus of mild steel specimen.

APPARATUS: Torsion testing Machine, steel rule, vernier calipers, mild steel specimen.

THEORY In many areas of engineering applications, materials are sometimes subjected to torsion in services, for example, drive shafts, axles and twisted drills. Moreover, structural applications such as bridges, springs, car bodies, airplane fuselages and boat hulls are randomly subjected to torsion. The materials used in this case should require not only adequate strength but also be able to withstand torque in operation.

Generally, torsion occurs when the twisting moment or torque is applied to a member.The torque is the product of tangential force multiplied by the radial distance from the twisting axis and the tangent, measured in a unit of N.m. In torsion testing, the relationship between torque and degree of rotation is graphically presented and parameters such as ultimate torsional shearing strength (modulus of rupture), shear strength at proportional limit and shear modulus (modulus of rigidity) are generally investigated.

In order to study the response of materials under a torsional force, the torsion test is performed by mounting the specimen onto a torsion testing machine as shown in **fig** and then applying the twisting moment till failure. It can be seen that higher torsional force is required at the higher degrees of rotation. Normally, the test specimens used are of a cylindrical rod type since the stress distribution across the section of the rod is the simplest geometry, which is easy for the calculation of the stresses. Both ends of the cylindrical specimen are tightened to hexagonal sockets in which one is fitted to a torque shaft and another is fitted to an input shaft. The twisting moment is applied by turning the input wheel to produce torque until the specimen fails.

To test the material in torsion the proper test procedure is needed. It involves mounting a shaft into the testing machine, applying torque incrementally and measuring both the applied torque and the corresponding angle of twist. Using the appropriate formulae, relationships and the measured dimensions, we can determine the shear stress and shear strain on the shaft. Then, one can plot the torque vs. angle of twist, and shear stress vs. shear strain from which one can find the material properties previously mentioned.

Torsion TEST:

A shaft of circular section is said to be in pure torsion when it is subjected to equal and opposite couples whose axis coincides with the axis of the shaft.

A torsion test measures the strength of any material against maximum twisting forces. It is an extremely common test used in material mechanics to measure how much of a twist a certain material can withstand

before cracking or breaking. This applied pressure is referred to as torque. Materials typically used in the manufacturing industry, such as metal fasteners and beams, are often subject to torsion testing to determine their strength under duress.

Even though torsion test is not as universal as tension test and do not have any standardized testing procedure, the significance lies on particular engineering applications and for the study of plastic flow in materials.

Torsion test is applicable for testing brittle materials such astool steels and the test has also been used to determine the forge ability of the materials by means of torsion testing at elevated temperatures.

