Parala Maharaja Engineering College

A CONSTITUENT COLLEGE OF B.P.U.T GOVT. OF ODISHA

LABORATORY MANUAL

(PC)MEPC 2202 MATERIAL TESTING LAB (MT)

Semester-III

Laboratory Location: Ground floor of workshop 1, Room no-

Department of

AUTOMOBILE ENGINEERING

Parala Maharaja Engineering College, Berhampur

A Government Engineering College affiliated to
Biju Patnaik University of Technology, Odisha, Rourkela, India
ପାରଳା ମହାରାଜା ଯାନ୍ତ୍ରିକ ମହାବିଦ୍ୟାଳୟ, ବ୍ରହ୍ମପୁର
(ସରକାରୀ ଯାନ୍ତ୍ରିକ ମହାବିଦ୍ୟାଳୟ)

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SAFETY IN THE LAB

- You are only allowed in the laboratory when there is a 'responsible person' present such as a demonstrator or the laboratory staff.

- Do not touch any equipment or machines kept in the lab unless you are asked to do so.

- A tidy laboratory is generally safer than an untidy one, so make sure that you do not have a confused tangle of electrical cables. Electrical equipment is legally required to be regularly checked, which means it should be safe and reasonably reliable: do not tamper or attempt to repair any electrical equipment (in particular, do not rewire a mains plug or change a fuse - ask one of the laboratory staff to do it). Never switch off the mains using the master switches mounted on the walls. Please make yourself aware of the fire exits when you first come into the lab. When the alarm sounds please leave whatever you are doing and make your way quickly, calmly and quietly out of the lab. You must always follow instructions from your demonstrators and the laboratory staff.

- You must keep walkways clear at all times and in particular coats and bags must be stowed away safely and must not pose a trip hazard.

- It is important that you make a point of reading the "Risk Assessment" sheet included in the manuscript of each experiment before you start work on the experiment.

- Please take notice of any safety information given in your scripts. If an experiment or project requires you to wear PPE (personal protective equipment) such as gloves and safety glasses, then wear them.

- Always enter the lab wearing your shoes. It is strictly prohibited to enter the lab without shoes.

- There must be NO smoking, eating, drinking, use of mobile phones or using personal headphones in the laboratory. This last point is not because we dislike your choice of music but because you must remain aware of all activity around you and be able to hear people trying to warn you of problems.

- Keep the lab neat and clean.

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List of Experiment

01	Determination of tensile strength of materials by Universal Testing Machine.
02	Determination of compressive strength of materials by Universal Testing Machine.
03	Determination of bending strength of materials by Universal Testing Machine.
04	Double shear test in Universal Testing Machine.
05	Determination of rigidity modulus of material.
06	Determination of fatigue strength of material.
07	Estimation of spring constant under tension and compression.
08	Load measurement using load indicator, Load Cells
09	Strain measurement using strain gauge.
10	Stress measurement using strain rosette.

Experiment-1

Determination of tensile strength of materials by Universal Testing Machine

Aim of the Experiment: To study the behavior of the given material under tensile load and to determine the following:

- Percentage elongation in length
- Percentage reduction in area
- Working stress or permissible stress or safe stress
- Young's modulus
- Yield stress
- Ultimate stress or Maximum tensile stress
- Breaking stress or Failure stress

Apparatus Required: Universal Testing machine, Dial gauge, Venire caliper and scale.

Practical importance: while designing a component, selection of metals for different applications is based on salient points such as limit of proportionality or elastic limit, yield strength, ultimate strength, and breaking strength. Therefore, from this tension test above said salient points can be calculated.

Theory: In engineering, tension test is widely used to provide basic design information on the strength of the materials. In the tension test a specimen is subjected to a continually increasing uniaxial tensile force while simultaneous observations are made of the elongation of the specimen. A stress-strain curve is plotted from the load-elongation measurements.

The parameters which are used to describe the stress-strain curve of a material are the tensile strength, yield strength or yield point, percent elongation and reduction of area. The first two are strength parameters; the last two indicate ductility.

Definitions:

- ***Limit of proportionality (A):*** It is the limiting value of the stress up to which stress is proportional to strain.
- ***Elastic limit:*** This is the limiting value of stress up to which if the material is stressed and then released (unloaded), Strain disappears completely and the original length is regained.
- ***Upper Yield Point (B):*** This is the stress at which, the load starts reducing and the extension increases. This phenomenon is called yielding of material.
- ***Lower Yield Point (C):***At this stage the stress remains same but strain increases for

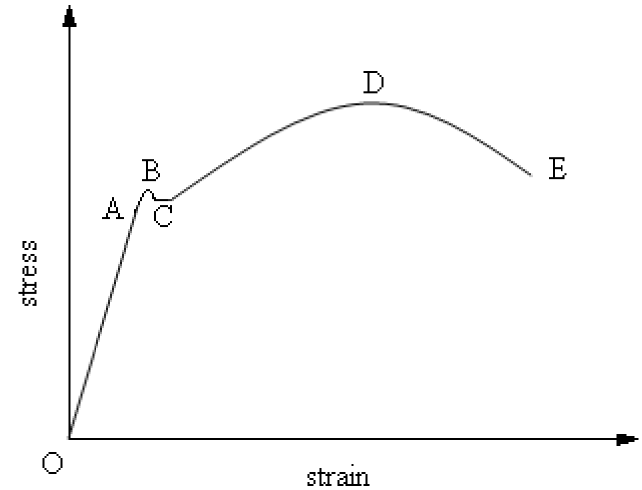
some time.

- ***Ultimate Stress (D):*** This is the maximum stress the material can resist. At this stage cross sectional area at a particular section starts reducing very fast (fig.1). 1

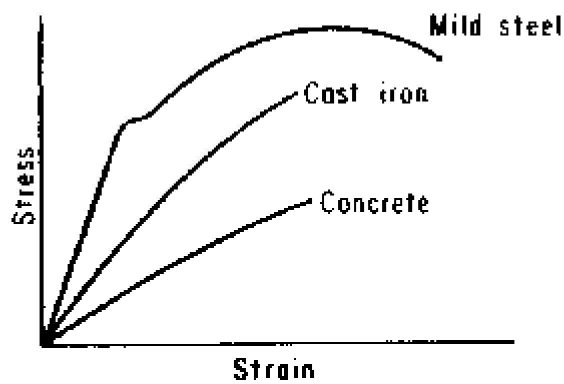
- This is called *neck formation*.

- ***Breaking Point (E):*** The stress at which finally the specimen fails is called breaking point.

Hooks law: Within the elastic limit, the stress is proportional to the strain for an isentropic material.



