SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)
Approved by AICTE, Affiliated to Anna University, Accredited by NBA,
'A 'Grade accreditation by NAAC, ISO 9001:2015 certified Institution
SRM NAGAR, KATTANKULATHUR – 603 203

DEPARTMENT OF CIVIL ENGINEERING

LAB MANUAL

Regulation : **2023**

Branch : **B.E. – Civil Engineering**

Year & Semester : **II Year / IV Semester**

CE 3466 - STRENGTH OF MATERIALS LABORATORY

Lab In-Charge

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Department of Civil Engineering

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INTRODUCTION

The Strength of Materials Laboratory is a vital component of engineering education and research, particularly in fields like mechanical, civil, and aerospace engineering. This laboratory focuses on the study of material behavior under various types of loads, including tension, compression, shear, bending, and torsion. Through practical experiments, students and researchers assess the mechanical properties of materials such as strength, elasticity, ductility, and hardness.

Equipped with devices like universal testing machines (UTM), hardness testers, impact testing machines, and torsion testing rigs, the lab enables a hands-on understanding of concepts like stress-strain relationships, material failure mechanisms, and structural integrity. This knowledge is essential for designing safe and efficient engineering systems and structures.

OBJECTIVES:

- To gain knowledge on the shear, compressive and tensile properties of materials.
- To understand gain knowledge on the impact and hardness properties of materials.
- To determine the deflection test on spring and steel beam.
- To understand about impact loading and testing.
- To study on various mix proportions and testing of concrete specimens.

LIST OF EXPERIMENTS

- TENSION TEST ON MILD STEEL
- DOUBLE SHEAR TEST
- TORSION TEST ON MILD STEEL BAR
- COMPRESSIVE TEST ON WOOD
- IMPACT TEST ON METAL SPECIMEN (Izod and Charpy)
- HARDNESS TEST ON METALS (Rockwell and Brinell Hardness Tests)
- DEFLECTION TEST ON METAL BEAM
- MAXWELL's RECIPROCAL THEOREM
- COMPRESSION TEST ON HELICAL SPRING
- MIX DESIGN AS PER IS STANDARDS
- TENSILE AND COMPRESSIVE STRENGTH TEST ON CONCRETE

LIST OF EXPERIMENTS

SI.No	CYCLE *(Tick)*	NAME OF THE EXPERIMENT
1.	I / II / III	Tension test on mild steel bar
2.	I / II / III	Double shear test
3.	I / II / III	Torsion test on mild steel rod
4.	I / II / III	Compression test on wood
5.	I / II / III	Impact strength (Izod) test
6.	I / II / III	Impact strength (Charpy) test
7.	I / II / III	Rockwell Hardness test
8.	I / II / III	Brinell Hardness test
9.	I / II / III	Deflection test on metal beam
10.	I / II / III	Maxwell’s reciprocal theorem
11.	I / II / III	Compression test on helical springs
12.	I / II / III	Mix Design as per IS Standards
13.	I / II / III	Compressive strength test on Concrete
14.	I / II / III	Tensile strength test on Concrete
15.		Demo Experiment
16.		Experiment beyond Syllabus

INDEX

EX.NO	DATE	NAME OF THE EXPERIMENT	PAGE NO	MARKS	STAFF SIGNATURE
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					

INSTRUCTIONS

1. Students should report to the labs concerned as per the timetable.
2. Students who **turn up late** to the labs will in **no case be permitted** to perform the experiment scheduled for the day.
3. Students need to **submit lab permission form** if they are **ABSENT** for the laboratory class.
4. After completion of the experiment, certification of the staff in-charge concerned in the observation book is must.
5. Students should bring a notebook of about 100 pages and should enter the readings/observations/results into the notebook while performing the experiment.
6. The record of observations (Record and Observation note) along with the detailed experimental procedure of the experiment performed in the immediate previous session should be submitted and certified by the staff member in-charge.
7. Not more than **4 students in a group** are permitted to perform the experiment on a set up.
8. The group-wise division made in the beginning should be adhered to, and no mix up of student among different groups will be permitted later.
9. The components required pertaining to the experiment should be collected from technical assisting staff after duly filling in the register maintained.
10. When the experiment is completed, students should return all the components/instruments taken for the purpose.
11. Any damage of the equipment or burnout of components will be viewed seriously either by putting **penalty** for individual or for total group.
12. Students should be present in the labs for the total scheduled duration.
13. Students are expected to prepare thoroughly well before the lab session to perform the experiment.
14. **DRESS CODE:**

    BOYS - Lab uniform with formal shoes (**Others shoes not allowed**)

    GIRLS - Formal Salwar Kameez with lab coat and formal shoes

    Without ID card, students will not be permitted to the laboratory

INTRODUCTION

Strength refers to the ability of a material or body to resist external forces applied to it. The strength of a material is its property that allows it to withstand these forces per unit of cross-sectional area. The greater the force a material can resist with respect to its cross-sectional area, the higher its strength.

External forces acting on a body are referred to as loads, and the design of structures and machines is based on these loads. Loads are measured in the same units as force and can be categorized into dead loads (constant, unchanging forces) and live loads (variable forces). The effect of these loads on a material may manifest as tensile, compressive, shearing, torsional, or bending stresses.

Stress is defined as the load per unit area and can be tensile, compressive, or shear depending on whether the material is being stretched, compressed, or sheared. Material strength can be analyzed through three main methods: strength, stiffness, and stability. Strain is the measure of deformation caused by an applied load. It is defined as the ratio of the change in a material's dimension to its original dimension.

Mechanical properties describe how a material behaves under external loads. Key properties include strength, elasticity, plasticity, ductility, brittleness, malleability, toughness, and hardness. A structural element that supports lateral or transverse forces is referred to as a beam.

For example, in grain boundary strengthening, the yield strength increases as grain size decreases, but excessively small grains can weaken the material. The strength of a material can be determined by dividing the load at the point of fracture or failure by the original C/S area.

EX.NO:

DATE:

TENSION TEST ON MILD STEEL BAR

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

PROCEDURE:

1. Measure the length (L) and diameter (d) of the specimen.
2. Mark the center of the specimen using dot punch.
3. Mark two points P and Q at a distance of 150mm on either side of the center mark so that the distance between P and Q 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 center mark so that that the distance between A,B will be equal to 5 times the rod diameter and is known as initial gauge length of rod.
5. Apply the load gradually and continue the application of load. After some times, there will be slightly pause in the increase of load .the load at this points is noted as yield point.
6. Apply load continually till the specimen fails and note down the ultimate load (p_a) and breaking load (p_b) from the digital indicator. Measure the diameter of the rod at neck (d_n)

FORMULA:

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

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

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

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

5. % Elongation in length = $\left(\frac{\text{Final gauge length } (I_f) - \text{Initial gauge length (Ii)}}{\text{Initial gauge length (Ii)}}\right)$

6. % Reduction in area = $\left(\frac{\text{Initial area (Ai)} - \text{Neck area } (A_n)}{\text{Initial area (Ai)}}\right)$