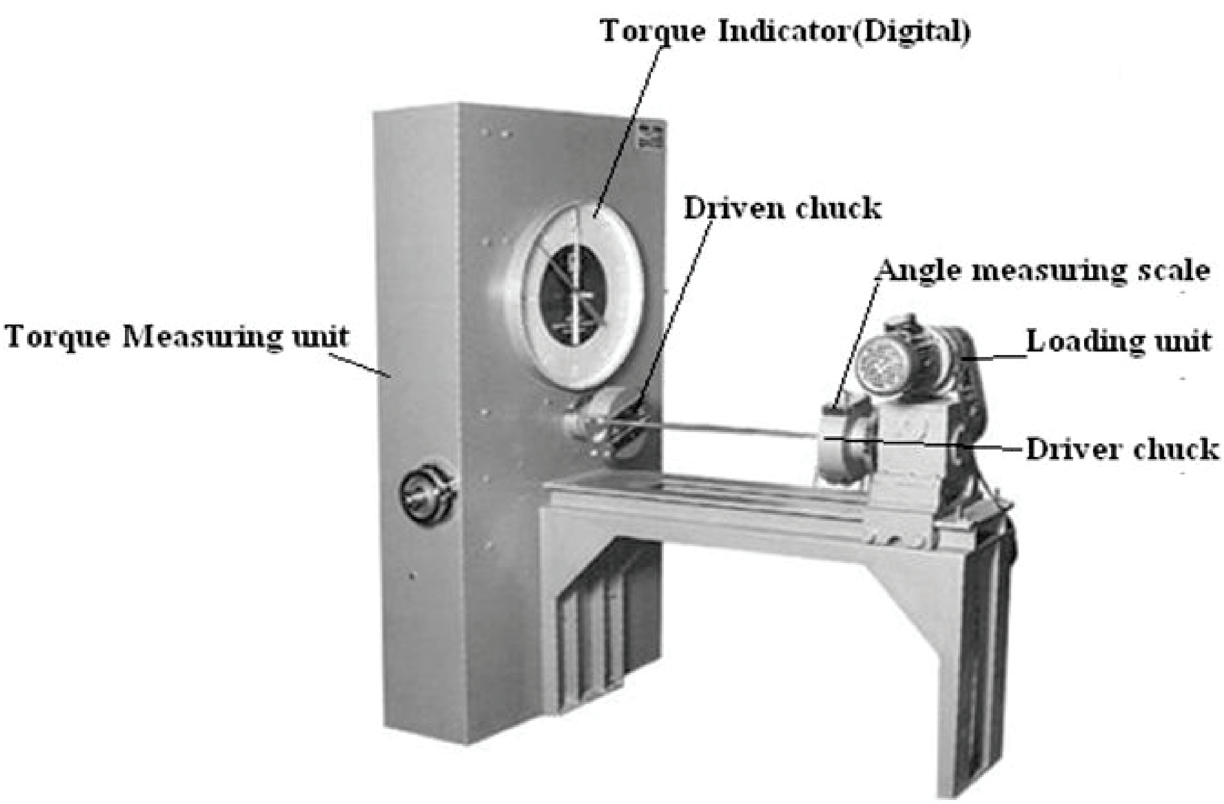


Fig .TorsiontestingMachine

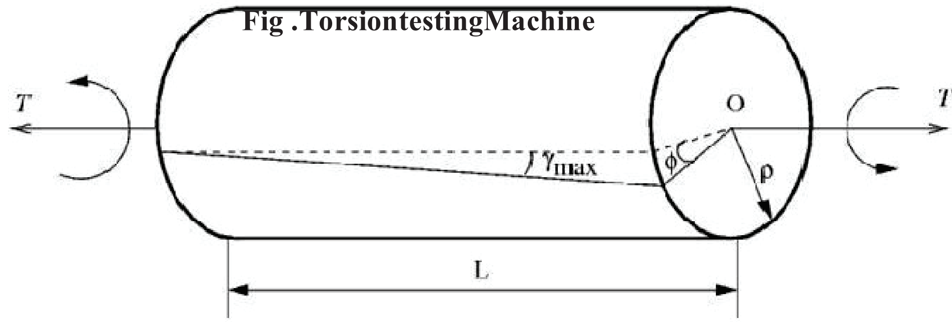
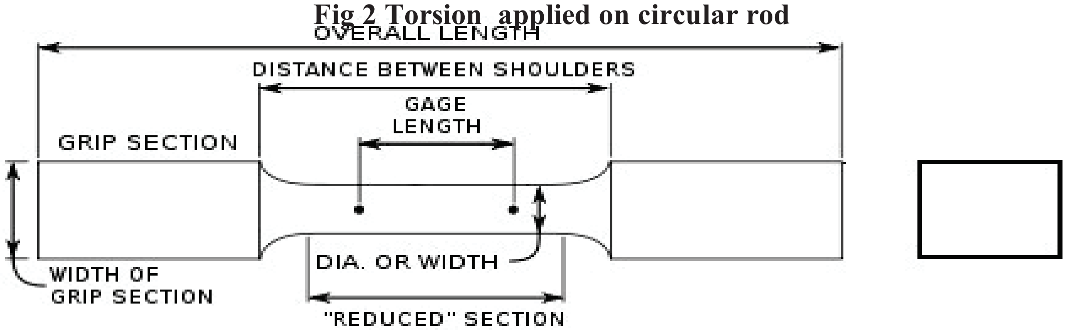


Fig 2 Torsion applied on circular rod



Test specimen(squre ends for gripping)

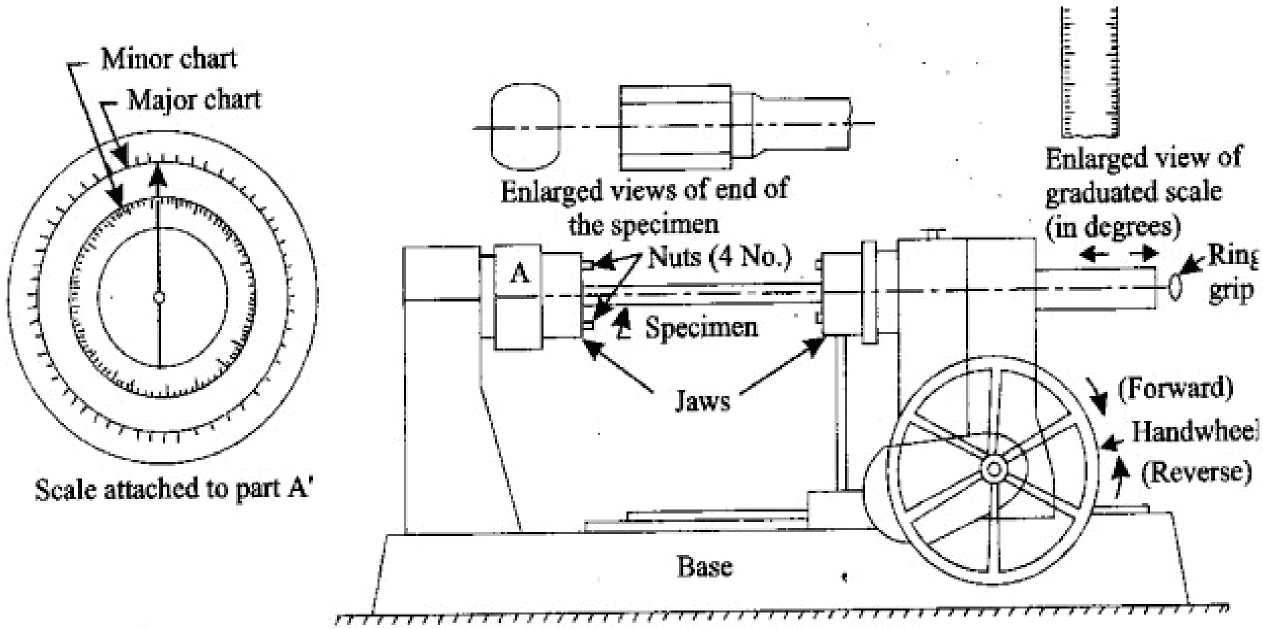
Overall Length=

Length of Reduced section =

Distance between shoulders =

Diameter of reduced section=

Width or dia of grip section =



● **Fig. 9.** Torsion testing machine.

Considering a cylindrical bar with one end being twisted as shown in fig1 , the twisting momentT is resisted
by the shear stress η existing across the specimen section. This shear stress iszero at the center of the bar,
increases linearly with its radius and finally reaches its maximum value at the peripheral of the bar. If the
cylindrical bar with a length of L, the twisting moment can berelated to the shear stress as follows

Where,

$T/J = C\theta/L$

T = Applied Torque; (Nm)

J = Polar Second Moment of Area; (mm2) G = Modulus of Rigidity; (N /

mm2) θ = Angle of Twist (over length l); (radians)

l = Gauge Length. (mm)

<u>The assumptions made in the experiment include but are not limited to the following:</u>

1. The Torque is applied along the centre of the axis of the shaft.
2. The material is tested at steady state (absence of strain rate effects).
3. The plane sections remain same after twisting.

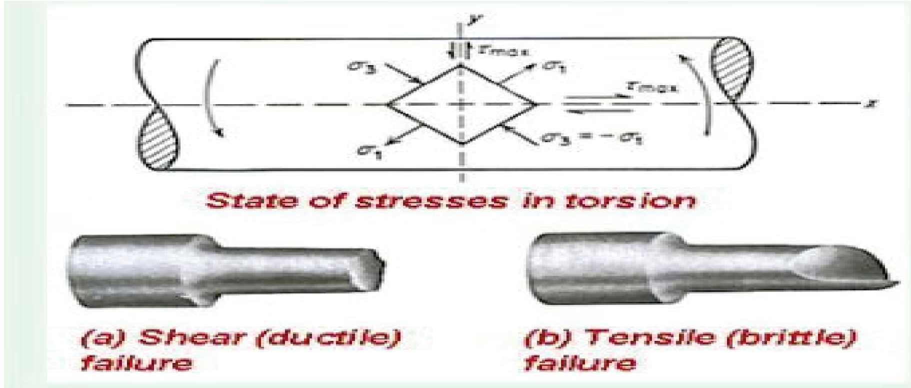
DESCRIPTION OF THE MACHINE:

The machine consists of two units that are loading unit and the measuring unit. A driving chuck and angle measuring scale is mounted on a lever spindle and lever spindle assembly is connected to a pendulum dynamometer.