Linear stress - strain Curve



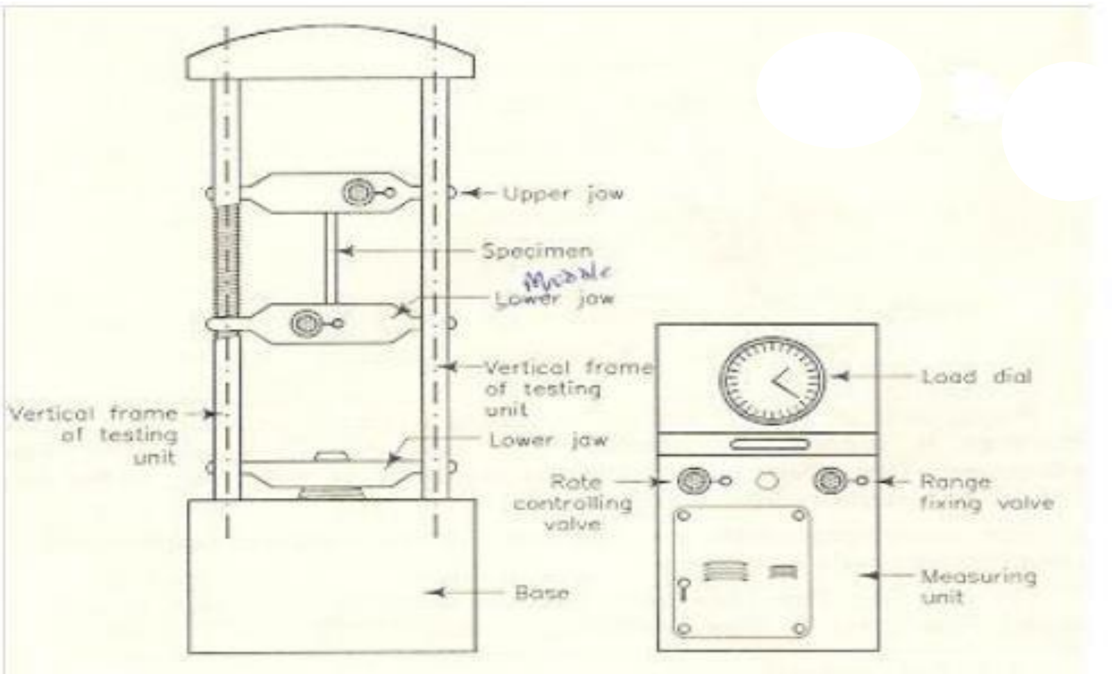
A - Elastic Limit

B-Upper Yield Stress

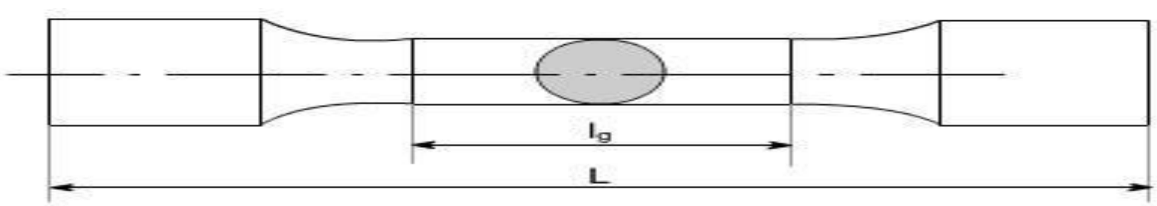
C-Lower Yield Stress

D-Ultimate Stress

Graph: Stress v/s Strain



Universal Testing Machine

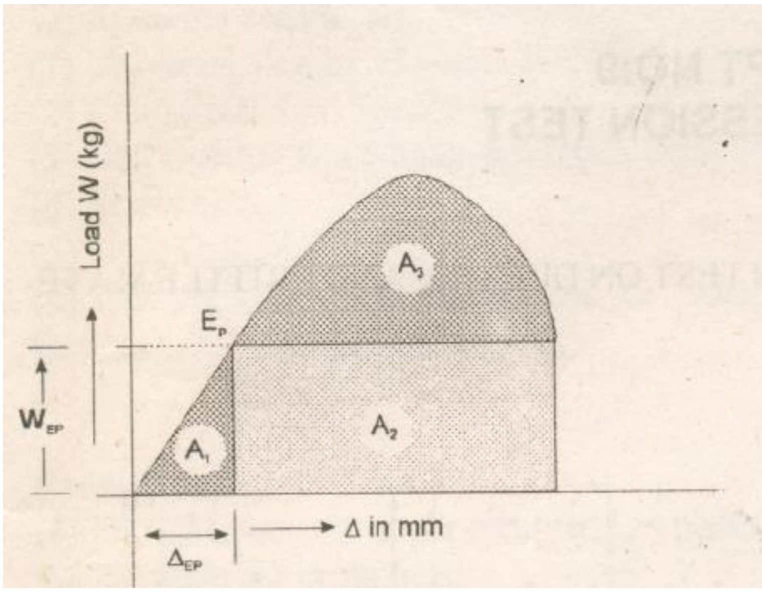


[specimen with circular X-section]

l_g = gauge length i.e. length of the specimen on which we want to determine the mechanical properties.
L= Total length of the specimen

Proof Resilience: It is defined as the "partial strain energy stored in the specimen from zero up to elastic point". Graphically, it is the area bounded below the graph from zero up to elastic point. Hence proof resilience=Approximately the Triangular area from zero up to elastic point (Fig:1)

Proof resilience = [1/2 ΔEP *WEP] kg- cm.*



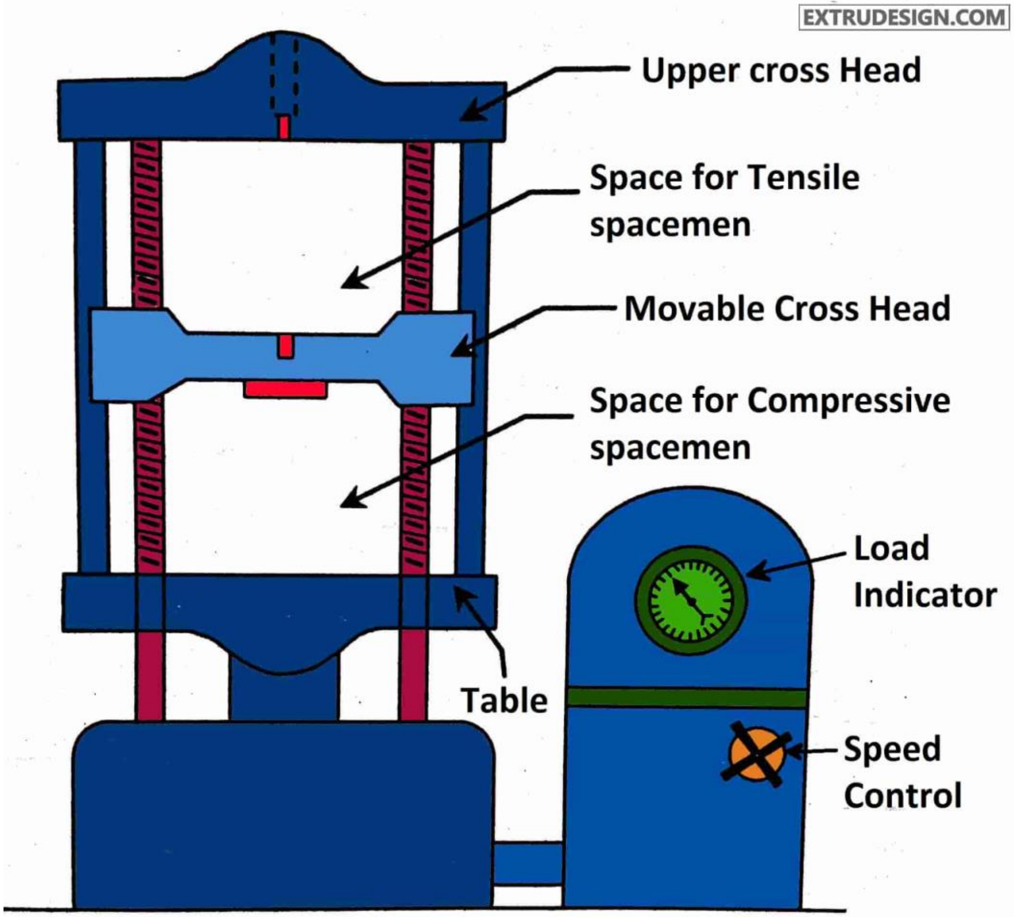
Modulus of Resilience: It is defined as the" Total strain energy stored in the specimen from 'zero up to the fracture point of the specimen". Graphically, it is the area bounded below the graph from zero up to the point of fracture From the Graph.

Modulus of Resilience=Triangular area Al + Rectangular area A2 + Remaining areaA3 Modulus of Resilience = (AI+A2+A2) kg.cm

Tabular Column:

Sl. No.	Load in KN	Load in N	Extension (δl) in mm	Stress in N/mm^2	Strain	Young's modulus N/mm^2
1						E = $\frac{stress}{strain}$
2						
3						
4						
5						
6						
7						
8						
9						
10						

11						Result from the graph
12						
13						
14						
15						



Procedure:

- The original dimensions of the specimen like original diameter, gauge length etc. is to be measured.
- The specimen is mounted on the Universal Testing machine between the fixed and movable jaws.
- The load range in the machine is adjusted to its maximum capacity (160 tones)
- The dial gauge is mounted on the machine at the appropriate positions and adjusted to zero.
- The machine is switched on and the tensile load is applied gradually.
- For every 5 KN of load, the readings of dial gauge is noted and tabulated.
- Remove the dial gauge at slightly below the expected load at yield point.

- Record the load at yield point, at the yield point the pointer on load scale will remain stationary for small interval of time and blue needle will come back by 2 or 3 divisions that point is lower yield point.
- The specimen is loaded continuously up to the ultimate load (red needle will stops) where there is formation of cup and cone at neck in the specimen, which is to be noted.
- With further loading the specimen breaks, and breaking load is noted.
- The specimen is removed and final dimensions are measured.

