DEPARTMENT OF CIVIL ENGINEERING

LABORATORY MANUAL

CE3412-- Materials Testing Laboratory

YEAR / SEMESTER	**:**	**III / 04**
DEPARTMENT	**:**	**Civi Engineering**
ACADEMIC YEAR	**:**	**2023-24**
REGULATION	**:**	**2021**

LIST OF EXPERIMENTS

Strength of Materials laboratory

1. Tension test on a mild steel rod
2. Double shear test on Mild steel and Aluminum rods
3. Torsion test on mild steel rod
4. Impact test on metal specimen
5. Hardness test on metals - Brinnell and Rockwell Hardness Number
6. Deflection test on beams
7. Compression test on helical springs
8. Strain Measurement using Rosette strain gauge
9. Effect of hardening- Improvement in hardness and impact resistance of steels.
10. Tempering - Improvement Mechanical properties Comparison

    (i) Unhardened specimen

    (ii) Quenched Specimen and

    (iii) Quenched and tempered specimen.
11. Microscopic Examination of

    (i) Hardened samples and

    (ii) Hardened and tempered samples.

STRENGTH OF MATERIALS LABORATORY

GENERAL INSTRUCTION

The following instructions should be strictly followed by the students in the strength of Materials Laboratory.

1. All the students are expected to come to the lab, with shoe, uniform etc., whenever they come for the laboratory class.

2. For each lab class, all the students are expected to come with observation note book, record note book, pencil, eraser, sharpener, scale, divider, graph sheets, French curve etc.

3. While coming to each laboratory class, students are expected to come observation note book prepared for the class.

4. All the students are expected to complete their laboratory work including calculations and get it corrected in the laboratory class itself.

5. While coming to the next lab classes are expected to submit the record note for correction.

6. All the equipments, tools accessories and expensive. Therefore, students are expected to handle the instruments with utmost care during the experiment.

7. The tools and accessories required for conducting the experiments can be obtained from the technician and the same should be returned as soon as the experiment over.

8. Breakage amount will be collected from the student(S) for causing damage to the instruments / equipments due to wrong operation or carelessness.

TABLE OF CONTENTS

TENSION TEST ON MILD STEEL ROD

Ex. No.: **Date:**

Aim:

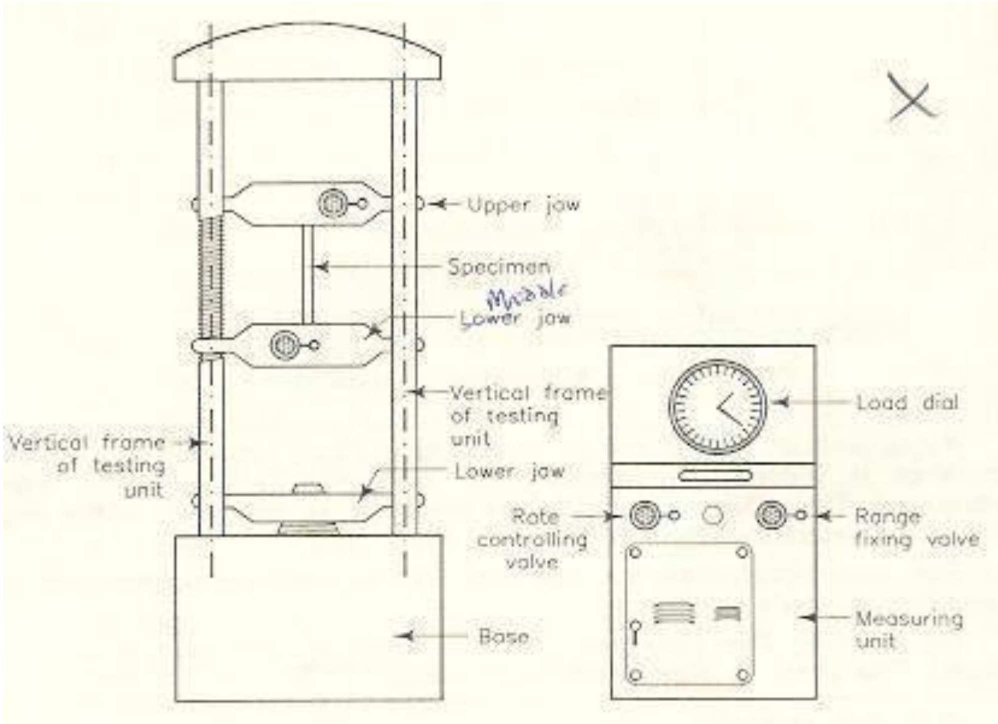
To conduct a tension test on given mild steel specimen for finding the following:
1. Yield stress
2. Ultimate stress
3. Nominal breaking stress
4. Actual breaking stress
5. Percentage Elongation in length
6. Percentage Reduction in area.

Apparatus Required:

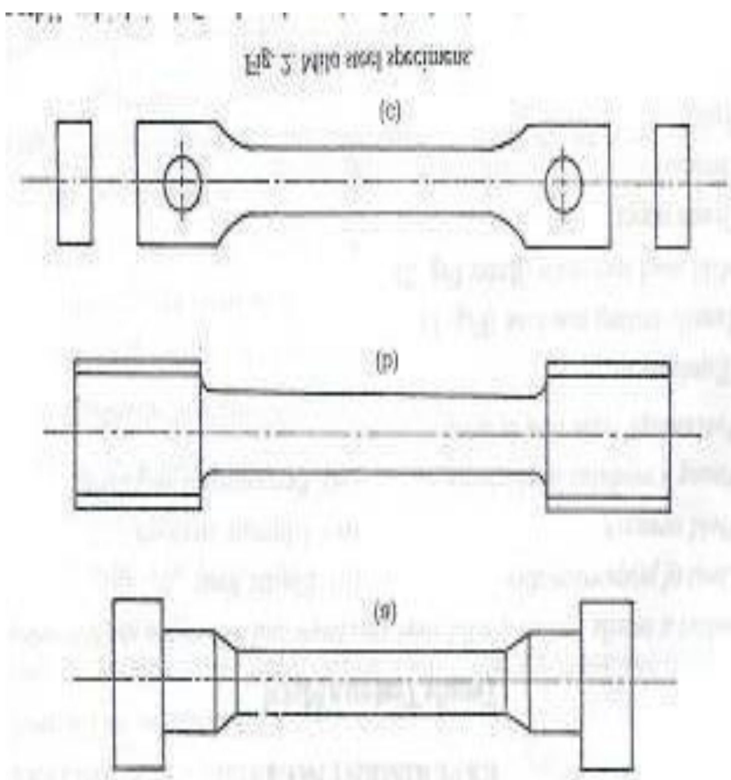
1. Universal Testing machine (UTM)
2. Mild steel specimen
3. Scale
4. Vernier caliper
5. Dot Punch
6. Hammer

Procedure:

1. Measure the length (L) and diameter (d) of the given specimen.
2. Mark the centre of the specimen using dot punch.
3. Mark two points P and Q at a distance of 150mm on either side of the centre mark so that the distance between P and Q will be equal to 300mm.
4.Mark two point A and B at a distance of 2.5 times the rod distance on the either side of the centre mark so that the distance between A & B will be equal to 5 times the rod diameter and is known as initial gauge length of rod. (li).
5. Insert the specimen in the middle cross head and top cross head grip of the machince so that the two points A and B coincide with grips.
6. Apply the load gradually and continue the applications of load. After sometime, there will be slightly pause in the increase of load. The load at this point is noted as yield point (Py).
7. Apply load continuously till the specimen fails and note down the ultimate load (Pa) and breaking load (P_b) from the digital indicator.
8. Remove the specimen from the machine and join the two pieces of the specimens.
9. Measure the distance between the two points A and B. This distance is known as final gauge length (li) of the specimen.
10. Measure the diameter of the rod at neck (dn).
11. Determine the yield stress, ultimate stress, nominal breaking stress, actual breaking stress, percentage elongation in length and percentage reduction in area using the following formula.



Universal testing machine



Mild Steel Specimen

Observation:

1. Material of the specimen =
2. Length of the specimen, L = mm
3. Diameter of the specimen, d = mm
4. Initial gauge length of the specimen I_i = mm
5. Final gauge length of the specimen I_i = mm
6. Diameter at neck d_n = mm
7. Yield load. P_y = KN
8. Ultimate load,P_u = KN
9. Breaking load, P_b = KN

Calculations:

1) Yield stress σ_y $= \dfrac{\text{Yield load } (P_y)}{\text{Initial Area } (A_i)}$

2) Ultimate stress σ_u $= \dfrac{\text{Ultimate load } (P_u)}{\text{Initial Area (Ai)}}$

3. Nominal breaking stress, σ_{bn} $= \dfrac{\text{Breaking load } (P_b)}{\text{Initial Area } (A_i)}$

4. Actual breaking stress, σ_{bn} $= \dfrac{\text{Breaking load (Pb)}}{\text{Neck Area } (A_n)}$

5. % Elongation in length $= \left(\dfrac{\text{Final gauge length } (I_i) - \text{Initial gauge length (Ii)}}{\text{Initial gauge length (Ii)}}\right) \text{x } 100$

6% Reduction in area $= \left(\dfrac{\text{Initial area (Ai)} - \text{Neck area } (A_n)}{\text{Initial gauge length (Ii)}}\right) \text{x } 100$

Where Ai = Initial Area = $\pi d^2 /4$

A_n = Area at neck = $\pi d_n^2 / 4$.