One end of the specimen is held in the driving chuck and other end is in driven chuck with suitable grips so that when machine is put in operation one end is rotated and the specimen is subjected to torsion. For measurement of twist angle, angle-measuring dial is provided on the gear box. A big size torque indication dial is fitted with a glass cover and is mounted at the front side of panel.

PROCEDURE:

1. Measure initial diameter, initial length and initial gauge length of the specimen. Record theseparameters on the table provided. Measure the diameter of the test specimen using the caliper (take an average of 5 readings).
2. Draw a line down the length of the test section of the specimen with a pencil; this serves as a visual aid to the degree of twist being put on the specimen during loading.
3. Grip the test specimen on to the torsion testing machine using square sockets and make sure the specimens are firmly mounted. Fit both ends of the specimen to input and torque shafts and set reading on the torque meter to zero.
4. Start twisting the specimen at strain increment of 0.5^{o}until failure occurs. Record the received data rotation in the table provided for the construction of torque and degree relationship.
5. Apply torque; record the angle of twist and torque at regular intervals till the specimen breaks.
6. Construct the relationship between shear stress and shear strain. Determine maximum shear stress, shear stress at proportional limit and modulus of rigidity.
7. Plot the graph between torque vs. angle of twist and find the rigidity modulus using the above formulae.



Types of failure in torsion

PRECAUTIONS:

1. Before starting the machine ensure that the specimen is firmly fixed between the jaws.
2. Don't touch the specimen when the machine is running.
3. Wash your hands with soap after removing the specimen.
4. Take all the readings carefully.

OBSERVATIONS:

1.Initialdiameterofthespecimen=

2.Initiallengthofthespecimen=

3.PolarMomentofInertia=

S.No	Torque"T" (Kg-cm x 9.81 x 10) N-mm	Angleof Twist" θ"		Modulus of Rigidity"G"
		Degrees (θ)	Radians(θ x π/180	
01				
02				
03				

CALUCULATIONS:

Modulus ofRigidity(G)=**TL/Jθ**

RESULT:

Rigidity Modulus of the material=________mm^2

VIVA Questions:

1. **Define torsion?**

Ans: In solid mechanics, **torsion** is the twisting of an object due to an applied torque. It is expressed in newton metres (N·m) or foot-pound force (ft·lbf). In sections perpendicular to the torque axis, the resultant shear stress in this section is perpendicular to the radius

2. **What is the formula torsion equation for circular shafts. Ans:**

$T/J = C\theta/L$

3. **Write assumptions for torsion on shafts.**

Ans: (i) The materiel is homogenous i.e of uniform elastic properties exists throughout the material.

(ii) The material is elastic, follows Hook's law, with shear stress proportional to shear

strain. (iii) The stress does not exceed the elastic limit

4. **What are the effects of torsion?**

Ans: **Effects of Torsion:** The effects of a torsional load applied to a bar are

(i) To impart an angular displacement of one end cross - section with respect to the other end.

(ii) To setup shear stresses on any cross section of the bar perpendicular to its axis.

5. **Define modulus of rigidity?**

Ans: Modulus of Elasticity in shear: The ratio of the shear stress to the shear strain is called the modulus of elasticity in shear OR Modulus of Rigidity and in represented by the symbol $G = \frac{\tau}{\gamma}$

6. **Define angle of twist.**

Ans: Angle of Twist: If a shaft of length L is subjected to a constant twisting moment T along its length, than the angle q through which one end of the bar will twist relative to the other is known is the angle of twist.

7. **Define shaft.**

Ans: The shafts are the machine elements which are used to transmit power in machines.

8. **What are the torque carrying engineering members?**

Ans: Many torque carrying engineering members are cylindrical in shape. Examples are drive shafts, bolts and screw drivers.

9. Write formula to calaculate polar moment of inertia(J)?

$$= \frac{\pi d^4}{32} \text{ for solid shaft}$$

$$= \frac{\pi(D^4 - d^4)}{32} \text{ for a hollow shaft.}$$

[D = Outside diameter ; d = inside diameter]

EXPERIMENT NO:- 4

COMPRESSIVE STRENGHT OF BRICK

AIM: - COMPRESSIVE STRENGTH OF BRICK:-

OBJECT: - The specimen brick is immersed in water for 24 hours.

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

FORMULA: -

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

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 its 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

S.NO	L X B XH Cm^3	AREA L X B Cm^2	Compressive Strength P/A(N/mm^2	Average Compressive Strength
01				
02				
03				
04				

CALCULATION:- -

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

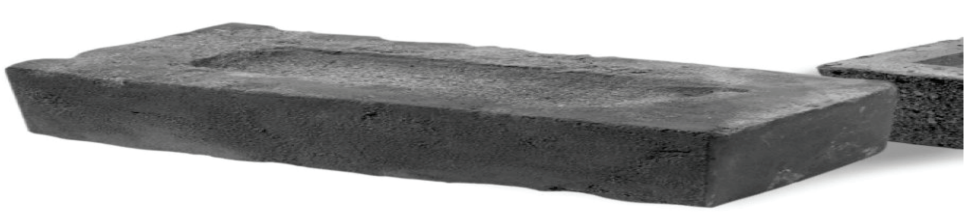
RESULT : - The average compressive strength of new brick sample is found to be ………. N/mm2

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.