Calculations:

- Stress = $\frac{\text{Load}}{\text{Area}} = \frac{P}{A_i}$ =…………….N/mm^2
- Strain= $\frac{\text{Changelength}}{\textit{Original length}}$ =…….
- Young's modulus = $\frac{\text{Stress}}{\text{Strain}}$ =………N/mm^2 (obtained from the graph)
- Working stress = $\frac{\textit{yieldstress}}{\textit{Factor of safety}}$ = …….. N/mm^2
- % Elongation= $\frac{\text{Finallength} - \text{Initiallength}}{\text{Initiallength}} \times 100 = (l_f - l_i) \times 100$……%
- % reduction in Area = $\frac{\text{Initial area-Final area}}{\text{Initial area}} \times 100 = \frac{(A_i - A_f)}{A_i} \times 100$……%
- Yield strength= $\frac{\text{Yield load}}{\text{Initial area}} = \frac{p_y}{A_i}$ = ……………N/mm^2
- Ultimate Tensile strength = $\frac{\text{Ultimate load}}{\text{Initial area}} = \frac{p_u}{A_i}$ = ……………N/mm^2
- Breaking strength= $\frac{\text{Breaking load}}{\text{Final Area}} = \frac{p_B}{A_f}$ = ……………… N/mm^2

Results and Conclusions:

- Working stress=
- Young’s Modulus of specimen=
- Yield stress=
- Ultimate stress=
- Breaking stress=
- % reduction in Area=

Experiment-2

Determination of compressive strength of materials by Universal Testing Machine

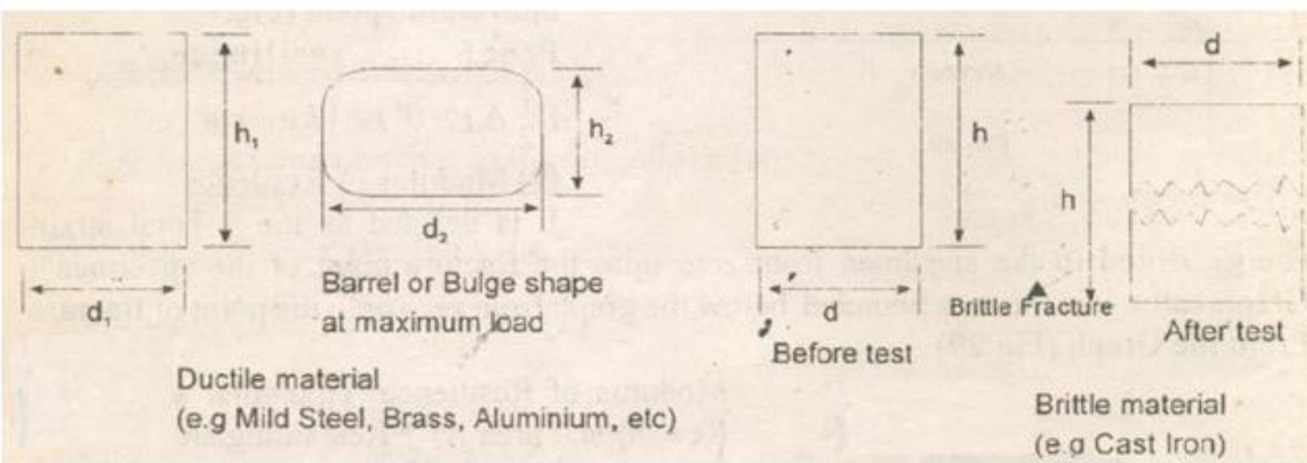
Aim of the Experiment: To study the behavior of the given material under Compressive load and to determine the following:

- Modulus of elasticity
- Maximum Compressive strength or ultimate stress
- Percentage Decrease in length
- Percentage Increase in area

Apparatus Required: Universal Testing machine, Dial gauge, Vernier caliper and scale.

Theory:

Principle: Ductile materials attain a Bulge or a Barrel shape after reaching the maximum compression load. No fracture takes place and there is change in cross- section and compression value remains the same on reaching the maximum load. For brittle materials, there will be no change in the cross-sections or height of the specimen due to the compression load. On reaching the maximum compression load, the specimen suddenly fractures as shown in the Fig.

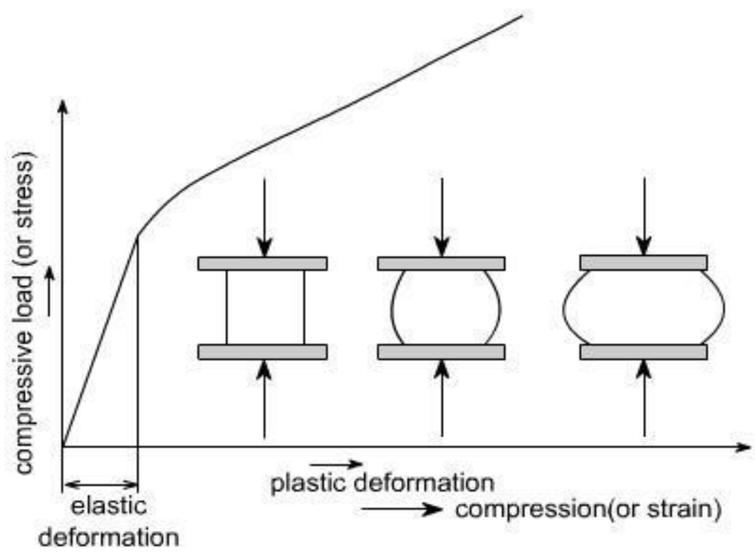


The compression test is just opposite to tension test, with regard to direction. However, there are certain practical difficulties which may induce error in this test. They are:

- Difficulty in applying truly axial load.
- There is always a tendency of the specimen to bend in addition to Contraction.

To avoid these errors, usually the specimen for this test shall be short in length (not more than 2 time the diameter)In a compression test, stress – strain curve is drawn up to the elastic limit of proportionality. Metals have approximately the same modulus of elasticity as in tension test. The curve, for ductile materials, continues almost without limit as there is no fracture of the material due to its ductility and cross sectional area increases continuously with increase in load. The specimen will shorten and bulge out. Compression test is mainly used for testing brittle materials such as cast iron, concrete etc. Brittle materials commonly fail along a diagonal plane due to shearing.

Graph: Stress v/s Strain



Stress v/s Strain

Procedure

- The original dimensions of the specimen like original dia., gauge length etc. is to be measured.
- The specimen is mounted on the Universal Testing machine between the fixed and movable jaws.
- The load range in the machine is adjusted to its maximum capacity (300 tones)
- The dial gauge is mounted on the machine at the appropriate positions and adjusted to zero.
- The machine is switched on and the compressive load is applied gradually.

- For every 10 KN of load, the readings of dial gauge is noted and tabulated.
- Remove the dial gauge at slightly below the expected load at yield point.
- Record the load at yield point, at the yield point the pointer on load scale will remain stationary for small interval of time and blue needle will come back by 1 or 2 divisions that point is lower yield point.
- The specimen is loaded continuously up to the ultimate load (red needle will stops) which is to be noted.

Calculations:

Stress = $\frac{\text{Load}}{\text{Area}} = \frac{P}{A_i}$ =…………….N/mm^2

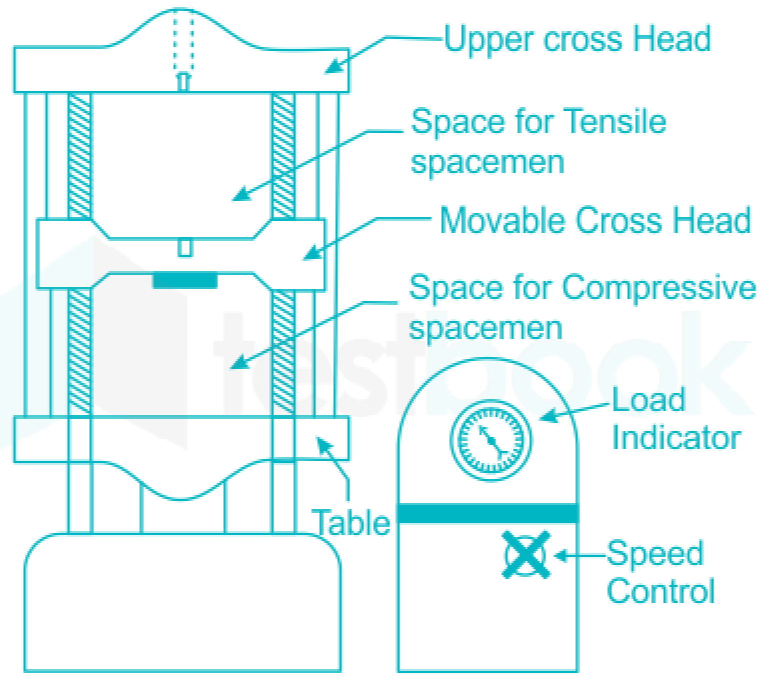
Strain = $\frac{\text{Change in length}(\boldsymbol{\delta l})}{\text{Original Length}(l)}$ = ……………