Result:

Tension test for the given specimen was conducted and the results are as follows:

1. Yield stress, σy = N/mm^2
2. Ultimate stress, σ_u = N/mm2
3. Nominal breaking stress, σ_{bn} = N/mm^2
4. Actual breaking stress, σ_{bn} = N/mm^2
5. Percentage Elongation in length =
6. Percentage Reduction in area =

TEST FOR TORSION ON MILD STEEL ROUND ROD

Experiment No: **Date:**

AIM:

To conduct torsion test on mild steel round rod and to determine the value of modulus of rigidity and maximum shear stress.

APPARATUS REQUIRED:

a. Torsion testing machine
b. Vernier caliper
c. Steel rule
d. Specimen

FORMULAE USED:

Modulus of Rigidity, (C)= $\frac{T \times L}{J \times \theta}$ N/mm^2

Maximum Shear Stress, (τ) = $\frac{T \times R}{J}$ N/mm^2

Where,

T $\rightarrow$ Torque, N-mm
J $\rightarrow$ Polar Moment of Inertia, mm^4
L $\rightarrow$ Gauge Length, mm
θ $\rightarrow$ Angle of Twist, Radians
R $\rightarrow$ Mean radius of shaft, mm

PROCEDURE:

1. Before testing, adjust the measuring range according to the capacity of the test piece.
2. Hold the specimen in driving chuck and driven chuck with the help of handles.
3. Adjust the angle measuring dial at zero position, black pointer at the starting position and pen in its required position.
4. Bring the red dummy pointer in line with the black pointer.
5. Start the machine and now the specimen will be subjected to torsion.
6. Take down the value of torque from the indicating dial for particular value of angle of twist (for every 5° of rotation).
7. Repeat the experiment until the specimen breaks into two pieces. Note the value of torque at this breaking point.
8. Tabulate the readings and draw graph between angle of twist and torque.
9. Find the value of T/θ from the graph and find the value of modulus of rigidity.
10. Find the maximum shear stress.

OBSERVATION & TABULATION:

i. Gauge Length (L) = __________ mm

ii. Mean Diameter of Specimen(d):

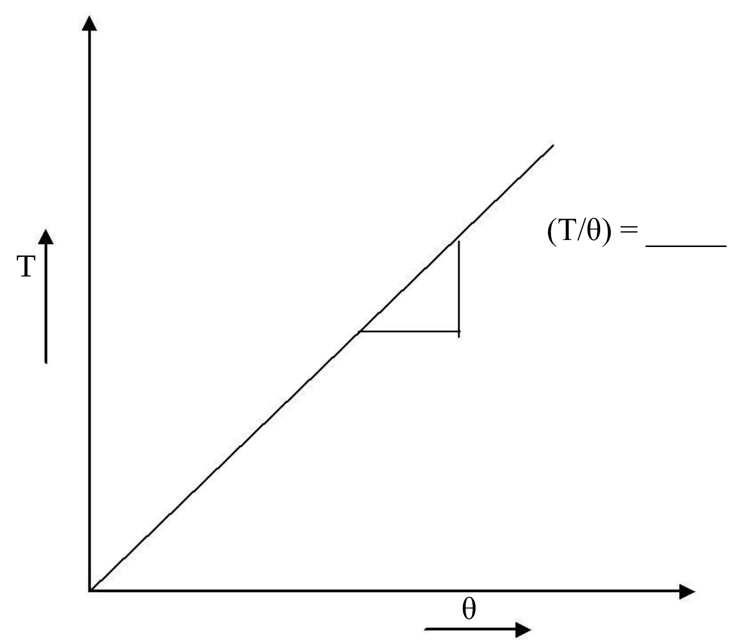
Vernier Caliper Reading: L.C. =__________ mm

Sl. No.	M.S.R. (mm)	V.S.R. (Div)	Observed Reading = M.S.R. + (V.S.R. x L.C.)	Correct Reading = Observed Reading ± Z.C.
			Mean	

Mean Diameter of the specimen (d) = __________ mm.

Sl. No.	Angle of Twist (θ) (Radians)	Torque (T) (N – mm)

GRAPH:



CALCULATIONS:

i. Polar Moment of Inertia (J) $= (\pi/32) \times d^4$

ii. Modulus of Rigidity, (C) $= \frac{T \times L}{J \times \theta}$ N/mm^2

iii. Maximum Shear Stress, (τ) $= \frac{T \times R}{J}$ N/mm^2

RESULT

For the given mild steel round rod specimen

Modulus of Rigidity, (C) = ____________ N/mm^2

Maximum Shear Stress, (τ) = ____________ N/mm^2

CHARPY IMPACT TEST

Ex. No.: **Date:**

Aim:

To determine the impact strength of the given specimen by conducting charpy impact test.

Apparatus and specimen required:

1. Impact testing machine with attachment for charpy test.
2. Charpy specimen
3. Vernier caliper
4. Scale.

Procedure:

1. Measure the length (l), breadth (b), & depth (d) of the given specimen.
2. Measure the position of notch (i.e. groove) from one end (l_g), depth of groove (d_g) and top width of the groove (w_g) in the given specimen.
3. Lift the pendulum and keep it in the position meant for charpy test.
4. Adjust the pointer to coincide with initial position (i.e. maximum value) in charpy scale.
5. Release the pendulum using the lever and note down the initial reading in the charpy scale.
6. Repeat the step 3 and 4.
7. Place the specimen centrally over the supports such that the groove in opposite to the striking face.
8. Release the pendulum again using the lever and note down the final reading in the charpy scale.
9. Find the impact strength of the given specimen by using the following relation:
   Impact strength = (Final charpy scale reading – Initial charpy scale reading)

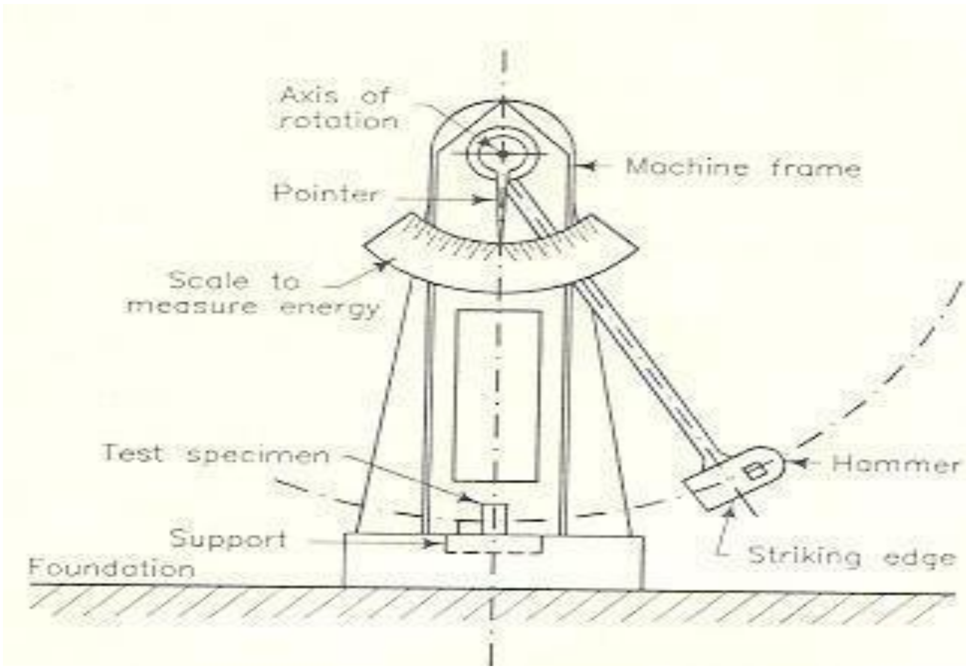
Observation:

1. Material of the given specimen	=	
2. Type of notch (i.e. groove)	=	
3. Length of the specimen, l	=	mm
4. Breadth of the specimen, b	=	mm
5. Depth of the specimen, d	=	mm
6. Position of groove from one end, (l_g)	=	mm
7. Depth of groove (d_g)	=	mm
8. Width of groove (w_g)	=	mm
9. Initial charpy scale reading	=	kg.m
10. Final charpy scale reading	=	kg.m

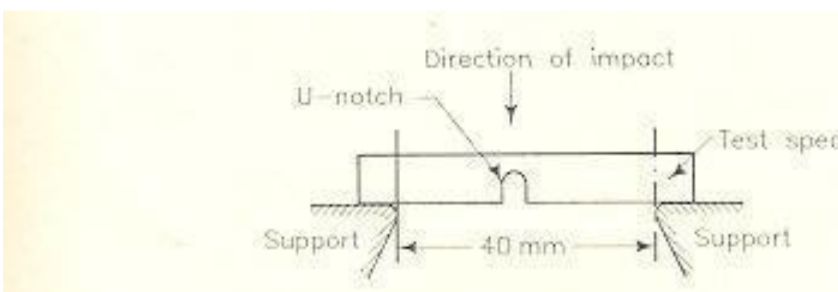
Result:

The impact strength of the given specimen is --------- Kg.m

CHARPY IMPACT TESTING MACHINE



SPECIMEN - CHARPY TEST



Charpy impact test.

FIG. 7-5

IZOD IMPACT TEST

Ex. No.: **Date:**

Aim:
To determine the impact strength of the given specimen by conducting Izod impact test.

Apparatus and specimen required:

1. Impact testing machine with attachment for Izod test.
2. Given specimen
3. Vernier caliper
4. Scale.

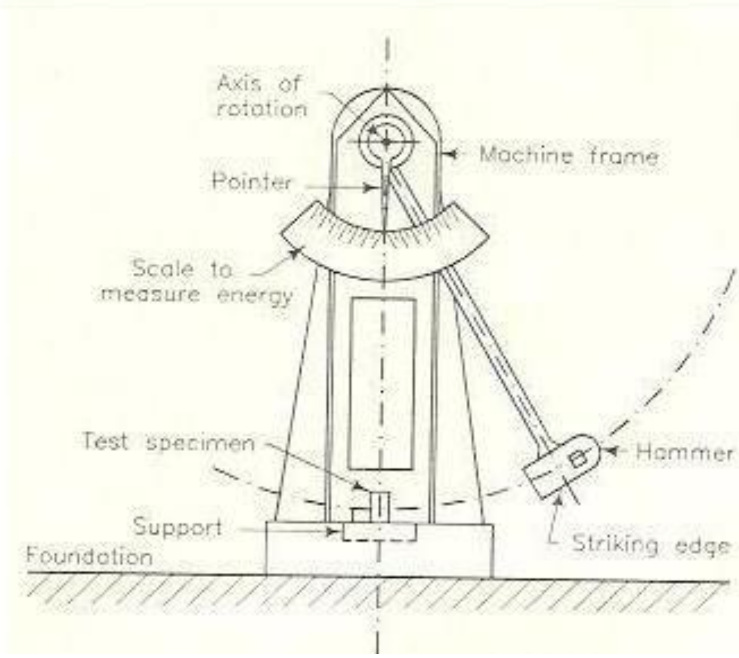
Procedure:
1. Measure the length (l), breadth (b), & depth (d) of the given specimen.
2. Measure the position of notch (i.e. groove) from one end (l_g), depth of groove (d_g) and top width of the groove (w_g) in the given specimen.
3. Lift the pendulum and keep it in the position meant for charpy Izod test.
4. Adjust the pointer to coincide with initial position (i.e. maximum value) in the izod scale.
5. Release the pendulum using the lever and note down the initial reading in the izod scale.
6. Repeat the step 3 and 4.
7. Place the specimen vertically upwards such that the shorter distance between one end of the specimen and groove will be protruding length and also the groove in the specimen should face the striking end of the hammer.
8. Release the pendulum again using the lever and note down the final reading in the izod scale.
9. Find the impact strength of the given specimen by using the following relation:
   Impact strength = (Final izod scale reading – Initial izod scale reading)

Observation:

1. Material of the given specimen	=	
2. Type of notch (i.e. groove)	=	
3. Length of the specimen, l	=	mm
4. Breadth of the specimen, b	=	mm
5. Depth of the specimen, d	=	mm
6. Position of groove from one end, (l_g)	=	mm
7. Depth of groove (d_g)	=	mm
8. Width of groove (w_g)	=	mm
9. Initial charpy scale reading	=	kg.m
10. Final charpy scale reading	=	kg.m

Result:
The impact strength of the given specimen is --------- Kg.m

IZODE IMPACT TESTING MACHINE



SPECIMEN - IZODE TEST

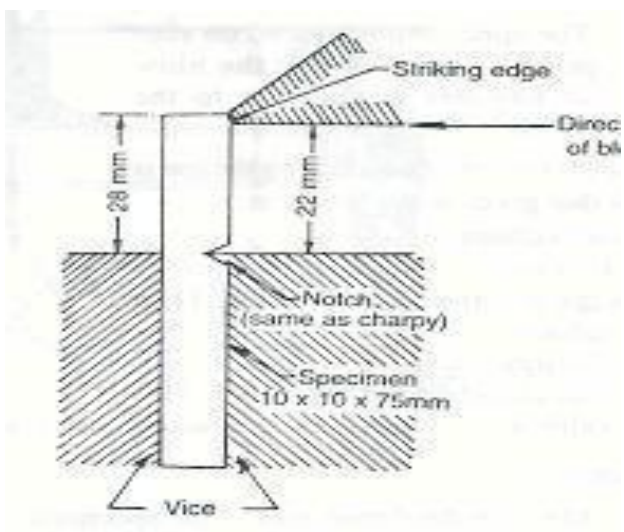


Fig. 10. Izod test.

ROCKWELL HARDNESS TEST

Ex. No.: **Date:**

Aim:

To determine the Rockwell hardness number for the given specimen.

Apparatus Required:

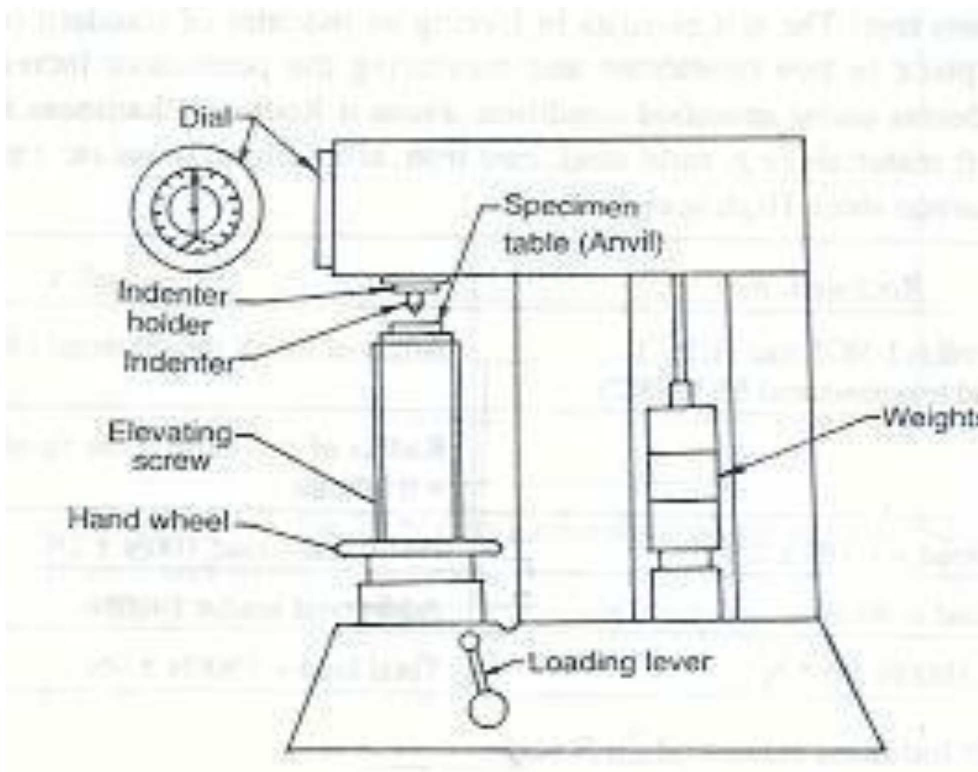
1. Rockwell hardness testing machine
2. Indentor
3. Test specimen
4. Stop watch

Procedure:

1. Identify the material of the given specimen
2. Know the major load, type of indenter and scale to be used for the given test specimen from the following table.

Sl.No.	Material type	Major load	Indenter	Scale
1	Hardened steel	150kg	Diamond cone 120º	C
2	Mild steel	100kg	1.58mm dia, steel ball	B
3	Aluminum	100kg	1.58mm dia. Steel ball	B
4	Brass	100kg	1.58mm dia. Steel ball	B
5	Copper	100kg	1.58mm dia. Steel ball	B

3. Fix the indentor and place the given specimen on the anvil of the machine.
4. Select the major load from the knob available on the right of the machine.
5. Raise the anvil using the rotating wheel till the specimen touches the indentor and then slowly turns the wheel till the small pointer on the dial reaches the red mark position. Now the specimen is subjected to a minor load of 10kg.
6. Push the loading handle in the forward direction to apply the major load to the specimen and allow the load to act on the specimen for 15 seconds.
7. Release the major load by pushing the loading handle in the backward direction and keep the minor 10kg load still on the specimen.
8. Read the Rockwell hardness number either from 'C' or 'B' scale, as the case may be, directly on the dial and record it.
9. Release the minor load of 10kg by rotating the hand wheel and lowering the screw bar.
10. Repeat the experiment to obtain at least 3 different sets of observations for the given specimen by giving a gap of at least 3mm between any two adjacent indentations and 1.5mm from the edge.
11. Find the average value, which will be the rckwell hardness number for the given specimen.



Rockwell hardness test equipment

Observation:

Sl.No.	Material	Major load	Indentor	Scale	Rockwell hardness number (RHC…… or RHB)
			Average		

Result:
The Rockwell hardness number for the given specimen = RHC ----------- (or) RHB -------

BRINELL HARDNESS TEST

Ex. No.: **Date:**

Aim:

To determine the Brinell hardness number for the given specimen.

Apparatus Required:

1. Brinell hardness testing machine
2. Microscope
3. Indenter
4. Test specimen
5. Stop watch

Procedure:

1. Identify the material of the given specimen
2. Know the value of P/D^2 and diameter of the indenter (D) type to be used for the given test specimen from the following table.

Sl.No.	Material type	P/D^2 value in kg/mm^2	Diameter of steel ball (D) indenter in mm
1	Steel and cast iron	30	2.5
2	Copperand Aluminum Alloys	10	2.5
3	Copper and Aluminum	5	2.5
4	Lead, Tin and Alloys	1	2.5

Where, P = Major load in kg.

3. Calculate the major load to be applied for the given test specimen by knowing the value of PD^2 and D.
4. Select the major load from the knob available on the right of the machine.
5. Fix the indentor and place the given specimen on the anvil of the machine.
6. Raise the anvil using the rotating wheel till the specimen touches the indentor and then slowly turns the wheel till the small pointer on the dial reaches the red mark position. Now the specimen is subjected to a minor load of 10kg.
7. Apply the major load to the specimen by pushing the loading – handle in the forward direction and allow the load to act on the specimen for 15 seconds.
8. Release the major load by pushing the loading handle in the backward direction.
9. Release the minor load of 10kg by rotating the hand wheel and lowering the screw bar.
10. Measure the diameter of indentation (d) using the microscope.

11. Calculate the Brinell hardness number for the given specimen using the following formula:

$$\text{Brinell hardness number} = \frac{\text{Load in kg}}{\text{Spherical area of Indentation of mm}^2}$$

$$= \frac{P}{\pi D/2\,[d - \sqrt{D^2 - d^2}]} \quad \text{kg/mm}^2$$

Where, P = Major load in kg.

D = Diameter of indenter in mm. d

= diameter of indentation in mm.

12. Repeat the experiment to obtain at least 3 different sets of observations for the given specimen by giving a gap of at least 3mm between any two adjacent indentations and 1.5mm from the edge.

11. Find the average value, which will be the Brinell hardness number for the given specimen.

BRINELL HARDNESS TEST

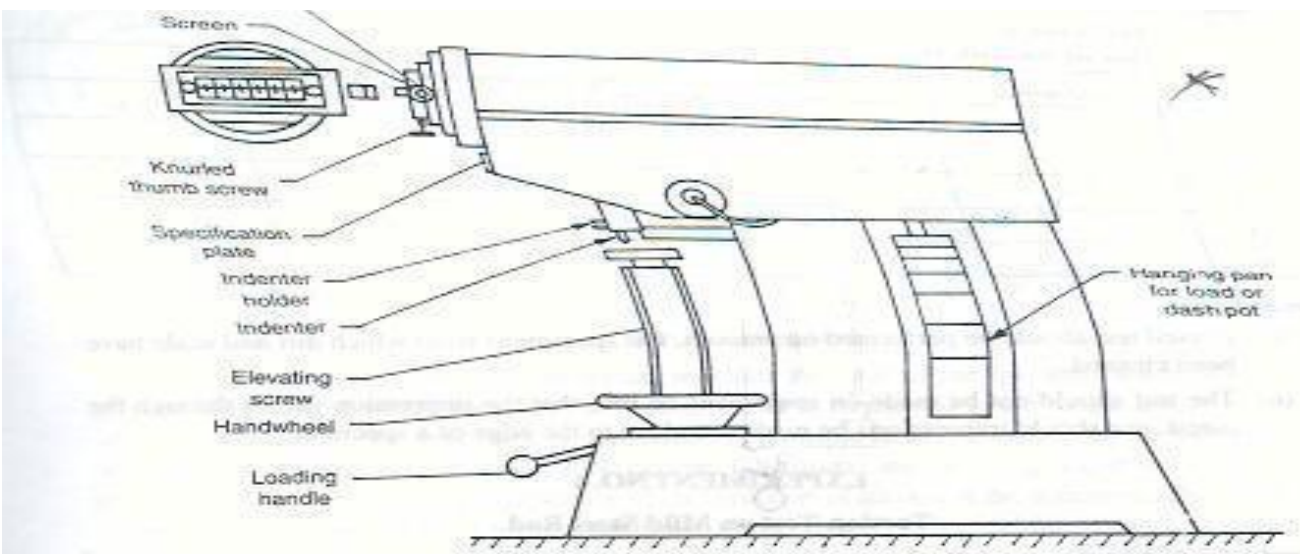


Fig. 7. Brinell hardness tester.

$$\text{Brinell hardness number, } BHN = \frac{2P}{\pi D\,(D - \sqrt{D^2 - d^2})}\,.$$

Test Requirements/Procedure:

Observation:

Sl.No.	Material	P/D^2 value in kg/mm^2	Major load (P) in kg	Diameter of steel ball indentor (D) in mm.	Dia of indentation (d) in mm	Brinell hradmess number (BHN) in kg/mm^2
Average						

Result:

The Brinell hardness number for the given specimen = ----------- kg/mm^2

DEFLECTION TEST ON BEAMS

Ex. No.: **Date:**

Aim:

To determine the Young's modulus of the given specimen by conducting bending test.

Apparatus and Specimen required:

1. Bending Test Attachment
2. Specimen for bending test
3. Dial gauge
4. Scale
5. Pencil / Chalk

Procedure:

1. Measure the length (L) of the given specimen
2. Mark the centre of the specimen using pencil / chalk
3. Mark two points A & B at a distance of 350mm on either side of the centre mark. The distance between A & B is known as span of the specimen (l)
4. Fix the attachment for the bending test in the machine properly.
5. Place the specimen over the two supports of the bending table attachment such that the points A &B coincide with centre of the supports. While placing, ensure that the tangential surface nearer to heart will be the top surface and receives the load.
6. Measure the breadth (b) and depth (d) of the specimen using scale.
7. Place the dial gauge under this specimen at the centre and adjust the dial gauge reading to zero position.
8. Place the load cell at top of the specimen at the centre and adjust the load indicator in the digital box to zero position.
9. Select a strain rate of 2.5mm / minute using the gear box in the machine.
10. Apply the load continuously at a constant rate of 2.5mm/minute and note down the deflection for every increase of 0.25 tonne load up to a maximum of 6 sets of readings.
11. Calculate the Young's modulus of the given specimen for each load using the following formula:

Young's modulus, $E = \dfrac{Pl^3}{48I\delta}$

Where, P = Load in N

L = Span of the specimen in mm

I = Moment of Inertia in mm^4 ($bd^3/12$)

b = Breadth of the beam in mm.

d = Depth of the beam in mm

δ = Actual deflection in mm.

12. Find the average value of young's modulus that will be the Young's modulus of the given specimen.

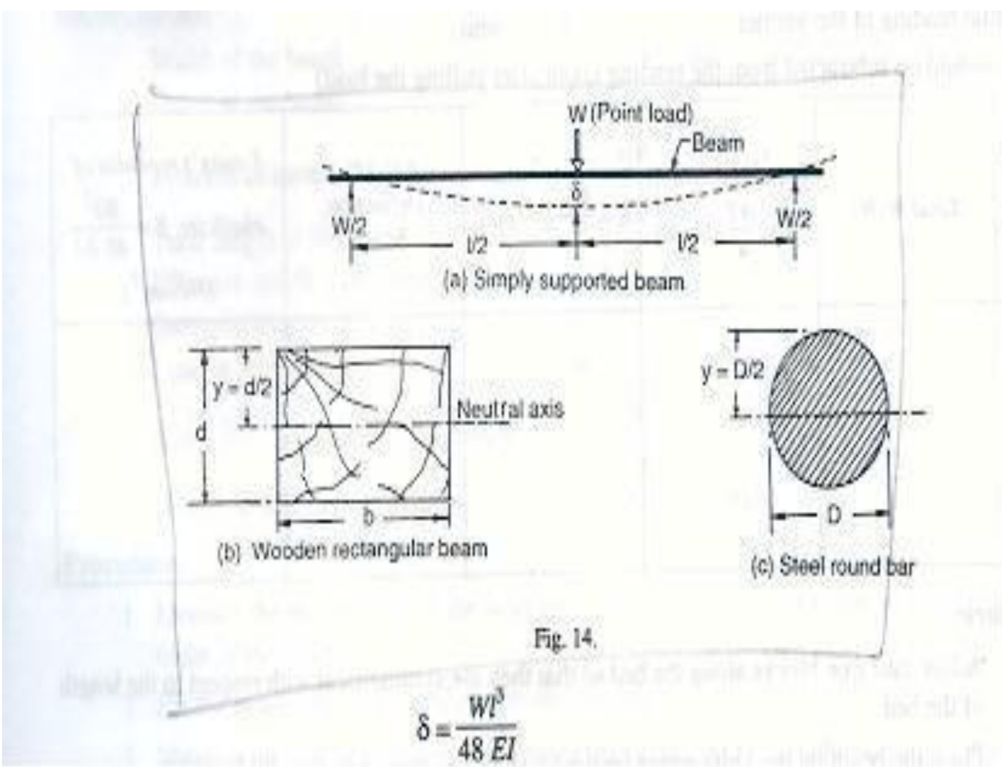
Observation:

1. Material of the specimen =
2. Length of the specimen, L = mm
3. Breadth of the specimen, b = mm
4. Depth of the specimen, d = mm
5. Span of the specimen, l = mm
6. Least count of the dial gauge, LC = mm

Sl.No.	Load in		Deflection in mm		Young's Modulus in N/mm^2
	T	N	observed	Actual	
				Average	

Result:

The young's modulus of the given wooden specimen = --------------------- N/mm^2



DEFLECTION TEST – SPECIMEN SETUP

TEST ON COMPRESSION SPRING

Ex. No.: **Date:**

Aim:

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

Apparatus and specimen required:

1. Spring test machine
2. Compression spring specimen
3. Vernier caliper

Procedure:

1. Measure the outer diameter (D) and diameter of the spring coil (D) for the given compression spring.
2. Count the number of turns i.e. coils (n) in the given compression specimen.
3. Place the compression spring at the centre of the bottom beam of the spring testing machine.
4. Rise the bottom beam by rotating right side wheel till the spring top rouches the middle cross beam.
5. Note down the initial reading from the scale in the machine.
6. Apply a load of 25kg and note down the scale reading. Increase the load at the rate of 25kg upto a maximum of 100kg and note down the corresponding scale readings.
7. Find the actual deflection of the spring for each load by deducting the initial scale reading from the corresponding scale reading.
8. Calculate the modulus of rigidity for each load applied by using the following formula:

Modulus of rigidity, $N = \underline{64PR^3n}\ d^4\delta$

Where, P = Load in N
R = Mean radius of the spring in mm (D –d
/2) d = Diameter of the spring coil in mm
δ = Deflection of the spring in mm
D = Outer diameter of the spring in mm.

9. Determine the stiffness for each load applied by using the following formula:
Stiffness, $K = P/\delta$
10. Find the values of modulus of rigidity and spring constant of the given spring by taking average values.

Observation:

1. Material of the spring specimen =
2. Outer diameter of the spring. D = mm
3. Diameter of the spring coil, d = mm
4. Number of coils / turns, n = Nos.
5. Initial scale reading = cm = mm

Sl.No.	**Applied Load in**		**Scale reading in**		**Actual deflection in mm**	**Modulus of rigidity in N/mm^2**	**Stiffness in N/mm**
	kg	N	cm	mm			
Average							

Result:

The modulus of rigidity of the given spring = ------------------- N/mm^2

The stiffness of the given spring = ------------------- N/mm^2

DOUBLE SHEAR TEST ON STEEL BAR

Ex. No.: **Date:**

Aim:

To determine the maximum shear strength of the given bar by conducting double-shear test.

Apparatus and specimen required:

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

Description:

In actual practice when a beam is loaded the shear force at a section always comes to play along with bending moment. It has been observed that the effect of shearing stresses compared to bending stress is quite negligible. But sometimes, the shearing stress at a section assumes much importance in design calculations. Universal testing machine is used for performing shear, compression and tension. There are two types of UTM.1. Screw type2. Hydraulic type. Hydraulic machines are easier to operate. They have a testing unit and control unit connected to each other with hydraulic pipes. It has a reservoir of oil, which is pumped into a cylinder, which has a piston. By this arrangement, the piston is made to move up. Same oil is taken in a tube to measure the pressure. This causes movement of the pointer, which gives reading for the load applied.

Procedure:

1. Measure the diameter (d) of the given specimen.
2. The inner diameter of the hole in the shear stress attachment is slightly greater than that of the specimen.
3. Fit the specimen in the double shear device and place whole assembly in the UTM.
4. Apply the load till the specimen fails by double – shear.
5. Note down the load at which the specimen fails (P).
6. Calculate the maximum shear strength of the given specimen by using the following formula:

$$\text{Maximum shear strength (c/s area in double shear)} = \frac{\text{Load at failure (P) in N}}{\text{2 x cross – sectional area of the bar in mm}^2}$$

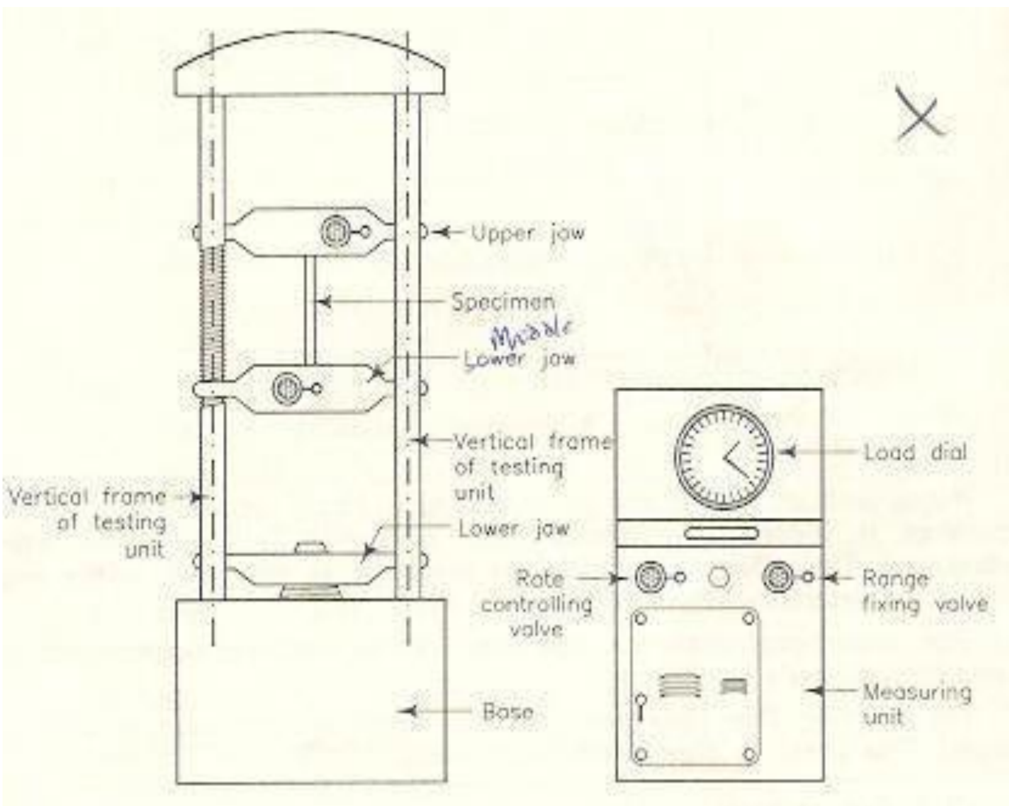
Observation:

1. Material of the specimen =
2. Diameter of the specimen, d = mm
3. Cross sectional area in double shear, (A) = $2 \times \pi d^2/4$ mm^2
4. Shear Load taken by specimen at the time of failure (P) = ------ KN

Result:

The maximum shear strength of the given specimen = ---------------------- N/mm^2

UNIVERSAL TESTING MACHINE



STRAIN MEASUREMENT ON CANTILEVER BEAM

Ex. No.: **Date:**

Aim:

To determine the Strain of the cantilever beam subjected to Point load at the free end and to plot the characteristic curves.

Apparatus required

Cantilever Beam Strainguage Trainer Kit
Weights and Multimeter

Formula used

Strain, $S = 6PL / BT^2E$

Where,
P=Load applied in Kg.
L = Effective length of the beam in cm.
B = Width of the beam in cm.
T = thickness of the beam in cm.
E = young's modulus = $2x10^9$Kg/cm^2.
S = Micro strain.

Theory:

When the material is subjected to any external load, there will be small change in the Mechanical properties like thickness of the material or change in the length depending upon the nature of load applied to the material. The change in mechanical properties will remain till the load is released. The change in the property is called Strain (or) material gets strained.

Strain $S = \partial L/L$

Since the change in length is very small, it is difficult to measure ∂L, so the strain is measured in micro strain. Since it is difficult to measure the length, Resistance strain gauge are used to measure strain in the material directly. Strain gauges are bonded directly on the material using special adhesive s. As the material get strained due to load applied the resistance of the strain gauge changes proportional to the load applied. This change in resistance is used to convert mechanical property into electrical signal which can be easily measured and stored for analysis.

The change in the resistance of the strain gauge depends on the sensitivity of the strain gauge which is expressed in terms of a gauge factor, S_g

$$S_g = \Delta R / R$$

The output $\Delta R/R$ of a strain gauge is usually converted into voltage signal with a Wheatstone bridge. If a single gauge is used in one arm of Wheatstone bridge and equal but fixed resistors is used in the other arm, the output voltage is $E_o = E_i / 4(\Delta R_g / R_g)$

$$\mathbf{E_o = 1/4(EiS_g\, \Delta)}$$

The input voltage is controlled by the gauge size and the initial resistance of the gauge. As a result, the output voltage E_O usually ranges between 1 to 10 ΔV / micro units of strain.

Procedure:

1. The instrument is switched on (i.e.,). The display glows to indicate the instrument is ON.
2. The Instrument is allowed to be in ON position for 10 minutes for initial worm-up.
3. From the selector switch, FULL or HALF bridge configuration is selected.
4. The potentiometer is adjusted for ZERO till the displays reads ' 000'
5. 1 Kg load is applied on the pan of the cantilever the CAL Potentiometer is adjusted till the display reads 377 micro strains. When the weights are removed the display should come to ZERO, in case of any variation, ZERO Potentiometer is adjusted again and the procedure is repeated again. Now the instrument is calibrated to read micro strains.
6. Then the loads are applied on the pan in steps of 100 gm up to 1kg. When the cantilever is strained, instrument displays exact micro strain.
7. The readings are noted down in the tabular column . Percentages error in readings, hysteresis and accuracy of the instrument can be calculated by comparing with the theoretical results.

Observation:

Sl.No.	Weight (gms)	Actual readings (using formula) Micro strains	Display readings		Error %
			While loading micro strains	While unloading micro strains	
1	100				
2	200				
3	300				
4	400				
5	500				
6	600				
7	700				
8	800				
9	900				
10	1000				

$$\% \text{ ERROR} = \frac{(\text{Actual reading} - \text{Display reading}) \times 100}{\text{Max Weight (gms)}}$$

Result:

Thus the strain of the cantilever beam subjected to free end loading, is obtained in micro strains and the characteristics curves – Load Vs Strain, Output Voltage Vs Strain and Actual Vs Display readings are plotted.

TEMPERING- IMPROVEMENT MECHANICAL PROPERTIES COMPARISON

Ex. No.: **Date:**

Aim:

To perform the heat treatment tempering on the given material C-40 steel.

Apparatus required:

1. Muffle furnace: tongs
2. Given material: C-40 steel
3. Quenching medium: water
4. Rockwell test setup

Procedure:

Quenching:
It is an operation of rapid cooling by immersing a hot piece into a quenching bath.

Tempering:
It is defined as the process of reheating the hardened specimen to some temperature before the critical range followed by any rate of cooling such are heating permit the trapped temperature to transform and relieve the internal stresses.

1. The given specimen is subjected to Rockwell hardness test and Rockwell hardness number is measured before hardening that the specimen is subjected to rough grinding.
2. The specimen is placed inside the combustion chamber of muffle furnace and is noted up to 830˚C
3. Then the specimen is soaked for 10 minutes at the same temperature 830˚C.
4. After soaking it is taken out from the furnace and it is quenched in the water.
5. The specimen is cooled, now the tempering is completed.
6. Again the specimen is subjected to Rockwell hardness test and Rockwell hardness number is measured.

Tabulation:

S.NO	Specimen Material	Load(Kgf)	Penetration	Scale	RHN

Result:

The heat treatment tempering on the given material C-40 steel and its Rockwell hardness number is measured

1. Rockwell hardness number before tempering =
2. Rockwell hardness number after tempering =

MECHANICAL PROPERTIES FOR UNHARDENED OR HARDENED SPECIMEN

Ex. No.: **Date:**

Aim

To find hardness number and impact strength for unhardened, hardened specimen or Quenched and tempered specimen and compare mechanical properties.

Material and equipment:

Unhardened specimen, Hardened or Quenched and tempered specimen, muffle furnace, Rockwell testing machine, impact testing machine.

Procedure:

HARDENING:

It is defined as a heat treatment process in which the steel is heated to a temperature within or above its critical range, and held at this temperature for considerable time to ensure thorough penetration of the temperature inside the component and allowed to cool by quenching in water, oil or brine solution.

Case (I) - Unhardened specimen

1. Choose the indenter and load for given material.
2. Hold the indenter in indenter holder rigidly
3. Place the specimen on the anvil and raise the elevating screw by rotating the hand wheel up to the initial load.
4. Apply the major load gradually by pushing the lever and then release it as before.
5. Note down the readings in the dial for corresponding scale.
6. Take min 5 readings for each material.

Case (II) - For Hardened specimen

1. Keep the specimen in muffle furnace at temperature of 700˚ to 850˚ for 2 hours
2. The specimen is taken from muffle furnace and quenched in water or oil.3. Then above procedure is followed to test hardness

Case (III) - For Tempered specimen

1. Keep the specimen in muffle furnace at temperature of 650˚ for 2 hours
2. Allow the specimen for air cooling after taking from muffle furnace
3. Then same procedure is followed foe the specimen

Observation:
Rockwell hardness test:
Cases for hardness =
Cross sectional area=

S.No	Material	temperature	Load (Kgf)	Indenter detail	scale	RHN			
						Trial 1	trail 2	Trail 3	Mean
1	Deep casehardened steel								
2	Deep casehardened steel								
3	Mild steel								
4	Mild steel								

CHARPY TEST

S.No	Material and Condition	Energy absorbed(Joules)	Cross-sectional area below the notch(mm)	Impact strength(J/mm)
1	Mild steel-unhardened			
2	Quenched			

Result:
Thus the hardening – heat treatment process is carried out.

MICROSCOPIC EXAMINATION OF (i) HARDENED SAMPLES AND (ii) HARDENED AND TEMPERED SAMPLES.

Ex. No.: **Date:**

Aim:
To prepare a specimen for microscopic examination.

Tools required:
Linisher – polisher grades of emery sheets (rough and Fine), disc polisher, metallurgical microscopes.

Procedure

The specimen preparation consists of following stages:

i) Rough grinding
ii) Intermediate Polishing
Iii) Fine Polishing
iv) Etching

(i) Rough grinding:

It is first necessary for specimen to obtain a reasonable flat surface. This is achieved by using a motor driven energy belt called Linisher-Polisher. The specimen should be kept over the moving belt which will abrade the specimen and make the surface flat. In all grinding and polishing operations, the specimen should be moved perpendicular the existing scratches, so that the deeper scratches will be replaced to a shallower one. This operation is done until the specimen is smooth, free from rust, burs, troughs and deep scratches.

(ii) Intermediate Polishing:

It is carried out using energy paper of cogressively fine grades. The emery paper should be of good quality. The different grades of emery paper used are 120,240,320,400 and 1/0,2/0,3/0,4/0 (Grain size from coarse to fine). The emery paper should be kept against the specimen and moved gently until a fine matrix of uniformly spaced scratches appears on the object. Final grade is then chosen and the specimen is turned perpendicular to the previous direction. This operation is usually done dry.

(iii) Fine Polishing:

An approximate flat scratch free surface is obtained by the use of wet rotary wheel covered with abrasive of alumina powder of 0.05 microns. In this operation, water is used as lubricant and carrier of the abrasive fine scratches and very thin layer produced due to previous operations.

(iv) Etching:

The polished surface is washed with water and etching is done by rubbing the polished surface gently with cotton wetted with etching reagent. After etching the specimen is again washed and then dried, it is then placed under the metallurgical microscope to view the microstructure of it. Thus the specimen is identified.

Result:

Thus the specimen was prepared for microscope observation for its identification.

SURVEY PRATICAL –I MANUAL

III SEMSTER – CIVIL ENGG.

Prepared By
S.Natrajan
Assistant Professor
Department of Civil Engineering

CE2207 SURVEY PRACTICAL - I

1. Study of chains and its accessories
2. Aligning, Ranging and Chaining
3. Chain Traversing
4. Compass Traversing
5. Plane table surveying: Radiation
6. Plane table surveying: Intersection
7. Plane table surveying: Traversing
8. Study of levels and levelling staff
9. Fly levelling using Dumpy level
10. Check levelling
11. LS and CS
12. Contouring

TOTAL : 60

Ex.No.1

TABULATION

LINE	LENGTH 'm'
Total	

Ex.No.1 ALIGNING AND MEASURING THE LENGTH OF THE GIVEN LINE

AIM:

To align and measure the length of the given line.

ACCESSORIES REQUIRED:

1. Chain
2. Ranging Rod
3. Cross staff.

PROCEDURE:

1. Two Ranging Rods are fixed as main survey stations A and B.
2. Three Ranging rods are fixed as intermediate points R_1 R_2 R_3 between the main survey stations A and B. Such that the distance between the ranging rods are less than 20m.
3. Ranging Rods R_1 R_2 R_3 are aligned by eye judgments such that all of them are in main survey line 'AB'.
4. A 20m metric chain is used to measure the distance between the intermediate points R_1 R_2 R_3
5. The distance between 'AR_1', 'R_1 R_2', 'R_2R_3', 'R_3 B', are measured and the total distance between stations A and B is arrived by adding the intermediate distances.

RESULT:

The given line is aligned, measured and its length is found to be -------------------

Ex.No.2 DETERMINATION OF THE AREA OF A CLOSED TRAVERSE

AIM:

To find the area of the closed traverse using Cross staff method.

ACCESSORIES REQUIRED:

1. Chain or tape
2. Arrows
3. Ranging Rod
4. Cross Staff.

PROCEDURE:

1. First two ranging rods are aligned in a straight base line AB.
2. Three Ranging rods are fixed in between 'A' and 'B' such that they are used along survey line 'AB', 'R'$_1$, 'R'$_2$, 'R$_3$ are the position of three ranging rods
3. The ranging rods are aligned by sight such that they lie along the survey line 'AB'.
4. The given area is divided into triangle and trapezium.
5. The base length and the perpendicular offset distance of the triangles and trapezium are measured and noted.
6. The length are tabulated and the area of the closed traverse.

RESULT:

The area of the given closed traverse by using cross staff is ------------------------

Ex.No.3 PLOTTING A CLOSED TRAVERSE BY PRISMATIC COMPASS

AIM:

To Plot a given closed demarked on the ground to the sheet of paper using Prismatic Compass.

ACCESSORIES REQUIRED:

1. Prismatic compass
2. Magnetic tape
3. Tripod
4. Ranging Rods

PROCEDURE:

1. The length of AB, BC, CD, DE and EA are measured and recorded.
2. The prismatic compass is placed at point A and the bearing AE and AB are determined with respect to magnetic North.
3. By Shifting the compass to B the bearing of BA and BC is taken.
4. Similarly by Shifting the complex to C, D, and E the bearing CB, CD and DC,DE and ED, EA are taken and recorded.
5. The included angles at stations A,B,C,D and E are calculated by the following Formulas

   Included angle A =Back Bearing of AE- Fore bearing of AB

   B = Back Bearing of BA- Fore bearing of BC

   C = Back Bearing of CB- Fore bearing of CD

   D = Back Bearing of DC- Fore bearing of DE

E = Back Bearing of ED- Fore bearing of EA

6. The sum of the included angles are checked and verified as (2n-4) right angles if not the error is equally distributed.

RESULT:

Thus the closed traverse has been plotted by prismatic compass and checked as from the formula (2n-4) right angles.

TABULATION

Instrument at	**Sight to**	**Line**	**Bearing**

Ex.No.7 PLOTTING A CLOSED TRAVERSE BY RADIATION METHOD

AIM:

To plot a closed traverse using plane table by radiation method.

ACCESSORIES REQUIRED:

1. Plane table
2. Through Compass
3. Spirit Level
4. Plumb bob with plumbing level
5. Alidade
6. Ranging Rods
7. Tape

PROCEDURE:

1. Initially about five ranging rods fixed on the ground such that they make a rough closed figure. Place the table over the tripod and fix that approximately at the centre of the traverse.
2. Level the tube using Spirit level and mark the table orient that along the magnetic north. Fix the paper over the table and select any point on it. Fix the pin on the point over the ground using a plumbing fork and plumb bob.
3. Fix the eye vane and the point ‘O’ and (vice versa) view any of the rods and make that bisect between the rod and point ‘O’ on the ground.-

4. Choose any point approximate scale and hence mark the point ‘A’ on the paper care must be taken while choosing the reduction scale such that all the distance could be drawn within the limits of the paper
5. Similarly other points are potted on the paper. Jointing all these points we will get a closed traverse.

RESULT:

Thus a closed traverse has be obtained by the radiation method of plane table survey.

Ex.No.8 DETERMINATION OF DISTANCE BETWEEN THE TWO INACCESSIBLE POINTS BY INTERSECTION METHOD

AIM:

To determine distance between two inaccessible Points.

ACCESSORIES REQUIRED:

1. Plane table
2. Through Compass
3. Spirit Level
4. Plumb bob with plumbing level
5. Alidade
6. Tape

PROCEDURE:

1. Initially place two ranging rods such that they form a straight line AB.
2. Place the plane table over the tripod and fix it over the point ‘A’. Level the table and orient along the north. Place the alidade along point ‘A’ bisect ranging rods at ‘B’ and measure the distance ‘AB’.
3. Using the approximate scale mark them on the paper, now bisect the inaccessible points P and Q.
4. Then shift the plane table to the other point ‘B’ and level the table and orient using back sight method.
5. Now with alidade along ‘B’ draw and bisect the previously drawn lines by viewing P and Q.

6. The intersection points are joined. The distance between two inaccessible points P and Q is measured in plan and actual ground distance PQ is founded out.

RESULT:

The distance between two inaccessible points on the ground is found out & the lengths between the points are

Ex.No.13 STUDY OF DUMPY LEVEL

AIM:

To study a dumpy level

LEVELLING DEFINITION:

Levelling is a branch of surveying.

To find the elevation of points with respect to the assumed (or) given data.

To establish points at a given elevation (or) at a different elevation with respect to the given (or) assumed data.

LEVEL:

The main purpose of level is to provide a horizontal line of sight.

ESSENTIAL PARTS OF A LEVEL:

(i) Level tube with spirit level.
(ii) Telescope
(iii) Levelling Head
(iv) Tripod

TELESCOPE:

The telescope is to provide clear line of sight

LEVEL TUBE :

It is used to provide or make the line of sight horizontal.

LEVELLING HEAD:

It is used to bring the bubble at the centre.

TRIPOD:

It is used to support the instrument in the horizontal position.

TYPES OF LEVEL:

(i) Dumpy Level
(ii) wye Level
(iii) Reversible level

(iv) Tilting level

LEVELLING STAFF:

A leveling staff is a straight rectangular rod having graduations, the foot of staff representing zero readily. The purpose of level is to establish a horizontal line of sight. The purpose of levelling staff is to determine the amount by which the station is above (or) below the line of sight.

Levelling staff are divided into two classes.

→ Self Reading Staff

→ Target Levelling Staff

RESULT:

The dumpy level is studied in detail.

Ex.No.14 CHECK LEVELLING

AIM :

To run check leveling the given points, reduce and check their levels.

INSTRUMENTS REQUIRED:

1. Dumpy Level
2. Telescope Staff
3. Tripod

PROCEDURE:

1. The field procedure and reduction of Levels of points are same as for Fly leveling.
2. The instrument position marked (1) is selected such that it can be observe staff reading on the maximum number of points 1,2,3,…… The points are shown on plan in figure. And in elevation as marked 1,2,3 respectively in figure along with the bench mark marked BM.
3. The instrument is setup and leveled & up over the station point.
4. Observe the reading on the staff held at B.M. Let us express the reading in accordance with the convention a when "a" is the staff reading on the point for the position of the instrument.
5. If the R.L. of B.M. is"h" and a is the staff reading on the BM. The first staff reading which is termed as backsight or B.S. Then the height of instrument position(1) may be designated as

   H.1 (1) = h + a_1 BM

   (or) H.1 = R.L + B.S.

6. In a similar way a^1, and a^2 are althought obtained the reading of the staff at the point 3 may not be obtainable. Hence a^2, is the last staff reading from the instrument point (1). It is termed as

foresight or F.S. in between B.S. and F.S. Sight like a^1, are called intermediate sight or I.S. This forms the first stage in the series of setup.

7. Now the R.L. of point (1) = H.I. (1)-$a^1{}_1$

   Or R.L. of point (2) = H.I (1) – $a^2{}_1$

   Or R.L. = H.I.- I.S or F.S.

8. The instrument position has to be shifted to instrument position (2) to take observations on other as many point as possible.
9. To calculate H.I.(2) first of all. The staff reading $a^2{}_2$ should be obtained, because the R.L.of the point is already calculated.

   At point 2 $a^2{}_1$, is the F.S. for previous instrument position and $a^2{}_2$ is the b.s. for subsequent instrument position such as staff point is termed as change point or C.P.
10. The R.L. of line of collimation now is

    H.1(2) = R.L. of the point (2) +a^2

    This forms the second stage of instrument setups.
11. After obtaining $a_2{}^3$, $a_2{}^4$ etc. The R.L. of points can be computed as

    The R.L. of point (3) = H.I.(2) – $a_2{}^3$

    The R.L. of point (4) = H.I. (2) – $a_2{}^4$ etc……
12. This procedure may be continued to the completion of the leveling work.
13. For the entire data, the arithmetic check will be

    $\sum$B.S. Ω $\sum$F.S. = Last R.L. – First R.L.

RESULT:

The various points were by using check Levelling.

Ex.NO.14

TABULATION

Back Sight	Intermediate sight	Fore sight	Height of Instrument	Reduced Level	Remarks (B.M.)

TABULATION

Back Sight	Intermediate sight	Fore sight	Rise	Fall	Reduced Level	Remarks

Ex.No.15 **FLY LEVELLING**

AIM :

To determine the elevation of given points with reference to the bench mark.

INSTRUMENTS REQUIRED:

1. Dumpy Level

2 .Telescope Staff

3. Tripod

PROCEDURE:

- Set up the level on the tripod at a convenient height and bring the foot screws approximately to the middle of its rim.
- By temporary adjustments bring the bubble at centre openout typical leveling field book columns.
- Sight the given points and take the staff reading and note down the readings at the appropriate columns.
- If there are any points for away and is not clearly visible take. A change point and the leveling is continued.
- After finishing the leveling, calculate the elevations by the rise and fall method and apply necessary checks.

RESULT:

Thus the fly leveling is carried out and the relative elevations of the demarked points have been found out.

Ex.NO.16

TABULATION

Back Sight	**Intermediate sight**	**Fore sight**	**Height of Instrument**	**Reduced Level**	**Remarks (B.M.)**

PROFILE LEVELLING (Longitudinal Sectioning & Cross Sectioning)

AIM:

To determine the configuration of ground survey by conducting Longitudinal & Cross Sectional levelling.

INSTRUMENTS REQUIRED:

(i) Dumpy Level
(ii) Levelling Staff
(iii) Tripod
(iv) Chain (or) Tape.

PROCEDURE:

- Establish the bench mark near the starting point of the proposed profile by running check levels. Erection to ranging rods along the longitudinal section and cross section alignment. Fix intermediate points at less than the chain (or) tape length.
- Then pegmeric the points at equal intervals say 5m on the proposed alignment.
- Setup the leveling alignment instrument on the side of the alignment such that it will cover maximum.
- Take the backsight on the benchmark to determine the HS of Instrument.
- Hold the staff at equal interval points and determine the reduce levels of the points by heights of instrument method.

- If the any point is not visible clearly take the change points on turning points and complex the profile leveling with necessary checks.

RESULT:

The longitudinal sectioning & cross sectioning is carried out and the profile is plotted on Graph sheet.

Ex.No.17 STUDY OF THEODOLITE

Theodolite is an important instrument used for measuring horizontal and vertical angle in surveying.

TYPES OF THEODOLITE:

They are classified as following Transit (or) simple theodolite is one in which the line of sight can be reversed by revolving the telescope through 180 $^\circ$ interval plane on the horizontal axis.

Non – Transmit theodolite is one in which the telescope can not be transmitted.

Component Parts of Transit Theodolite :

LEVELLING HEAD:

It consists of two parallel plates separated by 3 (or) 4 levelling screws upper parallel plate is called tribrach and lower one is called trivet.

SHIFTING HEAD:

It is of two plates movable relative to each other when this device is loosened the whole instrument can be shifted horizontally with in a circle of about 10mm.

SPINDLE:

There are two spindles one inside the other. The inner spindle is conical solid and fits in the outer spindle.

LOWER PLATE (Or) SCALE PLATE:

It carried a graduated horizontal circular plate attached to the outer hollow spindle which is known as the scale point (or) main plate.

UPPER PLATE:

Upper plate is attached to the inner solid spindle. It is carried two vernier designated as vernier A and B as it two extremities diametrically opposite to each other at 180° apart with magnification to magnify the reading.

PLATE LEVEL:

A level tube mounted on the upper plate is called plate level. The bubble is centered with the help of leveling screws.

A-Frame (Standards) :

Trunion screw is supported on this frame. T-Frame (index frame) and the arm of this vertical circle clamp are also attached to A-Frame.

COMPASS:

It is attached with the A – Frame. It is used to find the horizontal angles and North Point.

TELESCOPE:

It is mounted on the horizontal spindle called horizontal axis (or) trunion axis.

VERTICAL CIRCLE:

It is also called 'C' and 'D' scale. It has four quadrant of
0° to 90° (or) graduated from 360°

VERNIER FRAME:

It is also called as T-Frame (or) index Frame. It consists of vertical leg called Clipping arm.

ALLITUDE BUBBLE:

It is a sensitive level tube attached to the top of the T – Frame.

TRIPOD:

It is a stand to support the theodolite. It may be in wood (or) aluminum.

PLUMBOB:

It is suspended from the hook fitted to the bottom of inner axis for centering. The instruments exactly over a section. In modex theodolite the plumb box is replaced by a plummet arrangement is built with theodolite.

OPTICAL PLUMMET:

It is a small telescope used to find the centering of instruments.

TECHNICAL TERMS:

CENTERING:

It is the process of making (or) setting up the theodolite exactly over the station mark.

LEVELLING:

It is the process of making vertical axis of an instrument truly vertical.

VERTICAL AXIS:

The imaginary line passing through the common central axis of the inner end and outer spindle. It is also called as azimuth axis.

HORIZONTAL AXIS:

It is an axis about which the telescope and the vertical circle can be rotated in a vertical plane. It is also called as traverse axis.

AXIS OF TELESCOPE:

It is an imaginary line joining the optical centre of object glass and the centre of the eye – piece.

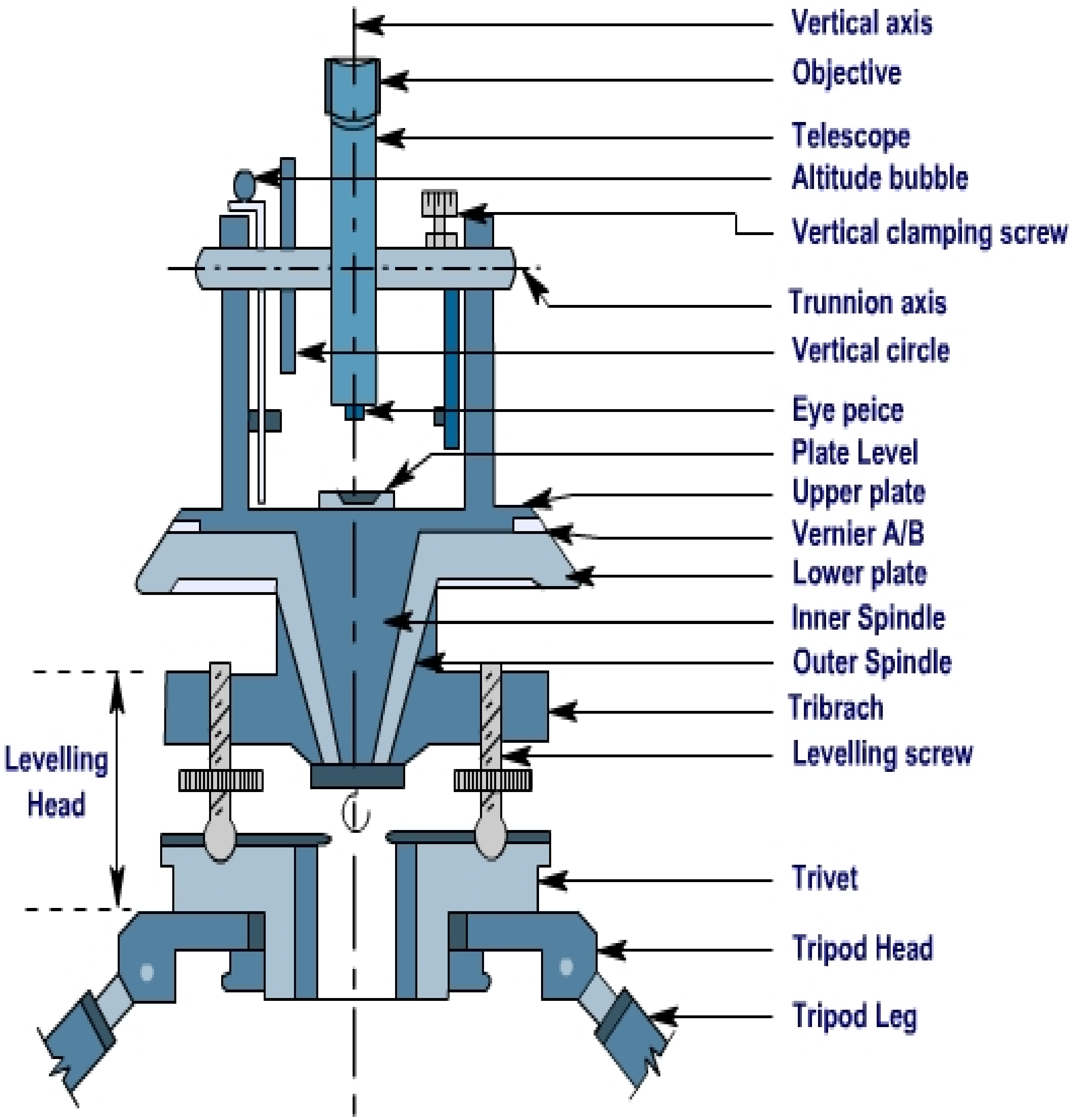


Figure 20.4 Sectional view of a Thedolite

AXIS OF PLATE LEVEL:

It is the straight line tangential to the longitudinal curve of the plate level tube at its centre.

TRANSITING:

It is the process of rotating the telescope axis over the horizontal axis through 180° in the vertical plane. It is also known as plunging (or) reversing.

FACE LEFT OBSERVATION:

It is the observation of horizontal (or) vertical angle when the vertical circle is to the left of the observer.

TELESCOPE NORMAL:

A telescope is said to be normal or direct when the vertical circle is the left and the bubble up in it is provided on the telescope.

TELESCOPE INVERTED:

A telescope is said to be inverted (or) reversed when the vertical circle is to the right and bubble down.

CHAINING FACE:

It is an operation of bringing the face of vertical circle from face left to face right or vice versa. This achieved by transiting the telescope and then swinging it.

V**ERNIER SCALE:**

Least count of veriner = s/n = value of the smallest main scale division / no. of division on veriner

RESULT:

Thus the study of theodolite is satisfactory.

Ex.No.18

TABULATION

Inst. at	Sight to	Face Left					Mean	Included angle	Remarks
		Vernier A			Vernier B				
		o	‘	“	‘	“			

Inst. at	Sight to	Face Right					Mean	Included angle	Remarks
		Vernier A			Vernier B				
		o	‘	“	‘	“			