EXPERIMENT NO:- 5

Comparison of compressive strength of clay brick & cement concrete cube

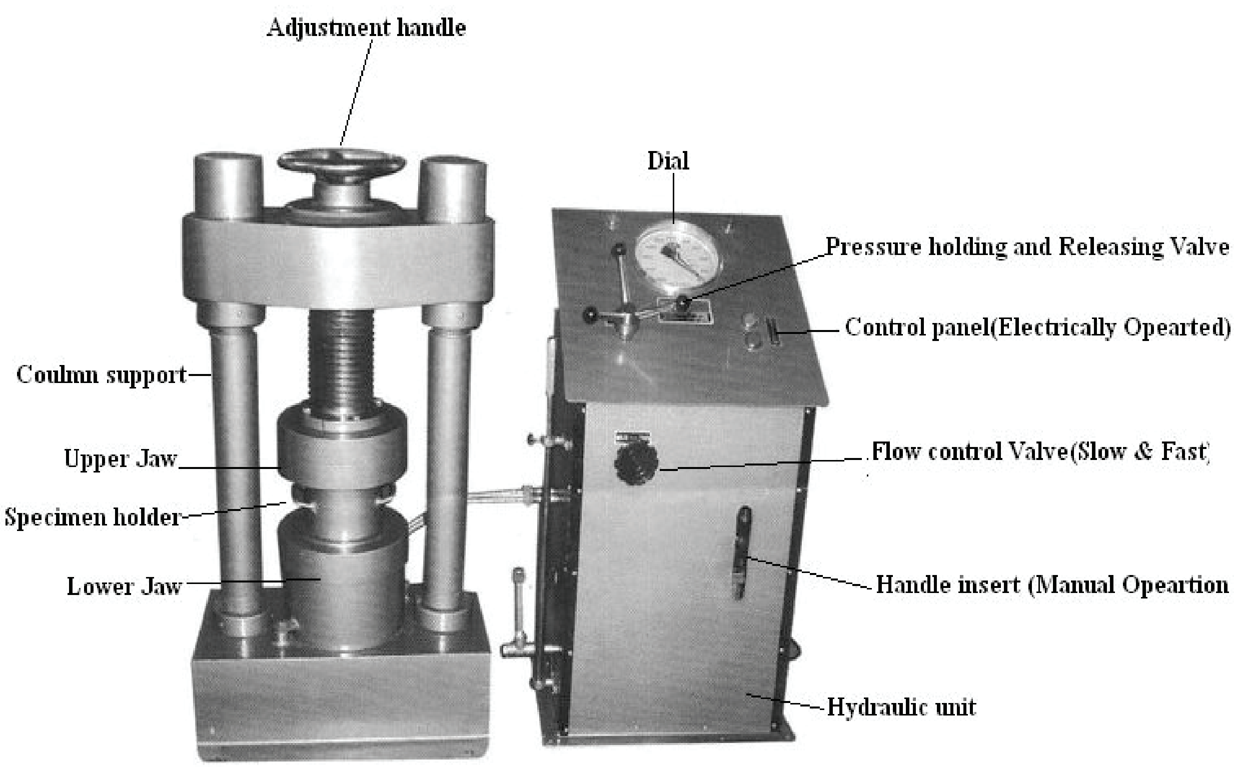
AIM: -To conduct a compression test on clay brick& Reinforced cement concrete cube and determine the compressive strength.

APPARATUS: Bricks, Vernier Caliper, Steel Rule, Etc.

FORMULA: -

Max. Load at failure
Compressive Strength (Final cracking) = -----------------------------
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. Measure its all dimensions. (LXBXH)
2. Place the brick on the lower platform of compression testing machine, with the oil delivery valve in close condition and pressure release valve in open condition, lead screw is adjusted so that the middle crosshead platen is just in contact with the specimen.
3. To apply load close the pressure release valve(left) and open the oil delivery valve(Right)
4. Note the load at initial crack and up to final crack.

S.NO	L X B XH Cm^3	AREA L X B Cm^2	Compressive Strength P/A(N/mm^2	Average Compressive Strength
Clay Bricks				
Cement Concrete cube				

PRECAUTION: - 1) Measure the dimensions of specimens accurately.

2) Specimen should be placed as for as possible in the of 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.

RESULT : -1. The average compressive strength of brick sample is found to be ………. (N/mm^2)

2. The average compressive strength of concrete cube sample is found to be ………. (N/mm^2

EXPERIMENT NO. 6

COMPRESSION TEST OF TIMBER PARALLEL TO GRAINS

OBJECTIVES

1. To test a timber specimen under compressive load parallel to grain.
2. To draw the stress-strain curve of the specimen.
3. To determine the proportional limit, modulus of elasticity, modulus of resilience, yield strength and ultimate strength of the specimen.
4. To compare the yield strength obtained by offset method with the proof strength.
5. To observe the failure surface.

EQUIPMENTS

1. Compression Testing Machine 2. Compressometer 3. Slide Calipers

SPECIMENS

1. Timber block of approximately (2” 2” cross-section and 8” height.)

PROCEDURE

1. Measure the dimensions of the specimen.
2. Record the gage length of the specimen and the compressometer constant.
3. Set the specimen in the testing machine and attach the compressometer suitably with the machine or the specimen to read the deformations.
4. Set the machine so that the loading plates just touch the specimen and adjust the compressometer dial to read zero at this stage.
5. Apply the load slowly and record the loads and compressometer readings at constant load intervals until the failure of the specimen.
6. Record the final (ultimate) load at failure and measure the final length between the gage marks.
7. Note the characteristics of the failure surface.

DATA SHEET FOR COMPRESSION TEST OF TIMBER PARALLEL TO GRAINS

Gage Length =   Cross-sectional Area of the Specimen =

S.NO	LOAD	DEFORMATION	STRESS	STRAIN

EXPERIMENT NO :- 7

COMPRESSION TEST OF TIMBER PERPENDICULAR TO GRAINS

OBJECTIVES

1. To test a timber specimen under compressive load parallel to grain.
2. To draw the stress-strain curve of the specimen.
3. To determine the proportional limit, modulus of elasticity, modulus of resilience, yield strength and ultimate strength of the specimen.
4. To compare the yield strength obtained by offset method with the proof strength.
5. To observe the failure surface.

EQUIPMENTS

1. Compression Testing Machine 2. Compressometer 3. Slide Calipers

SPECIMENS

1. Timber block of approximately (2” 2” cross-section and 8” height.)

PROCEDURE

1. Measure the dimensions of the specimen.
2. Record the gage length of the specimen and the compressometer constant.
3. Set the specimen in the testing machine and attach the compressometer suitably with the machine or the specimen to read the deformations.
4. Set the machine so that the loading plates just touch the specimen and adjust the compressometer dial to read zero at this stage.
5. Apply the load slowly and record the loads and compressometer readings at constant load intervals until the failure of the specimen.
6. Record the final (ultimate) load at failure and measure the final length between the gage marks.
7. Note the characteristics of the failure surface.