Young "modulus= $\frac{\text{Stress}}{\text{Strain}}$ =……… N/mm^2 (obtained from the graph)

% Decrease in Length = $\frac{(l_i - l_f)}{l_i}$ x 100=……………%

% Increase in area= $\frac{(A_f - A_i)}{A_i}$ x 100=………..%

Ultimate Compressive strength = $\frac{\text{Ultimate load}}{\text{Initial area } A_i}$ = p_u = ……………N/mm^2



Results and Conclusions:

- Modulus of elasticity =
- Maximum Compressive strength or ultimate stress=
- Percentage Decrease in length=
- Percentage Increase in area=

Experiment-3

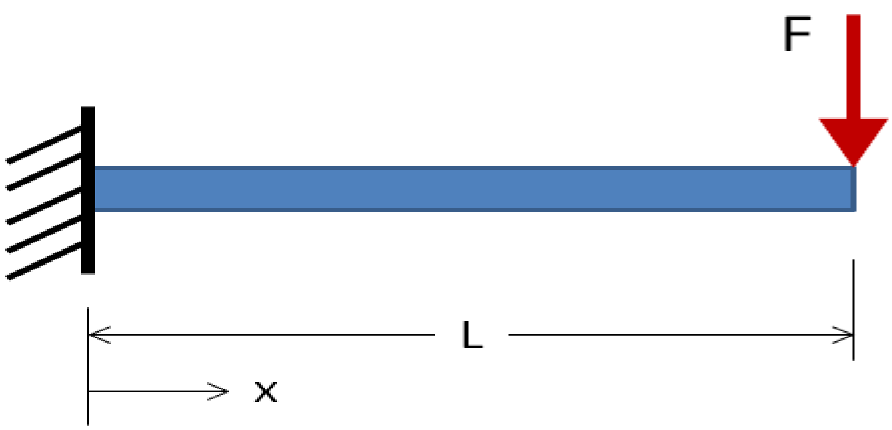
Determination of bending strength of materials by Universal Testing Machine

AIM OF THE EXPERIMENT: To determine the young's modulus for the given steel beam by conducting bending test.

APPARATUS: 1. Cantilever Beam 2. Dial Gauge 3. Weights

THEORY: This method is used for testing of the deflection at various points on the beam. Whenever a beam is loaded, it deflects from its original position. The amount by which a beam deflects depends upon its cross section and the applied load i.e. bending moment. To design a beam, strength and stiffness properties are required. As per the strength orientation criteria of the beam designed, it should be strong enough to resist B.M. and S.F. As per the stiffness criteria, it should be strong enough to resist the deflection of the beam.

Consider a cantilever beam 'AB' of length L and carrying a point load 'W' at a given distance 'a' as shown in fig.



With the help of Macaulay's method, Deflection of the beam at any section of a beam 'C' is Wa3/3EI And deflection at B i.e at free end is WL3/3EI Where, W =Deadweights, a = distance of point load from the fixed end
L = Length of the beam,

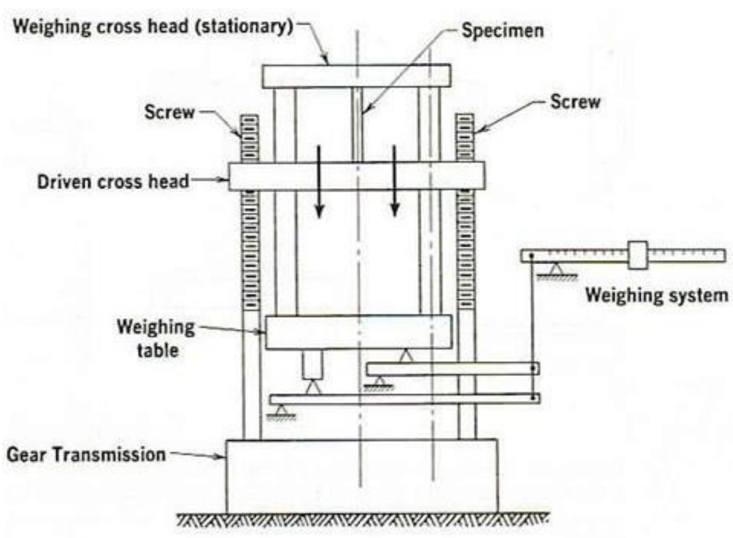
E = Young's modulus of elasticity
I = Moment of inertia . For rectangle $I = bd^3 /12$

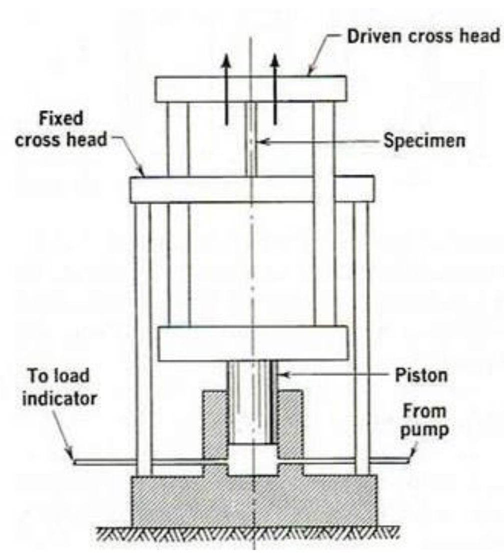
PROCEDURE:
1. Check the flatness of the given beam with the help of deflection gauge.
2. Place the hanger with the weights at a given distance on the beam.
3. Now measure the deflection of the beam at both point load at any section and free end of the beam.
4. Repeat the experiment at various points on the beam.
5. Compare the values obtained with theoretical values.

FORMULAE:

δc = deflection of the beam at a distance 'a' from the fixed end is given by $Wa^3/3EI$.

δb= deflection of the beam at free end is given by $WL^3/3EI$





PRECAUTIONS:
1. The beam must be loaded below its ultimate load. So that it may not fail under loading.
2. Adjust the dial indicator at the exact place where deflection needs to be calculated.
3. Note down the dial indicator readings carefully.

RESULT: Thus Young's Modulus E identified for the cantilever beam is__ N/mm2

Experiment-4

Double shear test in Universal Testing Machine

Aim of the experiment:

Double shear test is used to determine the shear strength (ultimate shear stress) of the mild steel specimen. Universal testing machine (UTM) is used for performing double shear test.

There are two types of UTM namely: screw type and hydraulic type. The latter is easier to operate.

Shear force is the load that cause two contiguous parts of the body to slide relative to each other in a direction parallel to their plane of contact. Shear Strength is defined as the maximum load typically applied normal to a fastener's axis that can be supported prior to fracture. Double shear is load applied in one plane that would result in the fastener being cut into three pieces, while single shear would result in two fastener pieces.

Apparatus required:

Universal testing machine (UTM)
Shear tool assembly
Specimen
Veneer caliper

Theory:

Shear strength of the material is the ultimate shear stress (Tmax) attained by the specimen, which under double shear given by,

$$\tau_{max} = F/2A$$

Where,

F: Maximum load at which the specimen breaks

A: cross-sectional area of the specimen.

The load range to which the machine is to be set for the test is selected bases on the expected maximum load F to be applied on the specimen.

This is calculated from the yield stress fy and the factor of safety (F.S), as follows:

Permissible shear stress τ for mild steel is,

$$\tau = 0.45fy$$

therefore,

$$\tau max = (F.S)\ 0.45fy$$

$$F = 0.9\ (F.S) fyA$$

Procedure

1. Determine the diameter of the given rod with the help of Vernier caliper. Measure the diameter of the specimen at three sections.
2. Calculate the maximum load expected to be applied on the specimen using equation (2) and select the load range to be used.
3. Set the UTM for the selected load range.
4. Set the correct set or disc to assemble the shear attachment with the right set of disc in it. Insert the specimen in to the disc so that it projects equally on either side.
5. Place the entire bear assembly with the specimen in it centrally over the baring plate on the lower table.
6. Bring the lower cross- head close to the top surface of the assembly.
7. Float the lower table and set the load pointer to zero.