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

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

$$\text{Stress} = \sigma = \frac{Load}{Area} = \frac{P}{A} \ldots\ldots\ldots\ldots\ldots\ldots\ldots \frac{N}{mm^2}$$

$$\text{Strain} = \epsilon = \frac{change\ in\ length}{original\ length} = \ldots\ldots\ldots\ldots$$

$$\text{Young's modulus} = E = \frac{strss}{strain} \ldots\ldots\ldots\ldots \frac{N}{mm^2}$$

OBSREVATION:

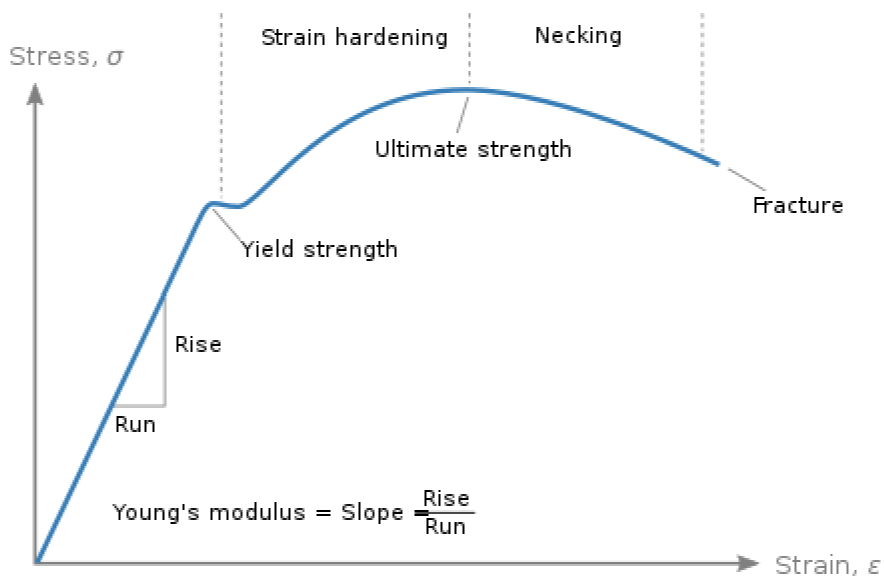
1. Material of the specimen = ________________
2. Length of specimen , L =_______________mm
3. Diameter of the specimen ,d =_______________mm
4. Initial gauge length of the specimen, L_I =_______________mm
5. Final gauge length of specimen, l_F =_______________mm
6. Diameter at neck, d_n =_______________mm
7. Yield point, Py =_______________kN
8. Ultimate load ,p_u =_______________kN
9. Breaking load, p_b =_______________kN

CALCULATION:

TABULATION:

S.I	Load (N)	Dial gauge reading		Elongation (mm)	Stress (N/mm^2)	Strain	Young's Modulus (N/mm^2)
		Initial	Final				
Sym							

GRAPH:



RESULT:

1. Yield stress = _______________ ***N/mm²***
2. Ultimate stress = _______________ ***N/mm²***
3. Nominal breaking stress = _______________ ***N/mm²***
4. Actual breaking stress = _______________ ***N/mm²***
5. Percentage elongation in length = _______________ ***%***
6. Percentage reduction in area = _______________ ***%***

EX.NO:

DATE:

DOUBLE SHEAR TEST ON STEEL BAR

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. Vernier caliper /screw gauge

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 ofthe 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 the down the load the specimen fails (p).
6. Calculate the maximum shear strength of the given specimen by using .

FORMULA:

$$\text{Maximum shear strength} = \frac{\overline{P}}{2\ xA}$$

P= load at failure, N

A= cross-sectional area of bar, mm^2

Calculation of the diameter (Mild Steel) :

Least Count of Vernier Calipers =

S.No.	M.S.D.	V.S.D.	M.S.D. + (V.S.D. x L.C.)
1			
2			
3			

Average = mm

OBSERVATION: (D0UBLE SHEAR TEST)

1. Material of the specimen =____________________
2. Diameter of the specimen (d) =__________________*mm*
3. Cross sectional area (A) = _________________mm^2
4. Load at failure (p) =___________________kN

1. Material of the specimen =____________________
2. Diameter of the specimen (d) =__________________*mm*
3. Cross sectional area (A) = _________________mm^2
4. Load at failure (p) =___________________kN

RESULT:

The maximum shear strength of the given specimen

Specimen 1 = _______________ ***N/mm²***

Specimen 2 = ______________ ***N/mm²***

EX.NO:

DATE:

TORSION TEST ON MILD STEEL BAR

AIM:

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

APPARATUS REQUIRED:

1. Torsion testing machine.
2. Venire caliper
3. Steel rule
4. Specimen

PROCEDURE:

1. Before testing, adjust the measuring range according to the capacity of the test piece.
2. Hold the test specimen driving chuck with the help of handles.
3. Adjust the angle measuring dial at zero position, block pointer at the starting position and pen its required position.
4. Bring the red dummy pointer in the line with black pointer.
5. Start the machine and now the specimen will be subjected to torsion.
6. Take the value of the torque from the indicating dial for particular value of angle of twist.
7. Repeat the experiment until the specimen breaks into two pieces. Note the value of torque at this breaking point.
8. Tabulate the reading 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: (TORSION TEST ON MILD STEEL)

1. RECORD THE FOLLOWING:

- Initial diameter of specimen =____________ *mm*
- Length of the specimen =____________ *mm*

SI.NO	Angle of twist ***degrees***	Angle of twist in radian ***θ (π/180)***	Torque ***N-mm***

TABULATION:

SI.NO	Radius of the Specimen ***mm***	Torque ***N-mm***	Angle of twist (θ) ***radian***	Shear stress ***N/mm^2***	Modulus of rigidity of material ***N/mm^2***	Strain energy ***N/mm***

FORMULA:

The general torsion theory for circular specimen:

$$\frac{T}{J} = \frac{\tau}{r} = \frac{G \times \theta}{L}$$

Where,

T =applied torque, (Nm)

J=Polar second moment of area, (mm^2)

G= modulus of rigidity, (N/mm^2)

θ=angle of twist, (radians)

L= gauge length,(mm)

CALCULATION:

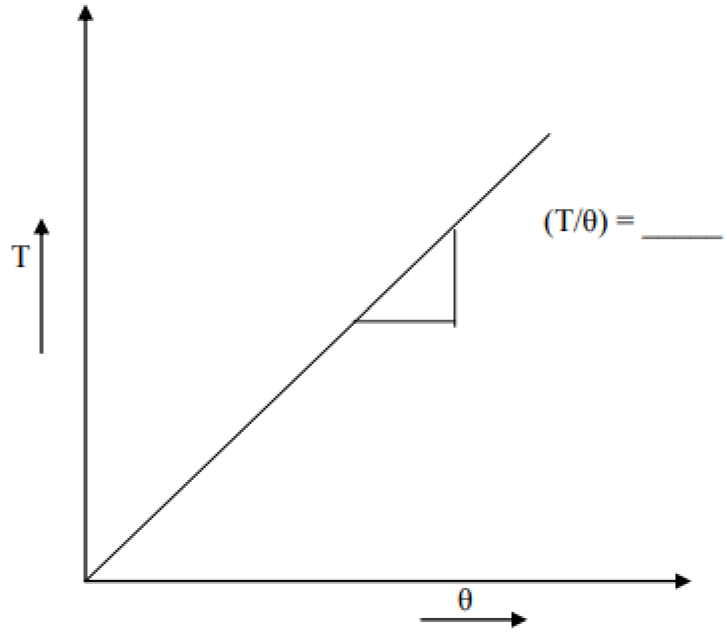
i. Polar Moment of Inertia (J) $= (\pi/32) \times d^4$

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

iv. Strain Energy, (U) = [τ^2 / 4G] x Volume N.mm

GRAPH:



RESULT:

1. Shear stress = _____________ ***N/mm²***
2. Modulus of rigidity = _____________ ***N/mm²***
3. Strain energy = _____________ ***N/mm***
4. Ultimate shear stress = _____________ ***N/mm²***

EX.NO:

DATE:

COMPRESSIVE STRENGTH ON WOOD

AIM:

To perform compression test of wood and determine compressive strength using UTM.