DATA SHEET FOR COMPRESSION TEST OF TIMBER PERPENDICULAR TO GRAINS

Gage Length =   Cross-sectional Area of the Specimen =

S.NO	LOAD	DEFORMATION	STRESS	STRAIN

EXPERIMENT NO :- 8

BUCKLING TEST OF SLENDER COLUMNS

OBJECTIVES

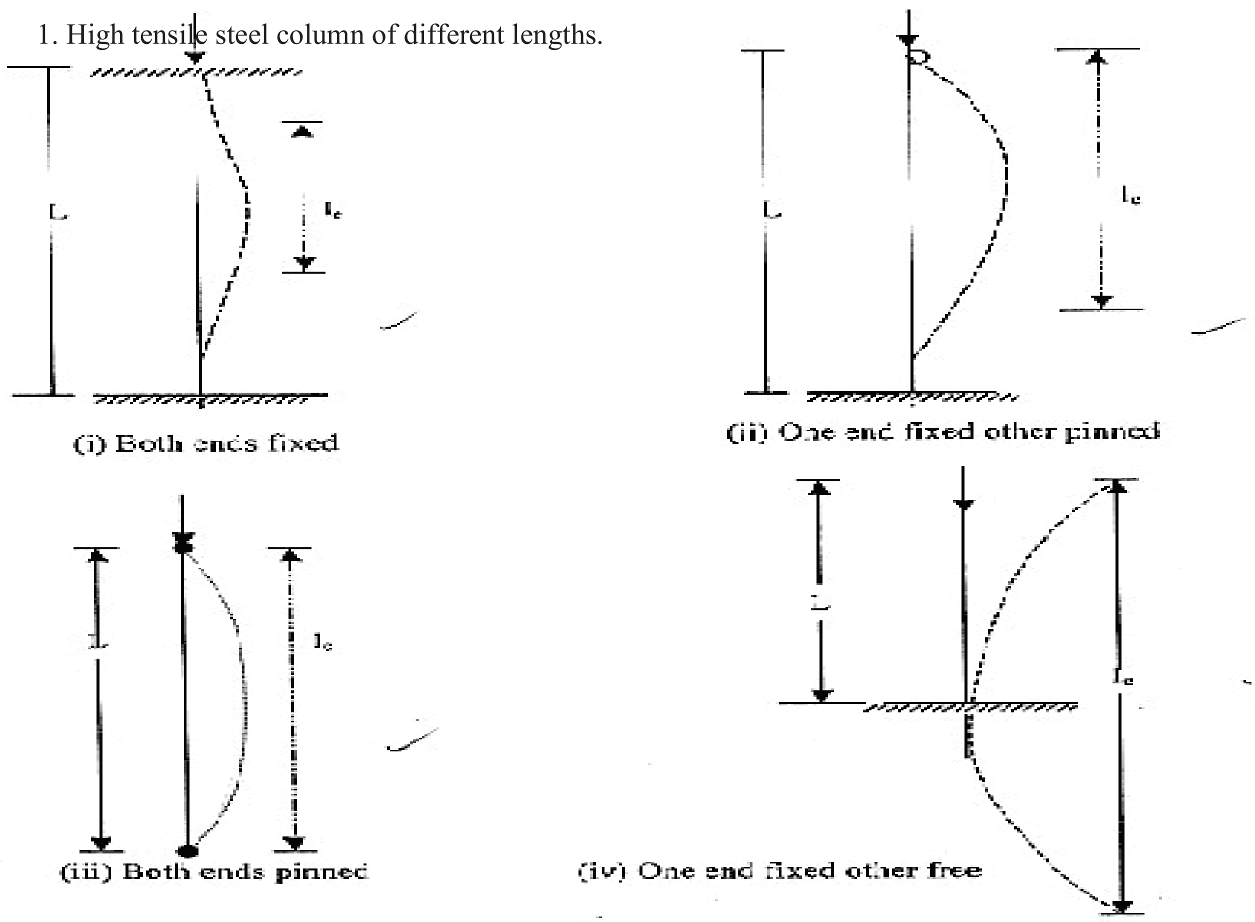
1. To determine the buckling loads of slender columns of different lengths and end conditions.
2. To compare the experimental and the theoretical critical loads.
3. To draw the column strength curve.

EQUIPMENTS

1. Column Testing Apparatus 2. Weights 3. Slide Calipers 4. Steel scale

SPECIMENS

1. High tensile steel column of different lengths.



Theory :-If compressive load is applied on a column, the member may fail either by crushing or by buckling depending on its material, cross section and length. If member is considerably long in comparison to its lateral dimensions it will fail by buckling. If a member shows signs of buckling the member leads to failure with small increase in load. The load at which the member just buckles is called as crushing load. The buckling load, as given by Euler, can be found by using following expression.

$$P = \frac{ʌ^2 EI}{le^2}$$

Where,

E = Modulus of Elasticity

$= 2 \times 10^5$ N/mm^2 for steel

I = Least moment of inertia of column section

Le = Effective length of column

Depending on support conditions, four cases may arise. The effective length for each of which are given as:

1. Both ends are fixed $l_e = L/2$
2. One end is fixed and other is pinned $l_e = L/¥\ 2$
3. Both ends are pinned $l_e = L$
4. One end is fixed and other is free $l_e = 2L$

PROCEDURE

1. Measure the length and the mean diameter of the column to be tested
2. Place the column in the column testing apparatus with the both end hinged..
3. Apply load by placing equal weights on both pans. Give a small lateral force to deflect the column laterally. Increase the load if the column straightens back upon removal of the lateral

force.

4. Continue the process until the applied load is just sufficient to hold the column in a bend condition; i.e., when the column does not straighten back after removal of lateral load. Record this load as the critical load.
5. Perform the experiment for columns with different lengths.
6. Repeat the above steps (1) to (5) for the following two end conditions:
   (a) One end hinged and one end fixed (b) Both end fixed.
7. Calculate the theoretical buckling load for each loading case.
8. Draw the column strength curve including the theoretical buckling curves.