8. Apply the load gradually until the specimen breaks.
9. Note the ultimate load applied on the specimen.
10. Finally, Compute the shear strength of the steel specimen.

Conclusion:

Experiment-5

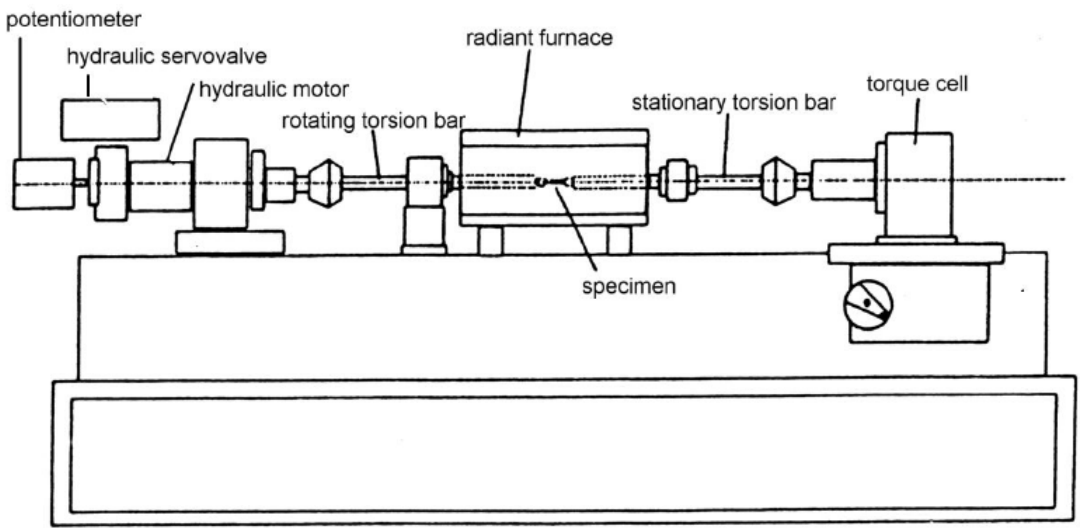
Determination of rigidity modulus of material

Aim of the Experiment: To determine the Torque and angle through which the specimen twist.

Object: To conduct a torsion test on a specimen and evaluate modulus of rigidity or shear modulus of the shaft material

Theory: The Torsion Testing Machine are designed to test variety of materials In torsion this machine applies a torque on the specimen held in its chuck and measure the torque applied and the angle through which the specimen twists.

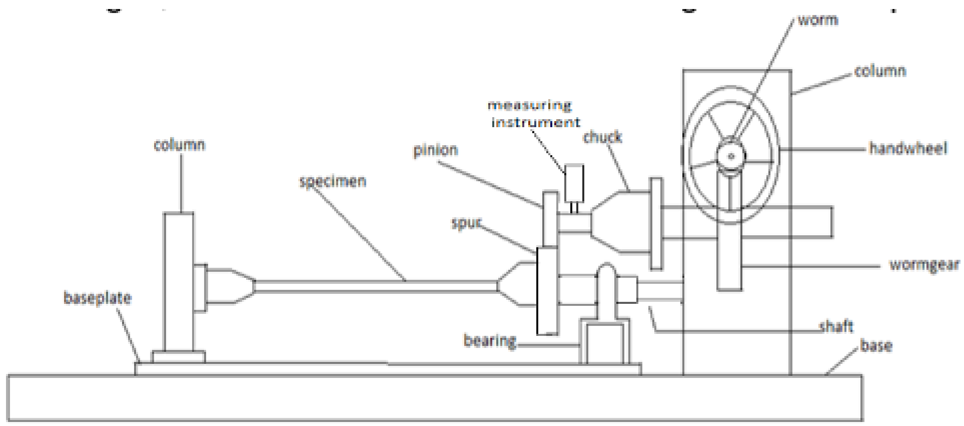
Description: The machine consists of two main parts viz. the driving unit and the measuring Panel. Both are connected to each other by mounting it over a common base frame.



Driving Unit: The driving unit consists of the trolley assembly, rollers over the table, in the slots meant for it. The trolley assembly consists of geared motor, a gear box assembly and the grips. The gear box assembly consists of worm, worm wheel, mounted on worm wheel shaft with the help of key for worm wheel, bearing for worm, bearing for worm wheel, oil seal & ring for worm and O ring for Worm wheel. The worm is driven by geared motor, which in turn rotate worm wheel shaft at 1.5 rpm.

The drive from geared motor is transferred to worm with the help of motor Sprocket, gear box sprocket and chain. The grip assembly is mounted over the worm wheel shaft and a pair of inserts to hold the specimen. There are two such grips assemblies, one mounted over worm wheel shaft and other mounted over the torque arm shaft.

In order to stop the rotation of grips as soon as the specimen fails, a limit x switch arrangements is provided at rear side of machine. It consists of limit suite actuator, pusher, adjusting knob, spring, spring stopper, limit switch bar and supports the position of adjusting knob is to be set after tightening the specimen in both side grips As soon as specimen fails the trolley moves back due to weight attached to and pusher pushed the adjusting knob forcing the actuator to operate limit swath and make the motor oil the machine is also provided with a starter and a reverse forward switch.



Measuring Panel: it torque am shaft extends from the shaft bearing bracket inside the panel over which is mounted the torque arm with key for torque arm. When the torque arm shaft and hence the torque arm rotates in either direction, (reverse or forward direction of torque) the torque arm transfers the force created by torque to the hanger, through its male vee and female vee pairs in such a fashion that upward force always acts on the hanger 1 and lifts it up.
The auto load changing facility consists of a cam shaft which contains in it four fulcrum cams. The cam shaft can be rotate by the range selector knob. The range Indictor disc indicates the range selected. There is another main lever which contains in it four fulcrum vee's, which engage one at a time with fulcrum cam’s, and two male vee's and its two ends. The selection of pair of fulcrum cam and vee by selecting the range decides the leverage between hanger 1 and hanger 2 Changing this pair changes the leverage and hence the range.

The upward force acting on hanger 1 is transferred to hanger 2, in a definite proportion, depending upon the range selected and cause the hanger 2 to be pulled in downward direction. This rotates the pendulum and rack pusher activates main rack to rotate pinion and hence the main pointer thus indicating the torque applied to the specimen. The pendulum weight decides to what degree the pendulum should get lifted.

The pendulum is very precisely assembled with two pendulums with two pendulum bearing and pendulum shaft mounted in pendulum supports. The main rack is guided over two rack guide pulley bearing very little friction. the main pointer and pinion are mounted on pointer shaft with bearing. The dummy pointer moves along with the main pointer but holds the maximum reading when main pointer returns back after failure of specimen.

Utilities Required:

- Electricity Supply: Single Phase, 220 V AC, 50 Hz, 5-15 Amp come Socket with earth connection.
- Specimen/ Test piece.

Experimental Procedure:

- **Starting Procedure:**
  - Ensure that ON/OFF switches given are at OFF position**.**
  - Check the free movement of trolley.
  - Take the test piece and measure the length and diameter of it.
  - Move the trolley accordingly and Fix the test piece in chucks carefully and tight it properly.
  - Switch on the power supply and check the zero reading.
  - Set the peak position and the units required from function counter.
  - Start the machine and wait till the test piece breaks.
  - Note down the torque.
- **Closing Procedure:**
  - When experiment is over switch OFF main switch.
  - Remove the broken test piece from chuck.

Observation & Calculation:

Observation Table		
Sl.No.	**Time(sec)**	**Torque**

Plot the graph time $V_{s.}$ to torque

Precaution & Maintenance Instruction:

- The mill scale/fragments of the broken test piece should be removed immediately or it will damage the jaw sliding of clamping grips.
- Don't run the machine when the test piece is not properly fitted in chucks.