APPARATUS:

A UTM or A compression testing machine ,cylindrical or cube shaped specimen of cast iron, aluminum or mild steel ,vernier caliper, liner scale , dial gauge .

PROCEDURE:

1. Dimension of test piece is measured at three different places along its height/length to determine the average cross sectional area.
2. Ends of the specimen should be plane for that the ends are tested on a bearing plate
3. The specimen is placed centrally between the two compression plate such that the centre of moving head is vertically above the centre of specimen.
4. Load is applied on the specimen by moving the movable head.
5. The load and corresponding contraction are measured at different intervals. The load interval may be as 500kg.
6. Load is applied until the specimen fails.

OBSERVATION :(compression test on wood)

Initial length/height of specimen, L/h =______mm
Initial depth of specimen, d =_______mm
Initial width of specimen, w =_______mm

S.I NO	Breaking Load (N)	Area of Specimen (A) mm^2	Recorded change in length mm	Compressive Strength

CALCULATION:

- Original cross section area A_o = ____________ ***mm^2***
- Final cross section area A_f = ____________ ***mm^2***
- Stress = ____________ ***N/mm^2***
- Strain =______________

RESULT:

The compressive strength of given specimen =_________________ ***N/mm^2***

EX.NO:

DATE:

IZOD IMPACT TEST

AIM:

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

APPARATUS AND SPECIMEN REQUIRED:

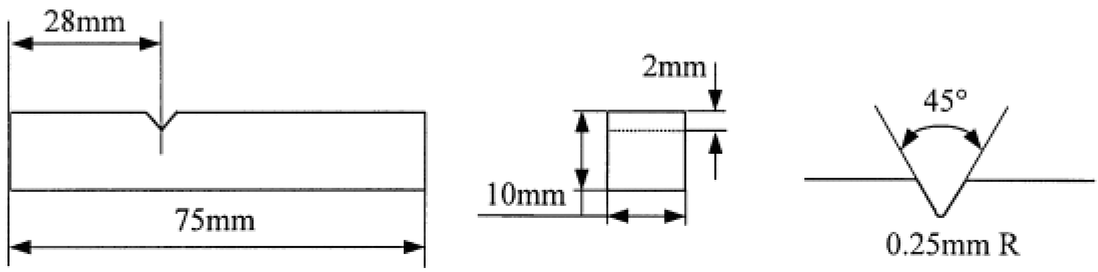
1. Impact testing machine with attachment for IZOD test.
2. Specimen
3. Vernier caliper
4. Scale

PROCEDURE:

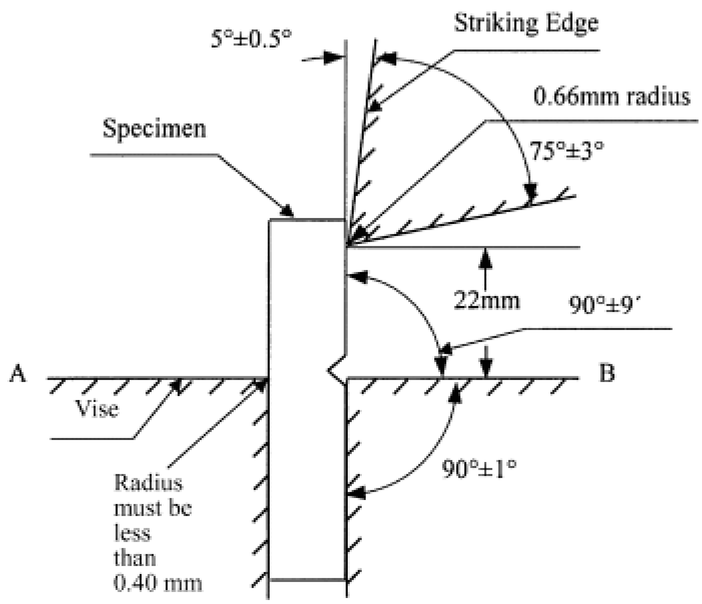
1. Measure the length (l), breath (b), depth (d) of the given specimen.
2. Measure the position of notch from the end, depth of groove, and top width of groove in the given specimen.
3. Lift the pendulum and keep it in the position meant for IZOD test.
4. Adjust the pointer to coincide with initial position in the IZOD scale.
5. Release the pendulum using the lever and note down the initial reading in the IZOD scale.
6. Place the specimen vertically upwards such that the shorter distance between one ends of the specimen and groove will be protruding length and also the groove in the specimen should face the striking end of the hammer.
7. Release the pendulum again using the and note down the final reading in the izod scale
8. Find the impact strength of the given specimen by using the following relation;

Energy Observed = (final izod scale reading – initial izod scale reading)

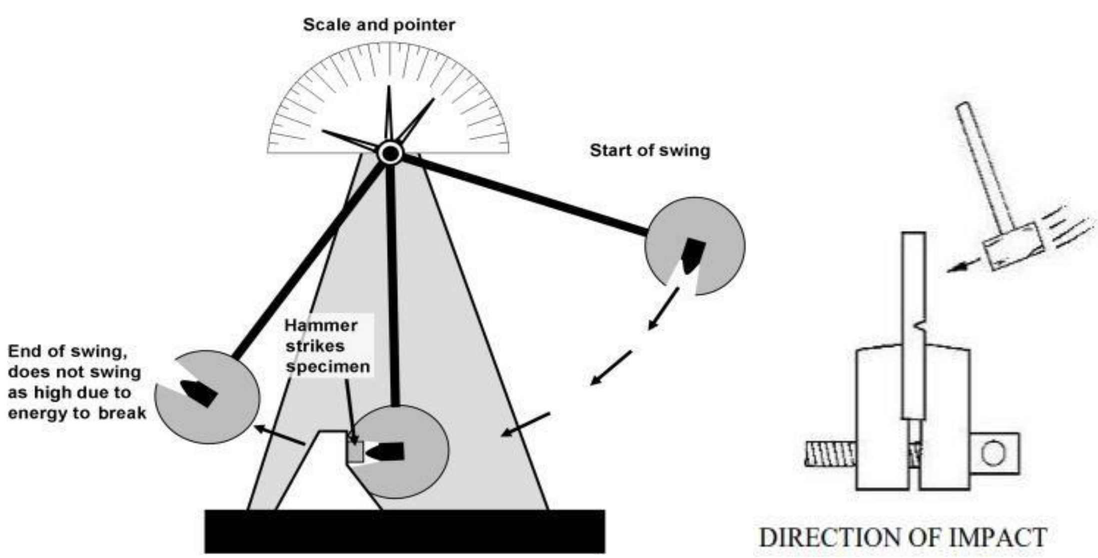
DIAGRAM:



(a) test specimen



(b) specimen-holding fixture



SPECIFICATION OF M/C AND SPECIMEN DETAILS :

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

• Least count of capacity (dial) scale = 2 joule

• Weight of striking hammer = 20.59 kg.