DATA SHEET FOR BUCKLING TEST OF SLENDER COLUMNS

Modulus of Elasticity (E) of Column Material =

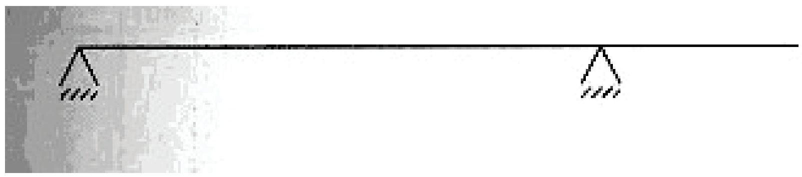
Support Conditions	Col^{m} Diameter (d)	Area (A	Min^{m} Radius of Gyr. (r_{min})	Col^{m} Length (L)	Effective Length (L_e)	Slenderness Ratio (= L_e/r_{min})	Critical Force (P_{cr}	Pcr (exp) (= P_{cr}/A	Pcr Theoritical
Both ends fixed									
Both ends pinned									
One end fixed and one end pinned									

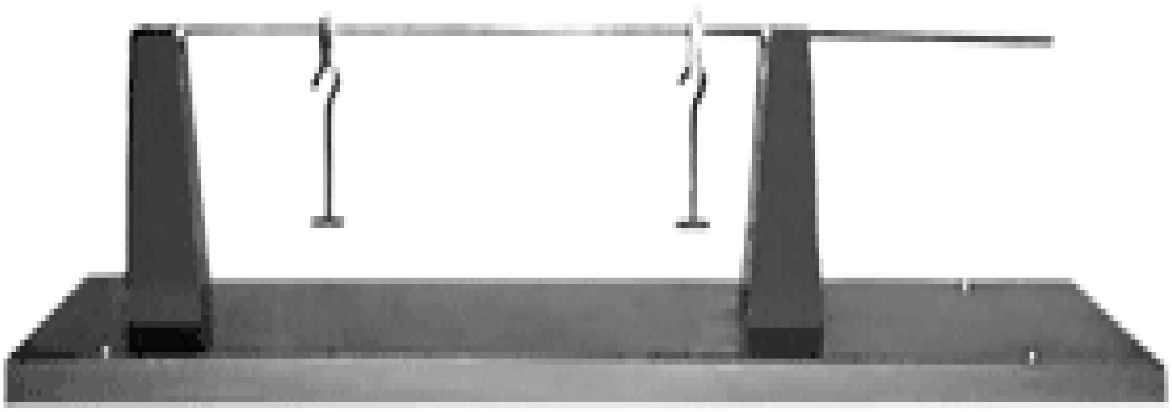
EXPERIMENT NO :-9

Aim: - To verify clerk Maxwell's reciprocal theorem

Apparatus: - Clerk Maxwell's Reciprocal Theorem apparatus, Weight's, Hanger, Dial Gauge, Scale, Verniar caliper.

Diagram:-





Theory : -

Maxwell theorem in its simplest form states that deflection of any point A of any elastic structure due to load P at any point B is same as the deflection of beam due to same load applied at A

It is, therefore easily derived that the deflection curve for a point in a structure is the same as the deflected curve of the structure when unit load is applied at the point for which the influence curve was obtained.

Procedure: -

i) Apply a load either at the centre of the simply supported span or at the free end of the beam, the deflected form can be obtained.

ii) Measure the height of the beam at certain distance by means of a dial gauge before and after loading and determine the deflection before and after at each point separately.

iii) Now move a load along the beam at certain distance and for each positions of the load, the deflection of the point was noted where the load was applied in step1.This deflection should be measured at each such point before and after the loading, separately.

iv) Plot the graph between deflection as ordinate and position of point on abssica the plot for graph drawn in step2 and 3.These are the influence line ordinates for deflection of the beam.

Observation Table

S.NO	LOAD AT A IN KG	DEFLECTION AT B IN mm	LOAD AT B IN KG	DEFLECTION AT A IN mm	REMARKS
01					
02					
03					

Result : - The Maxwell reciprocal theorem is verified experimentally and analytically.

Precaution: -
i) Apply the loads without any jerk.
ii) Perform the experiment at a location, which is away from any
iii) Avoid external disturbance.
iv) Ensure that the supports are rigid

FREQUENTLY ASKED QUESTIONS

Define Hooke's Law.

Ans. It states that when the material is loaded within the elastic limit the stress is directly proportional to strain.

i.e. Stress α strain. or Stress = constant x Strain

2. Define Strength of materials.

Ans. The strength of a material is its ability to withstand an applied stress without failure.

3. What is stress?

Ans. When load is applied on any object then a resisting force is induced, that resisting or reacting per unit area of cross-section is called stress.

4. What is strain?

Ans. Stress is change in dimensions upon original dimentions.

5. What is deformation?

Ans. Deformation is change in dimensions of any object due to applied load.

6. On which steel you have performed tension test. What is its carbon content?

Ans. On mild steel (0.3 to 0.6% carbon).

7. What kind of fracture has occurred in tensile specimen.

Ans. Ductile fracture.

8. Define temperature stress.

Ans. Stress introduced by uniform or nonuniform temperature change in a structure or material which is constrained against expansion or contraction.

9. What is hardness?

Ans. Hardness is the resistance of a material to localized deformation.

Or

Hardness is the mechanical resistance which a material asserts against the mechanical penetration of a harder test body.

10. What is toughness?

Ans. Toughness is the amount of energy per volume that a material can absorb before rupturing.

It is also defined as the resistance to fracture of a material when stressed.

11. Types of stresses.

Ans. Normal stresses(tensile & compressive), shear stresses

12. Types of strains.

Ans. Longitudinal strain(tensile & compressive), shear strain, volumetric strain.

13. What is volumetric strain?

Ans. Volumetric strain is change in volume upon original volume.

14. What is poisson's ratio?

Ans. It is the ratio of lateral(or transverse) strain to longitudinal strain.

15. Define longitudinal strain and lateral (transverse) strain.

Ans. Longitudinal strain is change in length upon original length.

Lateral strain is change in lateral dimensions (i.e. dimensions perpendicular to length) upon original lateral dimensions.

16. Differentiate Shear Strain and Shear stress.

Ans. Stress is a measure of how much force is taken by an object of particular size. shear stress is therefore shear force divided by area under shear. Clearly, increasing the force and/or decreasing the size or cross sectional area will result in larger stresses.

Shear strain is a measure of the deflection caused by a shear stress, and is related via the shear modulus (or modulus of rigidity) G, where G= shear stress/shear strain.

17. What is factor of safety?

Ans. The ratio of the breaking stress of a structure to the estimated maximum stress.

18. What is Ultimate strength?

Ans. Absolute maximum compressive, shear, or tensile stress a material can bear without failure is called ultimate strength.

19. Define elastic constants E,K & G.

Ans. Young's modulus of elasticity(E) is the ratio of normal stress to normal strain.

Bulk modulus of elasticity(K) is the ratio of normal stress to volumetric strain.

Shear modulus of elasticity or modulus of rigidity(C or G) is the ratio of shear stress to shear strain.