Don't touch the test piece when machine is performing twist

Conclusion:

Experiment-6

FATIGUE TESTING MACHINE

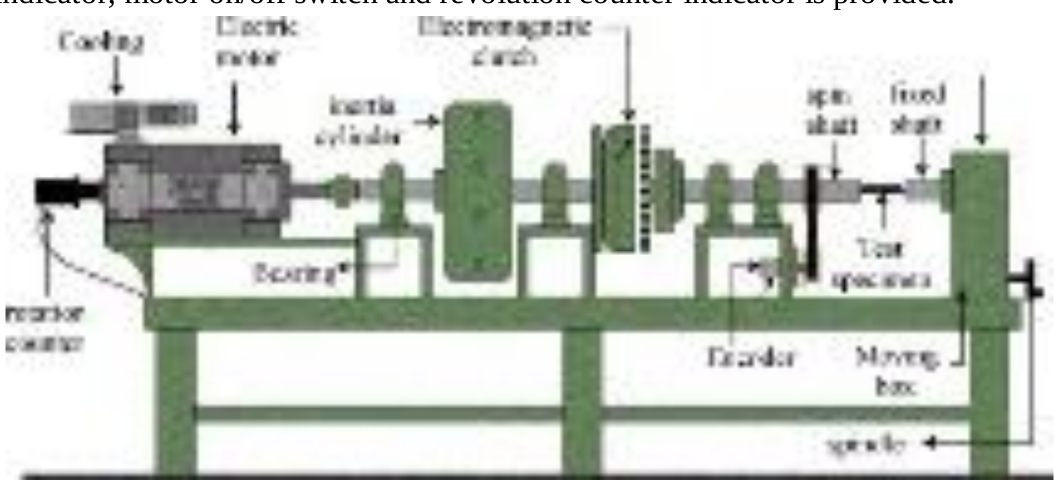
Aim of the Experiment: To study the effect of fatigue & to determine the fatigue strength.

Apparatus Required: Fatigue Testing Machine, Vernier caliper and Specimen.

Introduction: The Fatigue Testing Machine is designed for determining the fatigue strength under reversed bending stresses using S-N Curves. In modern machine designing, the fatigue Strength has become important for determining the dimensions of a component. For this reason the fatigue Test has become one of the most important dynamic test methods.

Theory: in the simple terms fatigue is tiredness. In the material science Fatigue is the property of any material to get deformed earlier than its elastic limits in the condition of constant loading. Fatigue is condition of weakening (loss of strength) of any material when subjects to a constant loading.

Description: The present setups consist of test sections which has two chucks where test piece has to be placed in between them. One chuck is connected to an arrangement through which load can be applied whereas another one is driven by a motor with the help of pulley and
belt. A horizontal shaft is provided on which load is to be applied on one side while another side is free and a switch is provided at the free end so when the test piece gets ruptured then the free end of shaft strikes the button and turn the motor off. There is a control panel provided with the set up on which mains indicator, motor on/off switch and revolution counter indicator is provided.

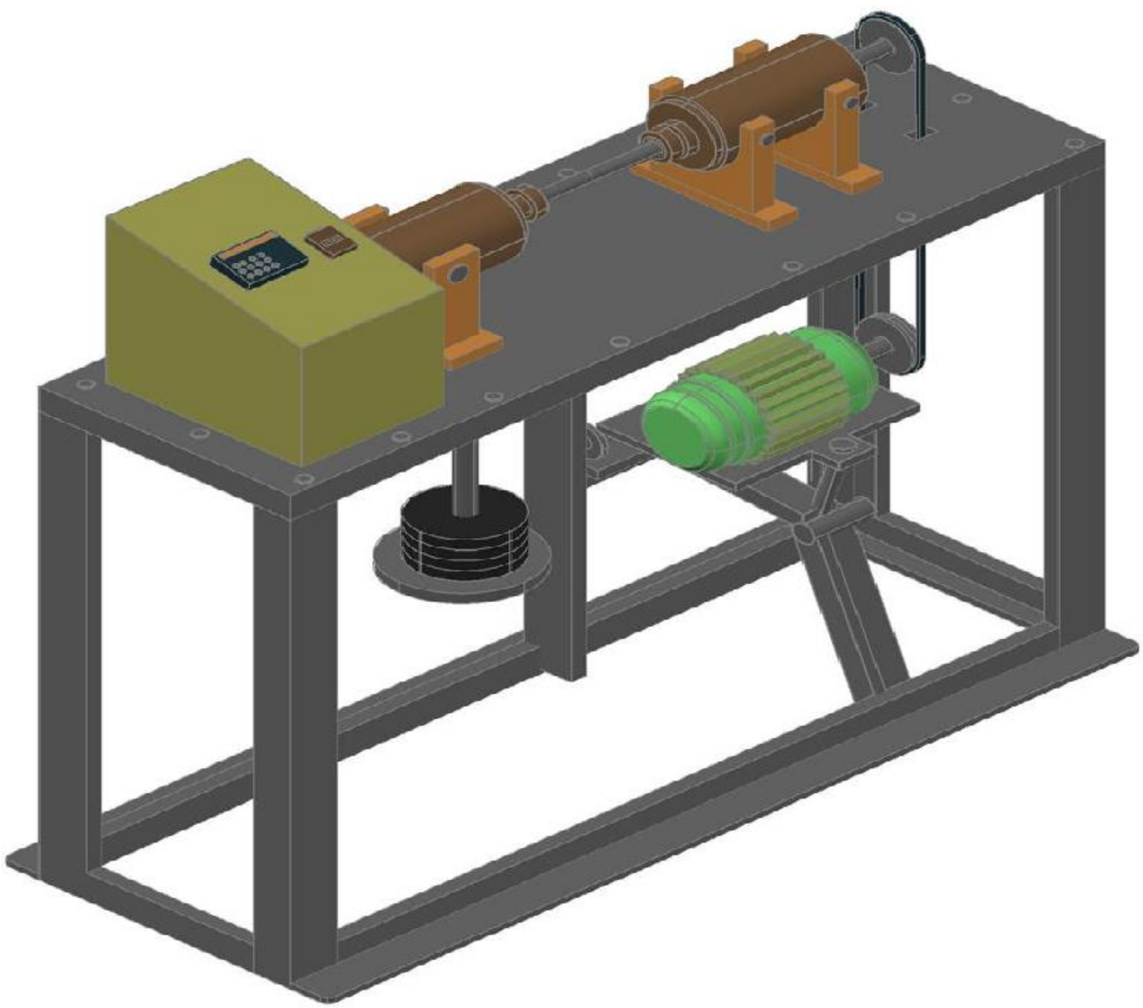


Utilities Required:

- Electricity Supply: Single Phase, 220 V AC, 50 Hz, 5-15 Amp combined sock with earth connection. Earth voltage should be less than 5 volts.
- Floor area required: 2 m x0.5 m

Experimental Procedure:

- **Starting Procedure:**
  - Ensure that motor switch is at off position.
  - Put the shaft at test section and tight it properly.
  - Apply the desired amount of weight.
  - Note down the diameter of shaft and the weight applied.
  - Check for the free movement of balancing shaft.
  - Now connect the power Supply and turn on the motor.
  - Let the apparatus run tilt the shaft gets ruptured.
  - Now note down the revolution from revolution indicator
  - Repeat the procedure for different shaft diameter.
  - Repeat the procedure for different weight.
- **Closing Procedure:**
  - When experiment is over reset the revolution reading to zero.
  - Turn off the motor.
  - Disconnect the power supply.



Observation & Calculation:

Data:

Arm Length, r =100
RPM of Motor = 1440 RPM
Acceleration due to gravity, g =9.81 m/s^2

Observation Table:

Observation Table			
Sl.No.	d (mm)	W (kg)	N_L
1			
2			
3			

Calculation:

t_o = (w x g x r)/ 1000 (N-m)

σ = (t_o x32)/π x (d / 1000)^3 (N-m^2)

t = N_L/(N x 3.03) (min)

Calculation Table:					
Sl.No.	**d (mm)**	**W (kg)**	**σ (N-m^2)**	**N_L**	**t (min)**

Nomenclature:

Nom	**Column Heading**	**Units**	**Type**
r	Arrow Length	m	Given
N	RPM of Motor	RPM	Given
W	Applied Load	Kg	Measured
g	Acceleration due to gravity	m/s^2	Given
d	Diameter of Shaft	mm	Measured
N_L	Number of Load Cycles to Rupture		Measured

F	Bending Moment	N-m	Measured
σ	Stress Amplitude	N/m^2	Measured
t	Duration	min	Measured

Precaution & Maintenance Instructions:

- Do not run the apparatus if test section is not covered.
- Shaft must be tightened properly

Troubleshooting:

- If mains indicator not glowing check for mains connection.