• Effective length of pendulum = 0.815 m

• Angle of hammer before striking = 90°

• Impact capacity = 164.6 joule (20.59 x 9.81 x 0.815 x (1- Cos 90°) = 164.6 J)

• Swing diameter of hammer = 1600 mm.

• Distance between supports = 40mm.

• Striking velocity of hammer = 5.6m/sec.

• Izod specimen made out of 10 mm square has V-notch of 2mm depth with included angle of 45° at the section where it is required to fracture by impact.

OBSERVATION :(IZOD IMPACT TEST)

1. Material of the given specimen =____________
2. Type of notch =____________
3. Length of the specimen ,L =___________mm
4. Breath of the specimen , b =___________mm
5. Depth of the specimen ,d =__________mm
6. Position of groove from one end, =__________mm
7. Depth of groove =__________mm
8. Width of groove =__________mm

$$\text{Impact Strength} = \frac{\text{Energy Absorbed (J)}}{\text{Cross-sectional Area (mm}^2\text{)}}$$

CALCULATION:

RESULT:

The strain energy in the test specimen is =_______________ ***J***

The impact strength of the given specimen is = _______________***J/mm²***

EX.NO:

DATE:

CHARPY IMPACT TEST

AIM:

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

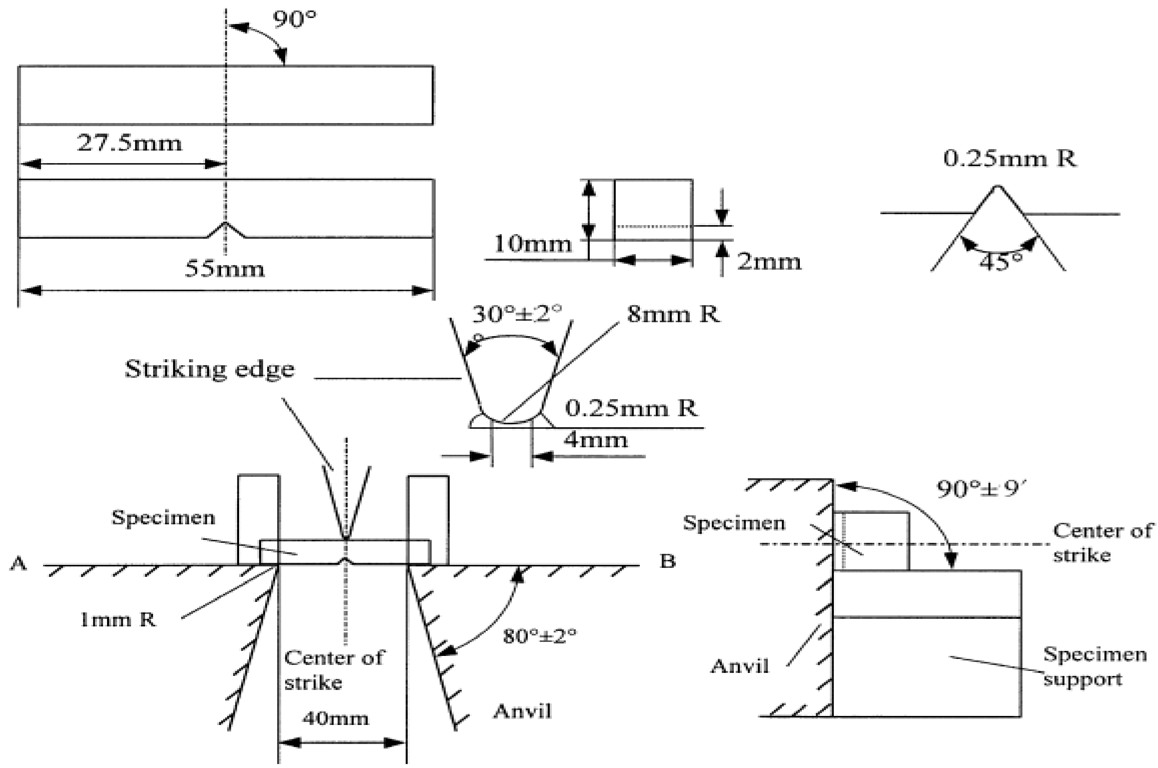
APPARATUS AND SPECIMEN REQUIRED:

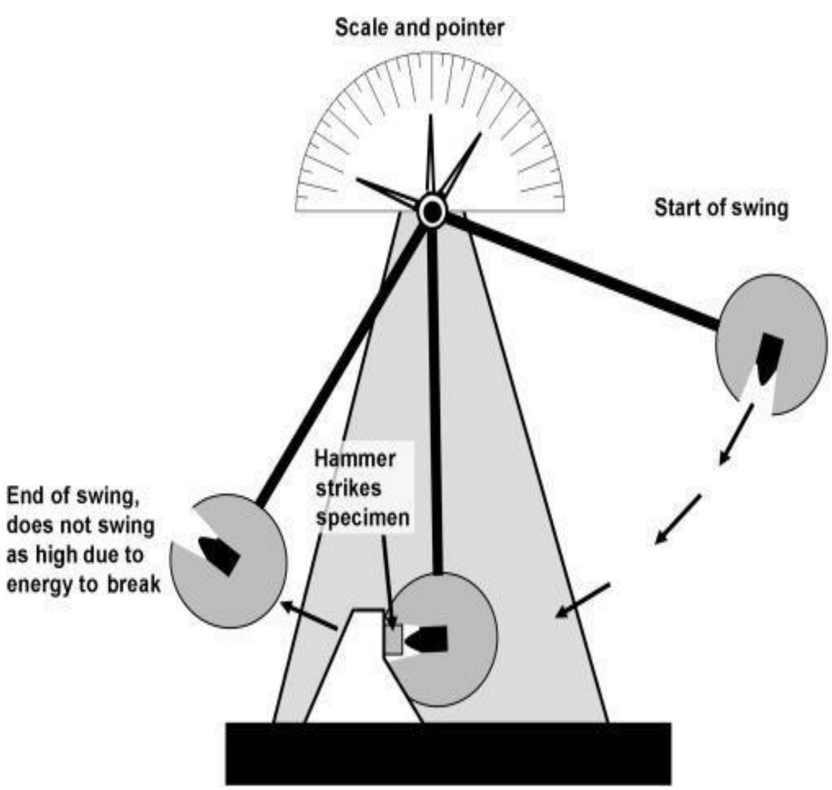
1. Impact testing machine with attachment for charpy test.
2. Specimen
3. Vernier caliper
4. Scale

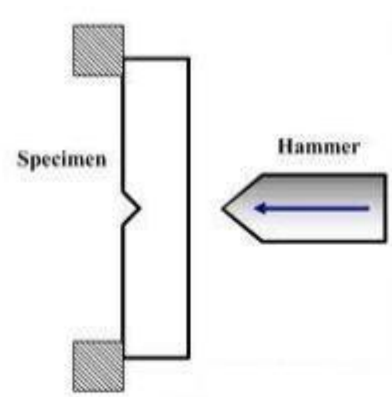
PROCEDURE:

1. Measure the length (l), breath (b), depth (d) of the given specimen.
2. Measure the position of notch from the end, depth of groove, and top width of groove 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 in the charpy scale.
5. Release the pendulum using the lever and note down the initial reading in the charpy scale.
6. Place the specimen vertically upwards such that the shorter distance between one ends of the specimen and groove will be protruding length and also the groove in the specimen should face the striking end of the hammer.
7. Release the pendulum again using the and note down the final reading in the charpy scale.
8. Find the impact strength of the given specimen by using the following relation;

DIAGRAM:







DIRECTION OF IMPACT

SPECIFICATION OF M/C AND SPECIMEN DETAILS:

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

• Least count of capacity (dial) scale = 2 joule

• Weight of striking hammer = 20.59 kg.

• Effective length of pendulum = 0.815 m

• Angle of hammer before striking = 140°

• Impact capacity = 307.6 joule (21.79 x 9.81 x 0.815 x (1- Cos 140°) = 307.6 J)

• Swing diameter of hammer = 1600 mm.

• Distance between supports = 40mm.

• Striking velocity of hammer = 5.6m/sec.

• Specimen for charpy is made out of 10 mm square rod having V -notch of 2mm depth with included angle of 45° at the section where it is required to fracture by impact.

OBSERVATION: (CHARPY IMPACT TEST)

1. Material of the given specimen =________________
2. Type of notch =________________
3. Length of the specimen ,L =_____________mm
4. Breath of the specimen , b =_____________mm
5. Depth of the specimen ,d =_____________mm
6. Position of groove from one end, =_____________mm
7. Depth of groove =_____________mm
8. Width of groove =_____________mm

$$\text{Impact Strength} = \frac{\text{Energy Absorbed (J)}}{\text{Cross-sectional Area } (\text{mm}^2)}$$

CALCULATION:

RESULT:

The strain energy in the test specimen is = _______________ ***J***

The impact strength of the given specimen is = _______________***J/mm²***

EX.NO:

DATE:

ROCKWELL HARDNESS TEST

AIM:

To study the Rockwell hardness testing machine and perform the Rockwell.

APPARATUS:

1. Rockwell hardness test
2. Diamond cone intender (Apex angle 120^0)
3. Ball indender (Diameter : $1/16^{th}$ of an inch)
4. Hard steel/ Brass/ Aluminium/ Copper Specimen

PROCEDURE:

1. Clean the test piece and place on the special of machine.
2. Make the specimen surface by removing dust, dirt, oil and grease etc.
3. Make the contact between the specimen surface and the ball by rotating the jack adjusting wheel.
4. Push the required button for loading.
5. Pull the load release lever wait for minimum 15second. The load will automatically apply gradually.
6. Remove the specimen from support table and locate the indentation so made.

Scale	Indenter Type	Load Applied (kgf)	Application/Material
C	Diamond Cone (120° cone angle)	150	Hard materials such as steel and cast iron.
B	Steel Ball (1/16 inch diameter)	100	Soft metals like brass, aluminum, and copper alloys.

TABULATION: (ROCKWELL HARDNESS TEST)

SI. NO	Specimen	Specimen scale	Load (Kgf)	Intender Type & dial	Dial reading *mm*			Average (HR)
					T1	T2	T3	

RESULT:

Rockwell hardness number

Specimen 1 =______

Specimen 2 =______

Specimen 3 =______

Specimen 4 =______

EX.NO:

DATE:

BRINELL HARDNESS TEST

AIM:

To study the Brinell hardness testing machine and the given specimen

APPARATUS:

1. Brinell hardness testing machine
2. Steel/ Brass/ Aluminium/Copper Specimen
3. Ball indenter
4. Microscope
5. Vernier Caliper & Emery Paper

SPECIFICATION:

- ❖ Ability to determine hardness up to 500 BHN
- ❖ Diameter of ball d= 2.5mm, 5mm, 10mm.
- ❖ Maximum application of load=3000kgf
- ❖ Method of load application=Lever type
- ❖ Capacity of testing the lower hardness range=1 BHN on application of $0.5D^2$ load.

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

3. Calculate the major load to be applied for the given test specimen by knowing the value of P/D^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.
7. Now the specimen is subjected to a minor load of 10kg.
8. Apply the major load to the specimen by pushing the loading (3000 kgf: Hard materials, 1000 kgf: Medium-hard materials, 500 kgf: Soft or thin materials.) handle in the forward direction and allow the load to act on the specimen for 15 seconds.
9. Release the major load by pushing the loading handle in the backward direction.
10. Release the minor load of 10kg by rotating the hand wheel and lowering the screw bar.
11. Measure the diameter of indentation (d) using the microscope.
12. Push the required button for loading
13. Pull the load release lever wait for minimum 30second. The load will automatically apply gradually.
14. Remove the specimen from support table and locate the indentation so made.
15. Calculate the Brinell hardness number for the given specimen using the following

Formula.

FORMULA:

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

$$HB = \frac{2P}{\pi D\left(D - \sqrt{D^2 - d^2}\right)}$$

Where,

P-load applied on the indenter, Kgf

D-Diameter of steel ball indenter, mm.

d- Diameter of ball impression, mm

TABULATION:

Specimen material	P/D2 value in **kg/mm²**	Diameter of ball intender ***mm***	Load (P) ***Kgf***	Diameter of ball impression			Average Diameter ***mm***	Brinell hardness number **HB (no unit)**
				d_1 ***mm***	d_2 ***mm***	d_3 ***mm***		

CALCULATION

RESULT:

Brinell hardness number of given material

Specimen 1 =______

Specimen 2 =______

Specimen 3 =______

Specimen 4 =______

EX.NO:

DATE:

DEFLECTION TEST ON BEAM

AIM:

To determine young's modulus of elasticity of material of beam simply supported at ends.

APPARATUS;

1. Deflection of beam apparatus.
2. Pan
3. Weights
4. Beam of different cross section and material(steel beam)

PROCEDURE:

1. Adjust cast iron block the bed so that they are symmetrical with respect to the length of thebed.
2. Place the beam on the knife edges on the block so as to project equally beyond each knifeedge. See that the load is applied at the centre of the beam.
3. Note the initial reading of venire scale.
4. Add a weight of 20 N and again note the reading of venire scale.
5. Find the deflection in each case by subtracting the initial reading of venires caliper

FORMULA:

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

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

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

OBSERVATION: (DEFLECTION TEST ON BEAM)

1. Material of the specimen =____________
2. Length of the specimen =___________mm
3. Breath of the specimen =___________mm
4. Depth of the specimen =___________mm
5. Span of the specimen =___________mm
6. Dial gauge least count =___________mm

TABULATION:

Sl.No	Load (P)		Deflection (δ)	Bending moment (M)	Bending stress (σ_b)	Young's modulus (E)	Stiffness
	Kg	***N***	***mm***	***N-mm***	***N/mm²***	***N/mm²***	***N/mm***

RESULT:

The young's modulus for steel beam is found to be =_________________ ***N/mm²***

The Stiffness for steel beam is found to be =_________________________***N/mm***

EX.NO:

DATE:

MAXWELL'S RECIPROCAL THEOREM

AIM:

To verify clerk Maxwell's reciprocal theorem

APPARATUS :

Clerk Maxwell's Reciprocal Theorem apparatus, Weight's, Hanger, Dial Gauge, ScaleVerniar caliper.

THEORY:

Maxwell theorem in its simplest form states that deflection of any point A of any elastic structure due to load P at any point B is same as the deflection of beam due to same load applied at A. It is, therefore easily derived that the deflection curve for a point in a structure is the same as the deflected curve of the structure when unit load is applied at the point for which the influence curve was obtained.

PROCEDURE:

1. Set up the beam on two supports ensuring it is securely fixed and level.
2. Apply a known load (P) at a specific point (Point A) on the beam.
3. Measure the deflection at another point (Point B) using a deflection dial gauge or displacement transducer.
4. Record the deflection at Point B caused by the load applied at Point A.
5. Move the load (P) to the second point (Point B) and apply it.
6. Measure the deflection at Point A caused by the load applied at Point B.
7. Calculate or measure the reaction forces at both supports (R_1 and R_2).
8. Using theoretical formulas, calculate the deflection at Point A due to a load at Point B and the deflection at Point B due to a load at Point A based on Maxwell's Reciprocal Theorem.
9. Compare the measured deflections with the theoretical deflections.
10. If the experimental deflections closely match the theoretical ones, Maxwell's Reciprocal Theorem is verified.
11. Repeat the experiment with different loads and positions to confirm the consistency of the theorem.

OBSERVATION: (DEFLECTION TEST ON BEAM)

1. Material of the specimen =____________
2. Length of the specimen =___________mm
3. Breath of the specimen =___________mm
4. Depth of the specimen =___________mm
5. Span of the specimen =___________mm
6. Dial gauge least count =___________mm

TABULATION:

S. No.	Load Applied (P)	Location of Load (m)	Deflection at Point A (δ_1) (mm)	Deflection at Point B (δ_2) (mm)	Reaction at Point A (R_1) (kN)	Reaction at Point B (R_2) (kN)	Theoretical Deflection at A due to Load at B (δ_1') (mm)	Theoretical Deflection at B due to Load at A (δ_2') (mm)	Maxwell's Reciprocal Theorem Verification

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

EX.NO:

DATE:

COMPRESSION TEST ON SPRING

AIM:

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

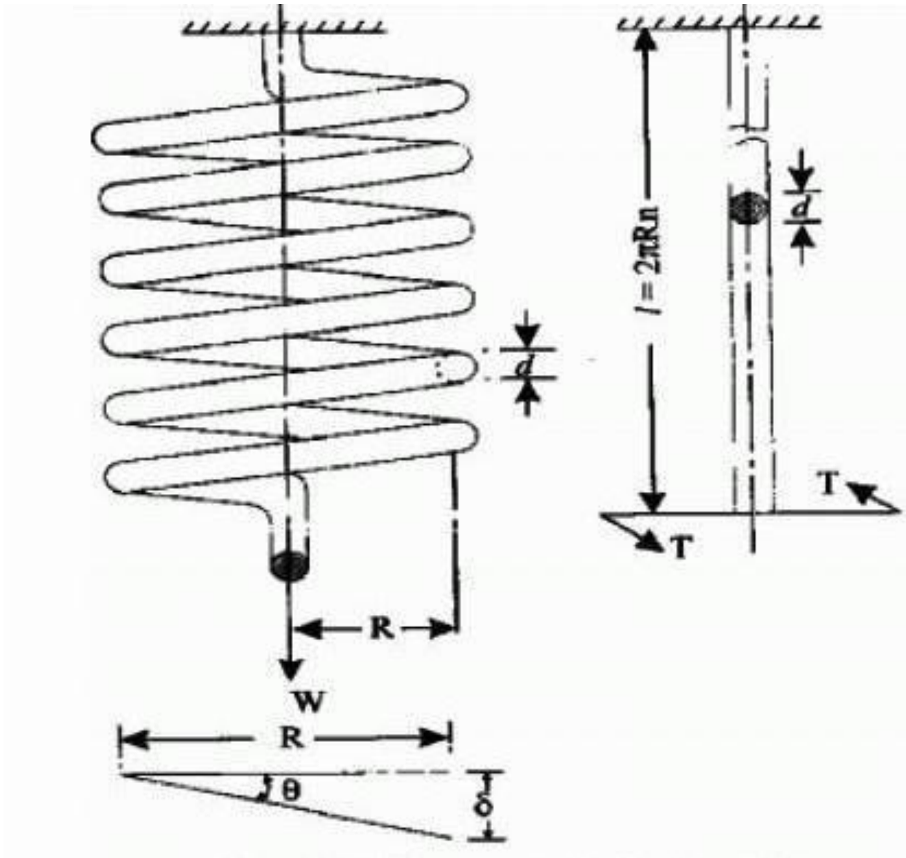
APPARATUS:

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

PROCEDURE:

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

DIAGRAM



OBSERVATION: (COMPRESSION TEST ON SPRING)

Material of the springs specimen	=			
Outer diameter of the springs, D	=	mm		
Diameter of the springs coil, d	=	mm		
Number of coils/turns	=	nos.		
Initial scale reading	=	cm	=	mm

FORMULAE USED:

1. ***Close coil Helical Spring***

$$\delta = \frac{64WR^3n}{Nd^4}$$

2. ***Open coil Helical Spring***

$$\delta = \frac{64WR^3n\sec\alpha}{d^4}\left[\frac{\cos^2\alpha}{N} + \frac{2Sin^2\alpha}{E}\right]$$

3. ***Stiffness, k=*** $\frac{p}{\delta}$

Where,

W or P = load in, N

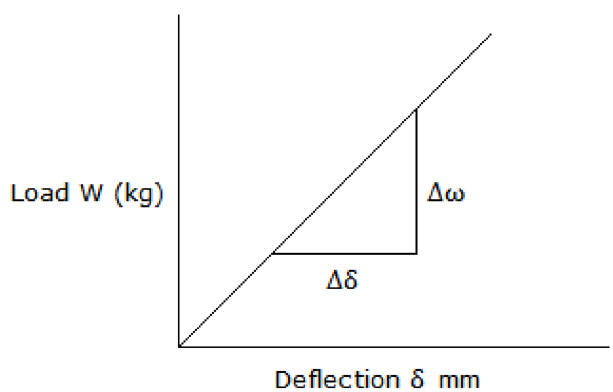
R=mean radius of the spring, mm (D-d/2)

d= diameter of the spring coil, mm

δ=deflection of the spring, mm

D=outer diameter of the springs, mm

GRAPH:



Load - Deflection Graph

TABULATION:

Sl.No	Applied load		Scale reading		Actual deflection	Modulus of elasticity	Stiffness
	Kg	***N***	***cm***	***mm***	***mm***	***N/mm²***	***N/mm***

RESULT:

1. The modulus of rigidity of the given spring =________________ ***N/mm²***
2. The Stiffness of the given spring

Experimental =____________ ***N/mm***

Graphically =____________ ***N/mm***

EX.NO:

DATE:

COMPRESSIVE STRENGTH OF CONCRETE

AIM:

To determine compressive strength of concrete.

APPARATUS:

1. Moulds for the test cubes,
2. Tamping rods
3. Curing tank
4. Scale
5. IS 456 – 2000 & IS 10262: 2009

PROCEDURE:

1. Calculate the material required for preparing the concrete of given proportions.
2. Mix them thoroughly in a mechanical mixer until a uniform color of concrete is obtained.
3. Pour concrete into oiled cube molds with medium viscosity oil. Fill the molds in two layers, each approximately 75 mm deep, and ram each layer with 35 evenly distributed blows.
4. Fill the molds in 2 layers, each approximately 50 mm deep, and ram each layer heavily.
5. Strike off the concrete flush with the top of the molds. Immediately after casting, cover the molds with wet mats.
6. Remove the specimens from the molds after 24 hours and cure in water for 28 days.
7. After 24 hours of casting, cap the specimens with neat cement paste (35% water content) using the capping apparatus. After 24 hours, immerse the specimens in water for final curing.
8. Perform compression tests on the specimens as soon as possible after removal from the curing pit. Keep the specimens moist with a wet blanket until testing.

9. Place the specimen centrally on the compression testing machine and apply the load continuously, uniformly, and without shock.
10. Observe and record the type of failure and appearance of cracks.

FORMULAE USED:

$$\sigma = \frac{Load}{Area} = \frac{P}{A} \ldots\ldots\ldots\ldots\ldots\ldots \frac{N}{mm^2}$$

P = Maximum load applied (N)

A = Area of the specimen (mm^2)

TABULATION:

Date of Casting:

Date of testing:

S. No.	Concrete Mix	Specimen Type	Dimensions of Specimen (mm)	First Crack Load (kN)	Ultimate Load (kN)	Compressive Strength (MPa)	Remarks

RESULT:

1. The average compressive strength of concrete sample is ………… (N/mm^2) at 3 days
2. The average compressive strength of concrete sample is ………… (N/mm^2) at 7 days
3. The average compressive strength of concrete sample is ………… (N/mm^2) at 28 days

EX.NO:

DATE:

SPLIT TENSILE STRENGTH OF CONCRETE

AIM:

To determine compressive strength of concrete.

APPARATUS:

1. Moulds for the test cubes,
2. Tamping rods
3. Curing tank
4. Scale
5. IS 456 – 2000 & IS 10262: 2009

PROCEDURE:

1. Calculate the material required for preparing the concrete of given proportions.
2. Mix the materials thoroughly in a mechanical mixer until a uniform color of concrete is obtained.
3. Pour the concrete into oiled cylinder molds with medium viscosity oil. Fill the molds in two layers, each approximately 50 mm deep, and ram each layer with 35 evenly distributed blows.
4. Strike off the concrete level with the top of the molds using a straightedge.
5. Immediately after casting, cover the molds with wet mats to prevent moisture loss.
6. Remove the specimens from the molds after 24 hours and cure them in water for 28 days.
7. After curing, carefully remove the specimens from the water and allow them to dry to remove excess surface water.
8. Place the specimens centrally on the testing machine with the cylindrical axis vertical.
9. Apply the load continuously and uniformly along the length of the specimen without shock.

10. Record the maximum load at which the specimen fails.
11. Note the type of failure, including any visible cracks or splits along the cylinder's length.
12. Calculate the split tensile strength using the formula

FORMULAE USED:

$$\text{Tensile Strength (MPa)} = \frac{2P}{\pi LD}$$

P = Maximum load applied (N)

L = Length of the cylinder (mm)

D = Diameter of the cylinder (mm)

TABULATION:

Date of Casting:

Date of testing:

S. No.	Concrete Mix	Dimensions of Specimen (mm)	First Crack Load (kN)	Ultimate Load (kN)	Tensile Strength (MPa)	Remarks

RESULT:

1. The average tensile strength of concrete sample is ………… (N/mm^2) at 3 days
2. The average tensile strength of concrete sample is ………… (N/mm^2) at 7 days
3. The average tensile strength of concrete sample is ………… (N/mm^2) at 28 days

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	Temp	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^2)
1	Mild steel-unhardened			
2	Quenched			

Result:

Thus the hardening – heat treatment process is carried out.

EX.NO:

DATE:

FLEXURAL STRENGTH OF A BEAM

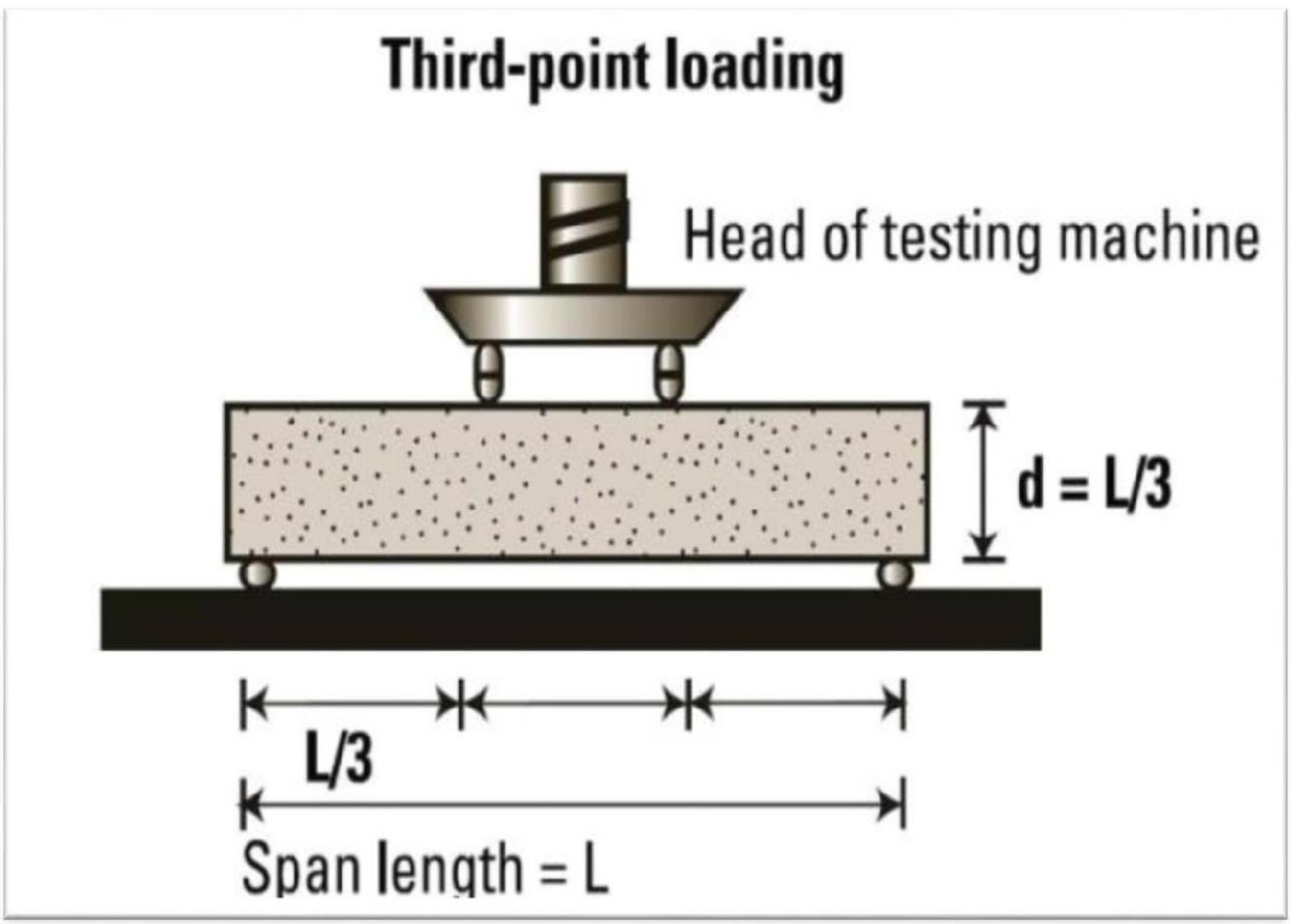
AIM:

To determine the Flexural Strength of Concrete beam

APPARATUS :

UTM, Beam mould of size 15 x 15x 70 cm (when size of aggregate is less than 38 mm) or of size 10 x 10 x 50 cm (when size of aggregate is less than 19 mm)

DIAGRAM:



PROCEDURE

1. Prepare the test specimen by filling the concrete into the mould in 3 layers of approximately equal thickness. Tamp each layer 35 times using the tamping bar as specified above. Tamping should be distributed uniformly over the entire cross section of the beam mould and throughout the depth of each layer.

2. Clean the bearing surfaces of the supporting and loading rollers, and remove any loose sand or other material from the surfaces of the specimen where they are to make contact with the rollers.

3. Circular rollers manufactured out of steel having cross section with diameter 38 mm will be used for providing support and loading points to the specimens. The length of the rollers shall be at least 10 mm more than the width of the test specimen. A total of four rollers shall be used, three out of which shall be capable of rotating along their own axes. The distance between the outer rollers (i.e. span) shall be **3d** and the distance between the inner rollers shall be **d**. The inner rollers shall be equally spaced between the outer rollers, such that the entire system is systematic.

4. The specimen stored in water shall be tested immediately on removal from water; whilst they are still wet. The test specimen shall be placed in the machine correctly centered with the longitudinal axis of the specimen at right angles to the rollers. For moulded specimens, the mould filling direction shall be normal to the direction of loading. The load shall be applied at a rate of loading of 400 kg/min for the 15.0 cm specimens and at a rate of 180 kg/min for the 10.0 cm specimens.

CALCULATION:

The Flexural Strength or modulus of rupture (f_b) is given by

$f_b = PL/bd^2$ (when **a** > 20.0cm for 15.0cm specimen or > 13.0cm for 10cm specimen)

or

$f_b = 3Pa/bd^2$ (when **a** < 20.0cm but > 17.0 for 15.0cm specimen or < 13.3 cm but > 11.0cm for 10.0cm specimen.)

Where,

a = the distance between the line of fracture and the nearer support, measured on the center line of the tensile side of the specimen
b = width of specimen (cm)
d = failure point depth (cm)
l = supported length (cm)
p = max. Load (kg)

RESULT:

The Flexural Strength or modulus of rupture (f_b) is ________________N/mm^2.

VIVA QUESTIONS

- Modulus of Elasticity for Mild Steel, Copper, Aluminum, Cost Iron etc.
- Examples for Ductile Materials
- Examples for Brittle Materials
- Examples for Malleable Materials .
- Failure of Ductile Material under Tension
- Failure of Brittle Material under Tension.
- Applications of Rockwell Hardness A – Scale, B-Scale, C-Scale.
- Type of Indentor used in the Three Different Scales of Rockwell Hardness Test.
- Different Types of Hardness Testing Methods.
- Size of the Ball to be used in Ball Indentor of Rockwell Hardness Test.
- Diameters of the different Balls used in Brinell Hardness Test.
- Which steel have you tested? What is its carbon content?
- What general information is obtained from tensile test regarding the properties of a material?
- Which stress have you calculated: nominal stress or true stress?
- What kind of fracture has occurred in the tensile specimen and why?
- Which is the most ductile metal? How much is its elongation?
- What is the deflection formula of cantilever beam?
- What is the difference between cantilever and simply supported beam?
- Write types of loads?
- Contra flexure means?
- Types of beams.
- What is deflection?
- Write the equation for the Slope for a cantilever beam with point load

- Write the deflection equation for the simply supported beam with point load at the center
- How many types of bending are there?
- What is torque?
- What is torsion equation?
- What is flexural rigidity?
- Define Section modulus.
- What is meant by stiffness?
- What are different types of springs
- Define helical spring
- What is the strain energy stored in the springs?
- In what way the values of impact energy will be influenced if the impact tests are conducted
- on two specimens, one having smooth surface and the other having scratches on the surface
- What is the effect of temp? On the values of rupture energy and notch impact strength?
- What is resilience? How is it different from proof resilience and toughness?
- What is the necessity of making a notch in impact test specimen?
- If the sharpness of V-notch is more in one specimen than the other, what will be its effect on the test result ?
- Does the shear failure in wood occur along the 45° shear plane?
- What is single & double shear?
- What is finding in shear test?
- What is unit of shear strength?
- What is resilience? How is it different from proof resilience and toughness?
- The ability of the material to resist stress without failure is called?
- The impact test is done to test_______of a material?
- In Charpy impact test, the specimen is kept as________________?

- In charpy test specimen, the angle of v-notch section is?
- What is the Maxwell's reciprocal theorem or define the Maxwell's reciprocal theorem?
- What are the purpose of providing dial gauge and magnetic base in the apparatus?
- Maxwell reciprocal theorem in structural analysis can be applied in-

  A. all elastic structures B. plastic structure C. symmetrical structures only D. prismatic element structure only
- What is the difference B/W Maxwell's reciprocal theorem and betties
- Define the following terms

1. Elasticity.	16. Strain Hardening.
2. Plasticity	17. Proof Stress.
3. Rigidity	18. Modulus of Resilience.
4. Ductility	19. Resilience.
5. Toughness	20. Percentage Elongation
6. Brittleness	21. Percentage Reduction in Area
7. Stress.	22. True Stress
8. Strain	23. True Strain
9. Tensile Stress	24. Ultimate Strength
10. Shear Stress	25. Breaking Strength
11. Limit of Proportionality	26. Elastic Constants
12. Elastic Limit	27. Young's Modulus
13. Yield Point	28. Shear Modulus
14. Upper Yield Point	29. Bulk Modulus
15. Lower Yield Point	30. Poissons/Ratio