20. What is Yield Strength?

Ans. The ability of a metal to tolerate gradual progressive force without permanent deformation. Yield strength is the stress at which a specified amount of permanent deformation of a material occurs.

21. Define impact strength.

Ans. The ability of a material to withstand shock loading.

22. What is beam.

Ans. A beam is a horizontal structural element in which longitudinal dimensions are very large in comparison of lateral dimensions and that is capable of withstanding load primarily by resisting bending.

23. What is difference between force and load.

Ans. Force is a push or pull applied on a body to change its state.
Load is the combined effect of external applied forces at any point.

24. Types of Loads.

Point load, uniformly distributed load, uniformly varying load.

25. What is torque?

Ans. Torque is the tendency of a force to cause or change rotational motion of a body. A force applied at a right angle to a lever multiplied by its distance from the lever's fulcrum (the length of the lever arm) is its torque.

26. What is Torsional force?

Ans. A force acting on a body that tends to twist the body.

27. What is torsional rigidity?

Ans. The applied torque needed to produce a unit angle of twist in a circular elastic material, it is a measure of a body's resistance to torsion.

28. Types of beams.

Ans. Simply supported beam, over hanging beam, Cantelever beam, continuous beam, fixed beam.

29. Define shear force and bending moment.

Ans. Shear force is the algebraic sum of all the vertical forces acting on either side of the section.

Bending moment is the algebraic sum of all the moments of the forces acting on either side of the

section.

30. What is point of inflection.

Ans. The point on beam at which the moment is zero is called point of inflection or point of contraflexure.

31. What are sagging and hogging moments?

Ans. If clockwise bending moments are taken as negative, then a negative bending moment within an element will cause "sagging", and a positive moment will cause "hogging". It is therefore clear that a point of zero bending moment within a beam is a point of contraflexure that

is the point of transition from hogging to sagging or vice versa.

32. When bending moment will be maximum?

Ans. Bending moment is maximum when shear force is zero.

33. What is Moment of inertia?

Ans. Moment of inertia is second moment of area or second moment of mass.

34. What is Polar moment of inertia?

Ans. The Polar Moment of Inertia is a geometric property of a cross section. Physically, it is a measure of how difficult it is to turn a cross-section about an axis perpendicular to it**.**

35. Define slope and deflection.

Ans. The deflection at any point on the axis of the beam is the distance between its position before and after loading.

Slope at any section in a deflected beam is defined as the angle in radians which the tangent at the section makes with the original position.

36. Explain about Principal plane.

Ans. The planes on which shearing stresses are zero are called principal planes.

37. Explain about Principal stresses.

Ans. The stresses normal to principal planes are known as principal stresses

38. Units of force, deflection, stress, strain, E, K, G.

Ans. SI Unit of force is Newton,

SI unit of deflection is meter,

SI unit of stress,E,K&G is N/m^2,

Strain is unitless quantity.

39. Purpose of UTM.

Ans. UTM is used to test the tensile stress and compressive strength of materials.

40. What are lifting machines?

Ans. Lifting machines are devices which are used to lift heavy load by applying less effort.

41. What is torsion equation?

Ans. $T/J = \tau/R = G\theta/L$

42. What is flexural rigidity?

Ans. The product EI is called flexural rigidity.

43. Define Mechanical Advantage,velocity ratio & efficiency. Ans. M.A. is the ratio of load lifted to effort applied.

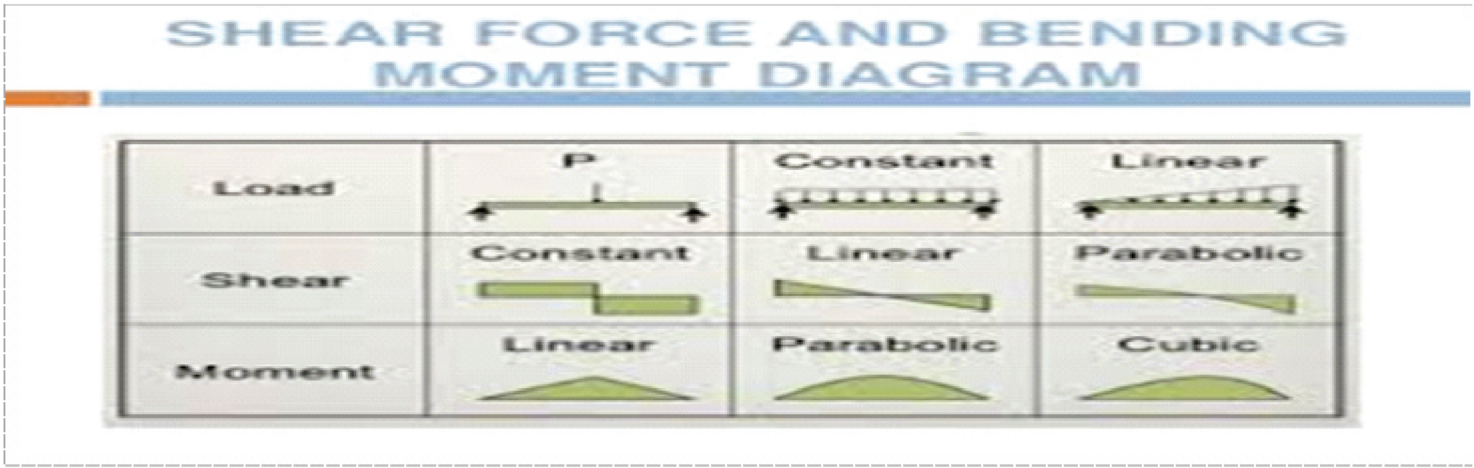
V.R. is the ratio of distance moved by effort to distance moved by load. Efficiency is the ratio of mechanical advantage to velocity ratio.

44. Define Section modulus.

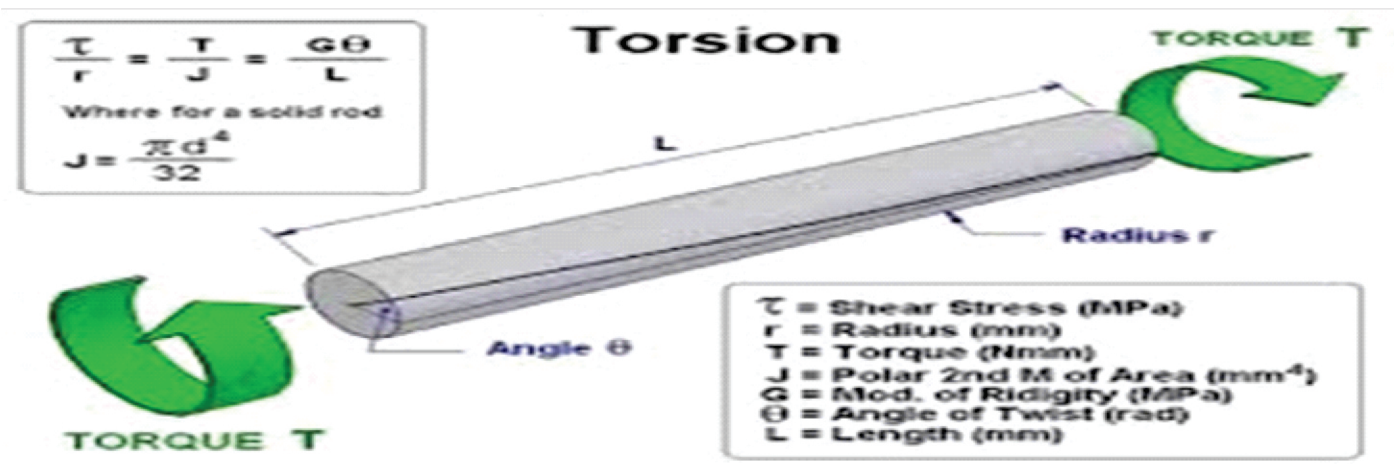
Ans. The elastic section modulus is defined as S = I / y, where I is the second moment of area (or moment of inertia) and y is the distance from the neutral axis to any given fibre.

45. What is a composite beam?

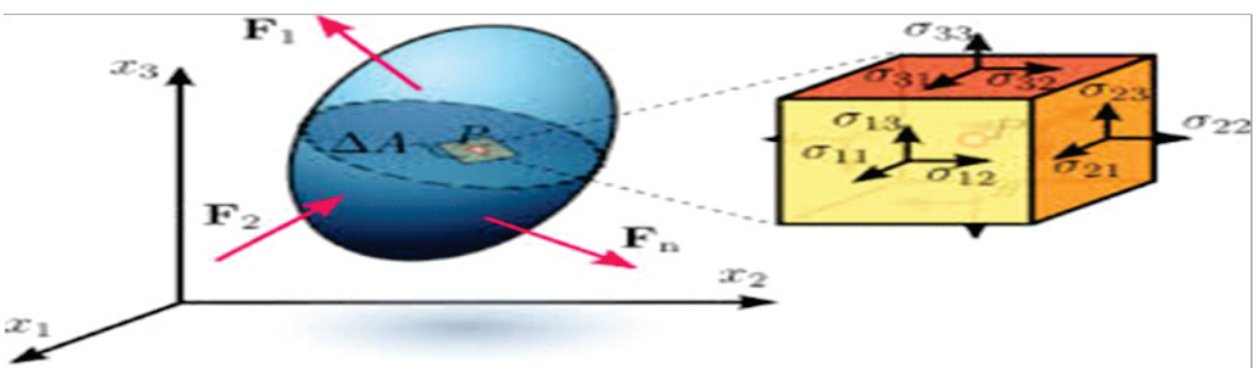
Ans. A structural member composed of two or more dissimilar materials joined together to act as a unit in which the resulting system is stronger than the sum of its parts.



SHEAR FORCE AND BENDING MOMENT DIAGRAM
Load
P
Constant
Linear
Shear
Constant
Linear
Parabolic
Moment
Linear
Parabolic
Cubic



Torsion
τ/r = T/J = Gθ/L
Where for a solid rod
J = πd⁴/32
TORQUE T
L
Radius r
Angle θ
TORQUE T
τ = Shear Stress (MPa)
r = Radius (mm)
T = Torque (Nmm)
J = Polar 2nd M of Area (mm⁴)
G = Mod. of Ridigity (MPa)
θ = Angle of Twist (rad)
L = Length (mm)



F1
x3
ΔA
P
F2
Fn
x2
x1
σ33
σ31
σ32
σ23
σ13
σ11
σ12
σ21
σ22

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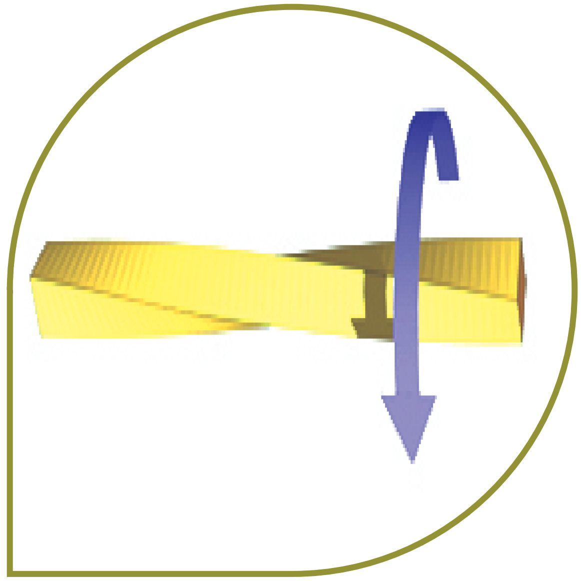

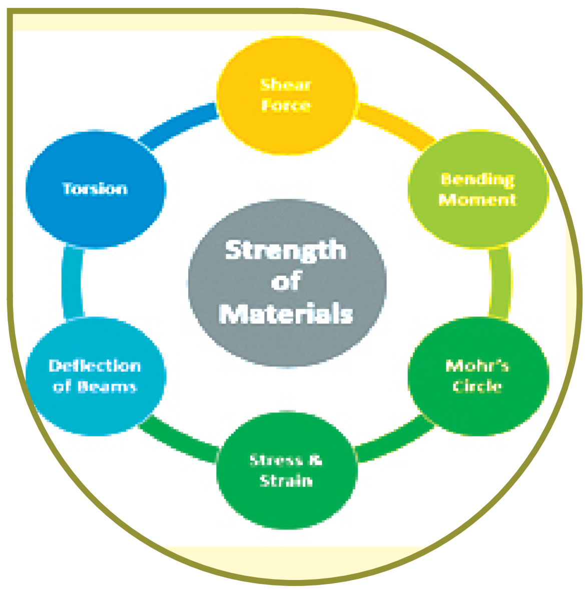

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