Experiment-7

Estimation of spring constant under tension and compression

AIM OF THE EXPERIMENT: Spring stiffness test to determine properties of the spring.

OBJECT: To conduct an experiment on spring to find the spring constant for the given spring and to compare the values with theoretical values.

THEORY: Experimental determination of the force-deformation behaviour of a spring is simple and straight forward. If the force-deformation behaviour is linear then one has a linear spring. In such a case the amount of force required to produce a unit deflection is called the spring constant of the spring.

In other words, F = k

Where, F is the force in Newton, k is the spring constant or stiffness of the spring (N/mm) and · is the spring deformation (elongation or compression in mm).

The spring constant of a spring can also be computed analytically. The geometric details of the spring and the elastic properties of the material of the spring are needed to compute this. However, the computational approach is not quite simple. When force is applied, spring as a whole is compressed or elongated but this overall deformation comes about due to torsional/bending deformation of the spring wire.

Knowledge of torsion and bending is essential to understand the analytical procedure. When the diameter of the wire (r) is small in comparison with the radius of the coil (R), an element of the spring between two closely adjoining sections through the wire can be considered as a straight circular bar subjected to torsion for the external loading configuration as shown.

The spring stiffness is given by where,

G is the shear modulus of the spring material (GPa),

n is the number of active coils,

r is the spring wire radius (mm) & R is the mean radius (mm) of the spring.

APPARATUS:

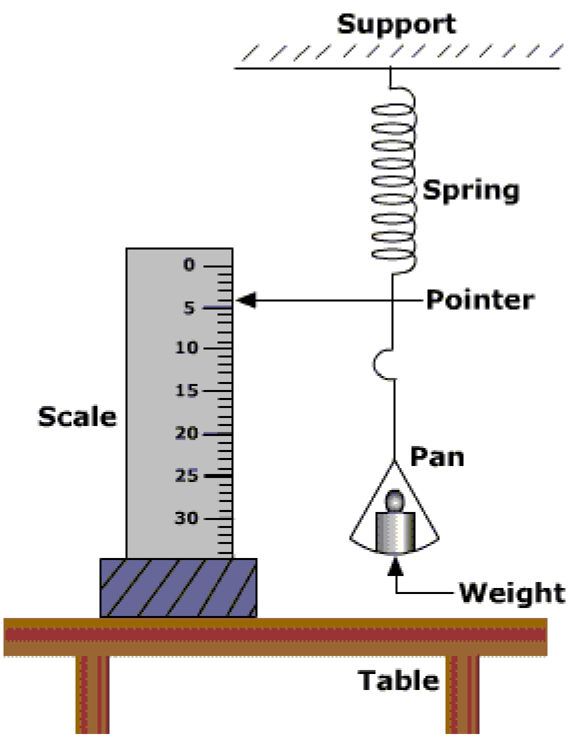
1. Helical springs of different diameters

2. Spring loading apparatus

The oscillation is given by $T = 2\pi \sqrt{M/K}$

Where, M= mass attached to the spring

K= spring constant (N/m)



PROCEDURE:

1. Measure the dimensions of the spring radius R and r (wire radius) using the vernier calipers.

2. Place the spring in the loading setup and then clamp it by tightening the screw.

3. Note down the venire scale reading for no load condition.

4. Load the spring in steps of 0.5 kg of weight up to 2.5 kg, and note down the readings from the vernier scale.

5. Remove the loads one by one when the loading is over and note down the deflection when each load is removed.

6. Take the spring out of the setup and repeat experiment on the other two springs.

7. Calculate the spring stiffness using the above readings.

OBESRVATIONS AND CALCULATIONS:

Spring No. _____________, length___________

Mean Radius (R)________________ Free Wire radius (r)_______________,

Number of coils (n) _______________ Initial reading of vernier______________

Sl. No	Load	Load	Loading	Loading	Unloading	unloading	Remark
	Kg	N	Vernear calliper	Deflection	Vernear calliper	Deflection	

RESULT: Draw a graph between load and deflection of the springs. Compare the stiffness values with that of theoretical values for all the springs and provide your comments.

Experiment-8

Load measurement using load indicator, Load Cells

Aim of the experiment: To study the performance characteristics of load cell.

DESCRIPTION:

Strain Gauge based Load Cell Measurement Trainer is designed for the students of InstrumentationCourse.Itallowsthestudentstounderstandtheconceptof LoadCell. It's application and its associated electronic circuits.

This Trainer Kit consists of:

1. Load Cell made of four banded metal strain gauges with arrangement to fix some load on it at the deformation.
2. Electronic circuitry along with a 3½ Digit Digital Voltmeter.

SPECIFICATION:

(i)	Load Cell	:	Strain Gauge Based.
	Measuring Range	:	0 – 5,Kg.
	Non – Linearity Error	:	1%.
	Resolution	:	0.01,Kg.
(ii)	Electronic Circuit		
	Excitation Source	:	DC Excitation(5,Volts)
	Amplifiers	:	Instrumentation Amplifier and Inverting Summing Amplifier with Zero and Gain adjustment.
	Termination	:	For4armstraingaugebridge.
(iii)	Digital Voltmeter		
	Display	:	3½DigitL.E.D.Display.
	Range	:	0 – 2,000,mVolt.F.S.

THEORY:

The Load Cell is an Electro –mechanical sensor employed to measure static and dynamic force.LoadCellscanbedesignedtohandleawiderangeofoperatingforceswithhigh level of reliability and hence its is one of the most popular transducer in industrial measurements.

The Load Cells derives it output from the deformation of an elastic member having high tensile strength. The basic design parameters in cludesr elativesize and shape material density and modulus of elasticity, strain sensitivity, deflection and dynamic response. Through a careful choice of the material and structural configuration. A linear relationshipbetweenadimensionalchangeandmeasuredforcecanbeachieved.The material so chosen should posses the following properties.

(i) LinearStressStrainrelationshipuptoafairlylargeelasticstrainlimit.
(ii) Low Strain Hysteres is over repeated loading.
(iii) Very low creep over long periods of loading.
(iv) Very low plastic flow due to strain.

The most popular configurations of load cells are:
(i) Column–type.
(ii) Proving Ring Type.
(iii) Cantilever Beam Type.
(iv) Shear–Type.

In all the configuration deformation is sensed by the strain gauges. It is important that in all cases the strain gauge should be suitably located so that the output strain is linearly proportional to the input force with minimum Hysteresis and creep, high readability and over load capacity. Some of the configuration have excellent immunity to adversesideeccentric loads.

In all types of load cells, the stress developed due to force on loading is measured with four electrical strain gauges. All four strain gauges are connected to form a four arm active Wheats one Bridge.

OPERATION:

a. Open the top cover of the trainer kit wooden box.

b. Connectthecantileverbeamtypeloadcellleadswiththetrainerkitterminals. Red lead with red terminal.
    i. Black lead with black terminal.
       Green lead with green terminal.
       Yellow lead with yellow terminal.

c. Connect the 3,pinmainsplugofthetrainingkittothemainssocket(230Volt,
    i. 10%,50Hzsupply)

d. Keep Digital Voltmeter switch at Kg Position.

e. Connectpatchcordbetweenoutputterminalanddigitalvoltmeterterminal.

2) Switch On the trainer kit, the display will light up and will show some reading.
3) Adjustzeropottoset0.00readingondisplaywithoutapplyanyloadonthepan.
4) Put1Kgs.Weightsonthepanofthecantileverbeamandadjustspanpotto show1.00readingondisplay.
5) Repeatsteps6to8.
6) Nowapplyloadsinstepsof100gmsadnotedownthereadinginthefollowing table in increasing and decreasing mode.
7) Now, plot the graph between applied load and Digital Voltmeter reading in Kgs. Witharesolutionof0.01Kgandappliedloadandmeasurenon-=linearity, Hysteres is error etc.

Tabulation:

Sl. No.	Load increasing Mode		Load in Decreasing Mode.	
	Load (inKg.)	DVM Reading(in mV)	Applied Load(inKg.)	DVM(in mV)

INSTRUMENTATION AMPLIFIER OUTPUT MEASUREMENT:

1. Keep Digital Voltmeter at mV position.
2. Connect patch cord between instrumentation output terminal and Digital Voltmeter terminal.
3. At no load condition display will show reading. Note down this reading.
4. Apply load in steps of 100gms. And note down readings in the given table in increasing and decreasing mode.
5. Now, plot the graph between applied load and Digital Volt meter reading in Kgs. With a resolution of 0.01Kg .and applied load and measure non-linearity, Hysteresis error etc.

TABLE– II

Sl. No.	Load increasing Mode		Load in Decreasing Mode.	
	Load(in Kg.)	DVM Reading(in mV)	Applied Load(in Kg.)	DVM(in mV)

OBSERVATIONS:

The result give below has been taken on prototype. The actual results may vary from unit to unit.

Experiment-9

Strain measurement using strain gauge

Aim of the Experiment: To determine the elastic constant (modulus of elasticity) of a Cantilever beam subjected to concentrated end load by using Strain gauge.

APPARATUS REQUIRED:

Load Cell with Strain Gauge

Digital Strain indicator Weights

THEORY:

A body subjected to external forces is in a condition of both stress and strain. Stress can be directly measured but its effect i.e., change of shape of the body can be measured. If there is a relationship between stress and strain, stresses occurring in a body can be computed if sufficient strain information is available. The constant connecting the stress and strain in elastic material under the direct stresses is the modulus of elasticity, i.e., $E=\sigma / \epsilon$ the principle of the electrical resistance strain gauge was discovered by Lord Kelvin, when he observed that a stress applied to a metal wire, besides changing resistance strain gauges are made into two basic forms, bonded wire and bonded foil. Wire gauges are sandwiched between two sheets thin paper and foil gauges are sandwiched between two thin sheets of epoxy.

The resistance factor 'R' of a metal depends on its electrical resistively, , its area, a and the length l, according to the equation R = l / a.

Thus, to obtain a high resistance gauge occupying a small area, the metal chosen has a high resistively, a large number of grid loops and a very small cross-sectional area. The most common material for strain gauge is a copper nickel alloy known as Advance. The strain gauge is connected to the material in which it is required to measure the strain, with a thin coat of adhesive. Most common adhesive used is Eastman, Deco Cement, etc. as the test specimens extends or contracts under stress in the direction of windings, the length and cross sectional area of the conductor alter, resulting in a corresponding increase or decrease in electrical resistance.

GAUGE FACTOR: The dimension less relationship between the change in gauge resistance and change in length is called Gauge factor of the strain, which is expressed mathematically, Gauge Factor, ?g = (?R/R) / (?l/l) In this relationship R and I represent, respectively the initial resistance and initial length of the strain gauge filament, while ?R & ?l represents the small change in resistance and length, which occurs as the gauge is strained along with the surface to which it is bonded.

This gauge factor of a gauge is a measure of the amount of resistance change for a given strain. The higher the gauge factor greater the electrical output for indication or recording purpose. The gauge factor is supplied by the manufacturer and may range from 1.7 to 4. The usual method of measuring the change of resistance in a gauge element is by means of Wheatstone bridge as shown in figure. It consists of Galvanometer, 4 resistor & a battery. Resistance R1 is the strain gauge is used for strain measurement, which is mounted on the specimen. The three resisters R2, R3 and R4 are internal to the device. Let us assume that the resistance has been adjusted so that the bridge is balanced.

Single Arm Mode (Quarter bridge). This bridge arrangement consists of a single active gauge in position, say R1 and three resistor are internal to the device. Temperature compensation is possible only if a self temperature compensating strain gauge is used. Two Arm Mode (Half bridge). In this mode, two resistors are internal to the device and the remaining two are strain gauges. One arm of this bridge is commonly laveled as active arm and the other as compensating arm. The bridge is temperature compensated.

Four Arm Mode (Full Bridge). In this bridge arrangement, four active gauges are placed in the bridge with one gauge in each of the four arms. If the gauges are placed on a beam in bending as shown in fig of the elastic constant by bending test experiment, the single from each of the four gauges will add. This bridge arrangement is temperature compensated. PANEL DETIALS: MAINS ON INDICATOR: To indicate the Power given to the system. CONSOLE ON SWITCH: Provided to activate the system.

STRAIN INDICATOR: To indicate the Distance moved.

SOFTWARE: FACILITATES TO DO THINGS IN COMPUTER FORMAT.

PREPARATION OF EQUIPMENT:

1. Connect the instrument to 1ph, 230V AC supply which is having proper earthing.

2. Switch on the Console

3. Select the BRIDGE Mode

4. Connect the Strain wires accordingly in the table below.

5. Make the Indicator to Read Zero. (ZERO POSITION)

6. Prepare the Loads to be added.

LIMITATIONS:

Range of Load cell: 10kg PROCEDURE:

1. For the Bridge selected and connected wires, slowly add the Weights in steps of 1kg.

2. Note the Reading on the Strain indicator

3. Repeat step 1 and step 2 until 10kg is loaded.

4. Note down the weights added, simultaneously in every step.

5. Calculate the error and % error

6. Modulus of Elasticity of the given load cell.

CONCLUSIONS OF THE RESULTS TABULATED: Summarizing the entire operation Describing the possible error factors Graph Plotting Techniques which can be adopted to minimize the errors in all aspects i.e, from start up to end.

APPLICATIONS: 1.In the ropes 2.In in the beams

Experiment-10

Stress measurement using strain rosette

AIM: To determine Principal stresses and strains induced at a point on the surface of the specimen when it is subjected to combined Bending moment & torque.

APPARATUS USED: Experimental setup, which includes strain gauges, mounted on the specimen, weights and strain indicator.

THEORY: Electrical resistance strain gauges are widely used because of its negligible mass, their Small size and faithful response to rapidly fluctuating strains. As the output is electrical, remote observation is possible. The output can be displayed, recorded or processed as required. Electrical resistance strain gauges are widely used in

1.Experimental study of stresses in transports vehicles, Aircraft, Ships, Automobiles and Trucks.
2. Experimental analysis of stresses in structures and machines, Apartment buildings, Pressure vessels, Bridges, Dams, Transmission towers, Steam and Gas turbines.
3. Experimental verification of theoretical analysis
4. Assist failure analysis.
5. As a sensing element in Transducers for measurement of force, load, pressure, displacement and Torque.

Strain gauges are very sensitive to temperature. The error in strain measurement due to temperature variation can be reduced to a minimum either through the use of suitable compensate gauge or By using self compensated gauges.

Strain gauges can be used for the measurement of strains on the free surface of any member. In electrical strain resistance gauge a change in length or strain produces a change in resistance. It is necessary to measure 3 strains at a point (x, y, XY) to completely define either the strain or stress field.

To determine Principal strains (1 and 2) and the direction of 1 relative to the X-axis. It is necessary to employ multiple element strain gauges and they can be arranged in combination to get three-element rectangular rosette or three-element delta rosette four-element rectangular rosette etc.

PROCEDURE:

1. • **Preparation:**

- Clean the surface of the test specimen where the strain rosette will be applied to ensure proper adhesion.
- Carefully mount the strain rosette on the prepared surface using the appropriate adhesive, ensuring correct orientation of the gauges.

- **Wiring:**
  - Connect the strain gauges to the data acquisition system or strain indicator, ensuring proper configuration for accurate strain measurement.
- **Calibration:**
  - If required, calibrate the measurement system using known weights or reference materials to ensure accurate strain readings.
- **Loading:**
  - Apply a known load to the test specimen using the loading apparatus.
  - Record the strain readings from each gauge in the rosette corresponding to the applied load.
- **Data Analysis:**
  - Use the recorded strain data to calculate the principal strains and stresses.
  - For a three-element rosette with gauges at 0°, 45°, and 90°, the principal strains (ε_1 and ε_2) can be determined using the following equations:

    $\varepsilon_1, \varepsilon_2 = [(\varepsilon_0 + \varepsilon_{90})/2] \pm \sqrt{\{[(\varepsilon_0 - \varepsilon_{90})/2]^2 + (\varepsilon_{45} - [(\varepsilon_0 + \varepsilon_{90})/2])^2\}}$

    where ε_0, ε_{45}, and ε_{90} are the strains measured by the gauges oriented at 0°, 45°, and 90°, respectively.

Safety Precautions:

- Ensure all electrical connections are secure to prevent short circuits.
- Handle the strain gauges and wiring with care to avoid damage.
- Apply loads within the material's safe limits to prevent structural failure.

Conclusion: