SRM VALLIAMMAI ENGINEERING COLLEGE

SRM Nagar, Kattankulathur – 603 203

DEPARTMENT OF CIVILENGINEERING

LAB MANUAL

Regulation : 2019

Branch : B.E. – Civil Engineering

Year & Semester : II Year / IV Semester

1903410- STRENGTH OF MATERIALS LABORATORY

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INTRODUCTION

The behavior and properties of structural materials such as steel, wood, cement etc., can be better understood by detailed, well-designed, first-hand experience with these materials. The students will become familiar with the nature and properties of these materials by conducting laboratory tests. These tests have been selected to illustrate the basic properties and methods of testing. All the experiments are carried out by IS codal provisions.

OBJECTIVES:

- To conduct the various tests on cement.
- To evaluate on the properties of helical spring .
- 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 of metal beam.

LIST OF EXPERIMENTS:

- TENSION TEST ON MILD STEEL
- DOUBLE SHEAR TEST
- TORSION TEST ON MILD STEEL BAR
- COMPRESSIVE TEST ON WOOD
- IZOD IMPACT TEST
- CHARPY IMPACT TEST
- ROCKWALL HARDNESS TEST
- BRINELL HARDNESS TEST
- DEFLECTION TEST ON METAL BEAM
- COMPRESSION TEST ON HELICAL SPRING
- TEST ON CEMENT
  - DETERMINATION OF FINENESS OF CEMENT BY DRY SIEVING
  - CONSISTENCY TEST ON CEMENT
  - DETERMINATION OF SETTING TIMES OF CEMENT
  - DETERMINATION OF SOUNDNESS OF CEMENT
  - DETERMINATION OF SPECIFIC GRAVITY OF CEMENT
  - DETERMINATION OF COMPRESSIVE STRENGTH OF CEMENT

TOTAL: 60 PERIODS

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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:**

    BOY**S** - 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 is particular mean by which a body or thing is strong. Strength of material is the property of the material by virtue of which the material can resist external force applied to it per unit of its cross sectional area. Greater this force with which the external force is resisted by unit cross sectional area of the material is its strength.

The external force acting on a body is called loads. Structure and machines are designed on the basis of loads. The units of load are the same as that of force. The load according to the manner of their member is dead load, live loads. The effect produced on a member is tensile load, compressive load, shearing loads, torsion loads, bending loads.

Stress as a load per unit area. Stress may be either tensile or compressive or shear according to whether member is being stretched, compressed or sheared.

The strength relies on three different type analytical method, strength stiffness and stability.

Strain is a measure of the deformation caused by the loaded body. The ratio of change in dimension of the body to the original dimension.

Mechanical properties can be described as the behavior of material under external loads. The important properties are strength, elasticity, plasticity, ductility, brittleness, malleability, toughness, hardness.

A structural member which carries lateral or transverse forces is termed as beam joint.

For example in grain boundary strengthening, although yield strength is maximized with decreasing grain size, very small sizes make the material.

It is determined by dividing the load at the time of fracture or breaking by the original cross sectional area

EX.NO:1

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

PROCEDUER:

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:

$$\text{Yield stress} = \frac{\text{yield point}}{\text{Initial area}}$$

$$\text{Ultimate stress} = \frac{\text{uitimate load}}{\text{Initial area}}$$

$$\text{Normal breaking stress} = \frac{\text{breaking load}}{\text{Initial area}}$$

$$\text{Actual breaking stress} = \frac{\text{breaking load}}{\text{Neck area}}$$

$$\text{Elongation in length} = \frac{\text{final length} - \text{initial length}}{\text{Initial length}} \text{ X100}$$

$$\text{Reduction in area} = \frac{\text{Initial area} - \text{neck area}}{\text{initial length}} \text{ X100}$$

OBSREVATION: (TENSION TEST ON MILD STEEL BAR)

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, p_y =________________KN
8. Ultimate load ,p_u =________________KN
9. Breaking load, p_b =________________KN

CALCULATION:

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:2

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

FORMULA:

$$\text{Maximum shear strength} = \frac{P}{2 \times A}$$

P= load at failure, N

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

$A=2X\pi D^2/4$

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*

RESULT:

The maximum shear strength of the given specimen =______________$\boldsymbol{N/mm^2}$

EX.NO:3

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***	Ultimate tensile stress ***N/mm^2***

FORMULA:

The general torsion theory for circular specimen:

$$\frac{T}{J} = \frac{G\theta}{L}$$

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)

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:4

DATE:

COMPRESSIVE STRENGTH ON WOOD

AIM:

To perform compression test of wood in 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, h =________mm

Initial diameters of specimen, d =_________mm

SI.NO	Applied load (p) *N*	Recorded change in length *mm*

CALCULATION:

- Original cross section area A_o =_____________ ***mm²***
- Final cross section area A_f =_____________ ***mm²***
- Stress =_____________ ***N/mm²***
- Strain =_____________

RESULT:

The compressive strength of given specimen =_________________ ***N/mm²***

EX.NO:5

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. Given 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;

Impact strength = (final izod scale reading – initial izod scale reading)

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
9. Initial izod scale reading =__________kg.m
10. Final izod scale reading =__________kg.m

TABULATION:

SI.NO	Energy observed Specimen ***J***	Effective cross sectional area $\boldsymbol{mm^2}$	Impact strength $\boldsymbol{J/mm^2}$

RESULT:

The impact strength of the given specimen is =______________$\boldsymbol{N/mm^2}$

EX.NO:6

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. Given specimen
3. Vernier caliper
4. Scale

THEORY:

An impact test of material that is ability of material to absorb energy during plastic deformation. The impact test measures the necessary to fracture a standard notch bar by applying an impact load.

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;

> Impact strength = (final charpy scale reading – initial charpy scale reading)

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
9. Initial charpy scale reading =____________kg.m
10. Final charpy scale reading =____________kg.m

TABULATION:

SI.NO	Energy observed Specimen ***J***	Effective cross sectional Area ***mm^2***	Impact strength ***J/mm^2***

RESULT:

The impact strength of the given specimen is =______________***N/mm^2***

EX.NO:7

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
3. Mild steel

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.

B scale ball intender -100kg

C scale diamond intender- 150kg

TABULATION: (ROCKWELL HARDNESS TEST)

SI.NO	Specimen scale	Load *kg*		Intender dimension	Dial reading *mm*			Average
		major	minor		R1	R2	R3	

RESULT:

Rockwell hardness number =______________________

EX.NO:8

DATE:

BRINELL HARDNESS TEST

AIM:

To study the Brinell hardness testing machine and the given specimen

APPARATUS:

1. Brinell hardness testing machine
2. Mild steel
3. Ball indenter
4. Microscope

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. 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 30second. The load will automatically apply gradually.
6. Remove the specimen from support table and locate the indentation so made.

FORMULA:

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

$$BHN = \frac{P}{\pi D/2(D-\sqrt{D^2-d^2})}$$

Where,

P-load applied on the indenter, Kg.

D-Diameter of steel ball indenter, mm.

d- Diameter of ball impression, mm

TABULATION:

Specimen material	Diameter of ball intender *mm*	Load (P) *Kg*	Diameter of ball impression			Average Diameter *mm*	Brinell hardness number **(no unit)**
			d_1 ***mm***	d_2 ***mm***	d_3 ***mm***		

RESULT:

1. Brinell hardness number of given material=______________

EX.NO:9

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 the bed.
2. Place the beam on the knife edges on the block so as to project equally beyond each knife edge. 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 $\sigma_Y = \frac{\overline{my}}{I}$

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)
	Kg	***N***	***mm***	***N-mm***	***N/mm²***	***N/mm²***

RESULT:

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

EX.NO:10

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.

FORMULAE USED:

Modulus of rigidity $C = \frac{64PR^3n}{d^4\delta}$

Where,

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

Stiffness, $k = \frac{p}{\delta}$

P=load in N

δ=Deflection on spring in mm

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

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***

EX.NO:11

DATE:

TENSION TEST ON SPRING

AIM:

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

APPARATUS:

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

PROCEDURE:

1. Measure the outer diameter (D) and diameter of the spring coil for the given tension spring.
2. Count the number of turns. i.e. Coil in the given tension specimen.
3. Place the tension spring at the centre of the bottom beam of the spring testing machine.
4. Raise 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.

Find the actual deflection of the spring for each load by deducting the initial scale reading from the corresponding scale reading

FORMULAE USED:

Modulus of rigidity C = $\frac{64PR^3n}{d^4\delta}$

Where,

P=load in N

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

d= diameter of the spring coil in mm

δ=deflection of the spring in mm

D=outer diameter of the springs in mm

Stiffness, k= $\frac{p}{\delta}$

Where,

P=load in N

δ=Deflection on spring in mm

OBSERVATION: (TENSION 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

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***

EX.NO:12

DATE:

DETERMINATION OF FINENESS OF CEMENT BY SIEVING

Objective: Determination of fineness of cement by dry sieving.

Reference: IS 4031 (Part-1):1988.

Apparatus: IS-90 micron sieve conforming to IS: 460 (Part 1-3)-1985; Weighing balance; Gauging trowel; Brush.

Material: Ordinary Portland cement

Procedure:

1. Weigh accurately 100 g of cement to the nearest 0.01 g and place it on a standard 90 micron IS sieve.
2. Break down any air-set lumps in the cement sample with fingers.
3. Agitate the sieve by giving swirling, planetary and linear movements for a period of 10 minutes or until no more fine material passes through it.
4. Collect the residue left on the sieve, using brush if necessary, and weigh the residue.
5. Express the residue as a percentage of the quantity first placed on the sieve to the nearest 0.1 percent.
6. Repeat the whole procedures two more times each using fresh 100 g sample.

Observations:

Sl. No.	Weight of sample taken (W) (in g.)	Weight of residue (R) (in g.)	%age of residue (=R/W*100)	Average % of residue
1.				
2.				
3.				

Result:

Percentage residue of cement sample by dry sieving is____________percentage.

Conclusions:

The given sample of cement contains less than/ more than 10% by weight of material coarser than 90 micron sieve. Therefore it satisfies/ not satisfies the criterion as specified by IS code.

EX.NO:13

DATE:

CONSISTENCY TEST ON CEMENT

Objective: Determination of percentage of water by weight of cement required to prepare a standard acceptable (consistent) cement paste.

Reference: IS 4031 (Part-4):1988.

Apparatus: Vicat apparatus conforming to IS: 5513-1998; Weighing balance; Gauging trowel; measuring cylinder.

Material: Ordinary Portland cement; Water.

Procedure:

1. Take 400 g of cement sieved through 90 micron IS sieve and keep it on a non- porous, non-absorbent plate.
2. Add 120 ml of water (*i.e.* 30% by weight of cement) to the cement and mix thoroughly with two trowels for 3 to 5 minutes till a uniform cement paste is achieved.
3. Fill the past in mould and level with trowel. Shake or tap to remove air bubbles.
4. Place the nonporous plate and the mould under the plunger.
5. Release the plunger gently to touch the surface of paste. Record the initial reading.
6. Release the plunger quickly and allow penetrating into the paste. When the plunger comes to rest, note the final reading.
7. Repeat the procedure with fresh paste varying the water percentage until the plunger penetrates to a depth 5 to 7 mm from the bottom of the Vicat mould.

Observations:

Sl. No.	Water added (in ml)	Percentage	Initial Reading	Final Reading	Height not penetrated (in mm)

Result:

Percentage of water required to achieve normal consistency of cement paste is_______.

EX.NO:14

DATE:

DETERMINATION OF SETTING TIMES OF CEMENT

Objective: Determination of initial and final setting time of cement and determine whether the values satisfy IS standards.

Reference: IS 4031 (Part-5):1988

Apparatus: Vicat apparatus conforming to IS: 5513-1998; Weighing balance; Gauging trowel; measuring cylinder; stop watch.

Material: Ordinary Portland cement; Water.

Procedure:

1. Prepare a uniform cement paste by gauging 400 g of cement with 0.85 times the water required to give a paste of standard consistency. The procedure of mixing and filling the mould is same as standard consistency.
2. Start the stopwatch or note down the time when water is added to the cement.

Determination of initial setting time:

3. Place the test block confined in the mould and resting on the non-porous plate, under the rod bearing the initial setting needle (with cross section 1 mm^2); lower the needle gently until it comes in contact with the surface of the test block and quickly release, allowing it to penetrate into the test block
4. Repeat this procedure until the needle, when brought in contact with the test block and released as described above, fails to pierce the block beyond 5.0 ± 0.5 mm measured from the bottom of the mould. Note the time.
5. The difference of time between operations (2) and (4) provides the initial setting time of cement.

Determination of final setting time:

6. Replace the initial setting needle of the Vicat apparatus by the needle with an annular attachment.
7. The cement shall be considered as finally set when, upon applying the needle gently to the surface of the test block, the needle makes an impression thereon, while the attachment fails to do so.
8. The interval of time between operation (2) and (7) provides the final setting time of cement.

Observations:

- Weight of given sample of cement is____________ g.
- The normal consistency of a given sample of cement is ____________%
- Volume of water addend (0.85 times the water required to give a paste of standard consistency) for preparation of test block_____________________________ml

Time in minutes :	
Height in mm fails to penetrate	

Initial setting time of cement (in min): ____________________

Final setting time (in min): ____________________

Conclusion:

The given sample of cement satisfied/ does not satisfy criterion for initial setting time.

The given sample of cement satisfied/ does not satisfy criterion for final setting time.

EX.NO:15

DATE:

DETERMINATION OF SOUNDNESS OF CEMENT

Objective: Determination of soundness of cement by Le-Chatelier method.

Reference: IS 4031 (Part-3):1988.

Apparatus: Le- Chatelier apparatus conforming to IS: 5514-1969; Measuring cylinder; Gauging trowel; Balance; Water bath.

Material: Ordinary Portland cement; Water; Grease

Procedure:

1. Weigh accurately 100 g of cement to the nearest 0.15 g and add to it 0.78 times the water required to give a paste of standard consistency (i.e. 0.78×P).
2. Place the lightly grease mould on a lightly grease glass sheet and fill it with cement paste, taking care to keep the edges of the mould gently together.
3. Cover the mould with another piece of lightly grease glass sheet, place a small weight on this covering glass sheet and immediately submerge the whole assembly in water at a temperature of 27 ± 2^0℃.
4. Keep this assembly under water for 24 hrs. After this, take the mould out of water and measure the distance between two indicators. Submerge the mould again in the water.
5. Bring the water to boiling with the mould kept submerged, and keep it boiling for 25 to 30 minutes.
6. Remove the mould from the water allow it to cool and measure the distance between the indicator points.
7. The difference between these two measurements represents the expansion of the cement.
8. Repeat the whole procedures two more times each using fresh 100 g sample.

Observations:

Samples:	
Distance between pointers before boiling (D_1) in mm	
Distance between pointers after boiling (D_2) in mm	
Expansion of the cement = E_1 = (D_2- D_1) in mm	
Average expansion of the cement in mm	

Result:

Average expansion of the cement is obtained is ___________mm.

EX.NO:16

DATE:

DETERMINATION OF SPECIFIC GRAVITY OF CEMENT

Objective: Determination of specific gravity of cement using Le-Chatelier flash.

Reference: IS 4031 (Part-11):1988.

Apparatus: Le Chaterliers flask, weighing balance, kerosene (free from water).

Material: Ordinary Portland cement; Water; Grease

Procedure:

1. Dry the flask carefully and fill with kerosene or naphtha to a point on the stem between zero and 1 ml.
2. Record the level of the liquid in the flask as initial reading.
3. Put a weighted quantity of cement (about 60 g) into the flask so that level of kerosene rise to about 22 ml mark, care being taken to avoid splashing and to see that cement does not adhere to the sides of the above the liquid.
4. After putting all the cement to the flask, roll the flask gently in an inclined position to expel air until no further air bubble rise3s to the surface of the liquid.
5. Note down the new liquid level as final reading.

Observations:

- Weight of cement used in g. (W_1) : _______
- Initial reading of flask in ml (V_1) : _______
- Final reading of flask in ml (V_2) : _______
- Volume of cement particle ($V_2 - V_1$) : _______
- Weight of equal volume of water in g. (W_2) : _______
- Specific gravity of cement (W_1/ W_2) : _______

Result and conclusion:

Specific gravity of the given cement obtained as ___________.

EX.NO:17

DATE:

DETERMINATION OF COMPRESSIVE STRENGTH OF CEMENT

Objective: Determination of compressive strength of cement.

Reference: IS 4031-1988 (Part-6).

Apparatus: Vibration Machine, Poking Rod, Cube Mould of 70.6 mm size conforming to IS: 10080-1982, Balance, Gauging Trowel, Watch, Graduated Glass Cylinders, etc.

Material: Ordinary portland cement (43 grade); Water; Grease, Standard sand (IS: 650- 1966).

Procedure:

Preparation of cement mortar cubes:

1. Take 200gms of cement and 600 g of standard sand (i.e. ratio of cement to sand is 1:3) in a non-porous enamel tray and mix them with a trowel for one minute.

2. Add water quantity (P/4 + 3.0) % of combined weight of cement and sand and mix the three ingredients thoroughly until the mixture is of uniform colour. ('P' is the consistency of cement). The time of mixing should be less than three minutes and not more than four minutes.

3. Immediately after mixing fill the mortar into greased cube moulds of sizes

70.6 mm.

4. Compact the mortar either by hand compaction in a standard specified manner or on the vibrating table.
5. Place the moulds in cabin at a temperature of $27^{o} \pm 2^{o}$ C for 24 hours
6. Remove the specimen from the moulds and submerge them in clean water for curing.

Testing of cement mortar cubes:

7. Take the cube out of water at the end of three days with dry cloth. Measure the dimensions of the surface in which the load is to be applied. Let them be 'L' and 'B' respectively.
8. Place the cube in compressive testing machine and apply the load uniformly at the rate of 14N/mm2 per minute.
9. Note the load at which the cube fails. Let it be 'F'.
10. Calculate the compressive strength of the cube by using formula F/AA . Where A is the area of loaded surface (i.e. L×B).
11. Repeat the same procedure (steps 7 to 10) for other two cubes.
12. Repeat the whole procedure (Step 7 to 11) to find the compressive strength of the cube at the end of 7 days and 28 days.

Observations:

(a) For 3 days strength:

Sl. No.	Length (L) in mm	Breadth (B) in mm	Load (F) in N	Compressive strength in N/mm^2
1				
2				
3				

Average =

(b) For 7 days strength:

Sl. No.	Length (L) in mm	Breadth (B) in mm	Load (F) in N	Compressive strength in N/mm^2
1				
2				
3				

Average =

(c) For 28 days strength:

Sl. No.	Length (L) in mm	Breadth (B) in mm	Load (F) in N	Compressive strength in N/mm^2
1				
2				
3				

Average =

Results:

The type and grade of cement :

The compressive strength of cement at the end of

i) 3 days :____________. N/mm^2.

ii) 7 days :____________. N/mm^2.

iii) 28 days :____________. N/mm^2.

EX.NO:

DATE:

FLEXURAL STRENGTH OF A BEAM

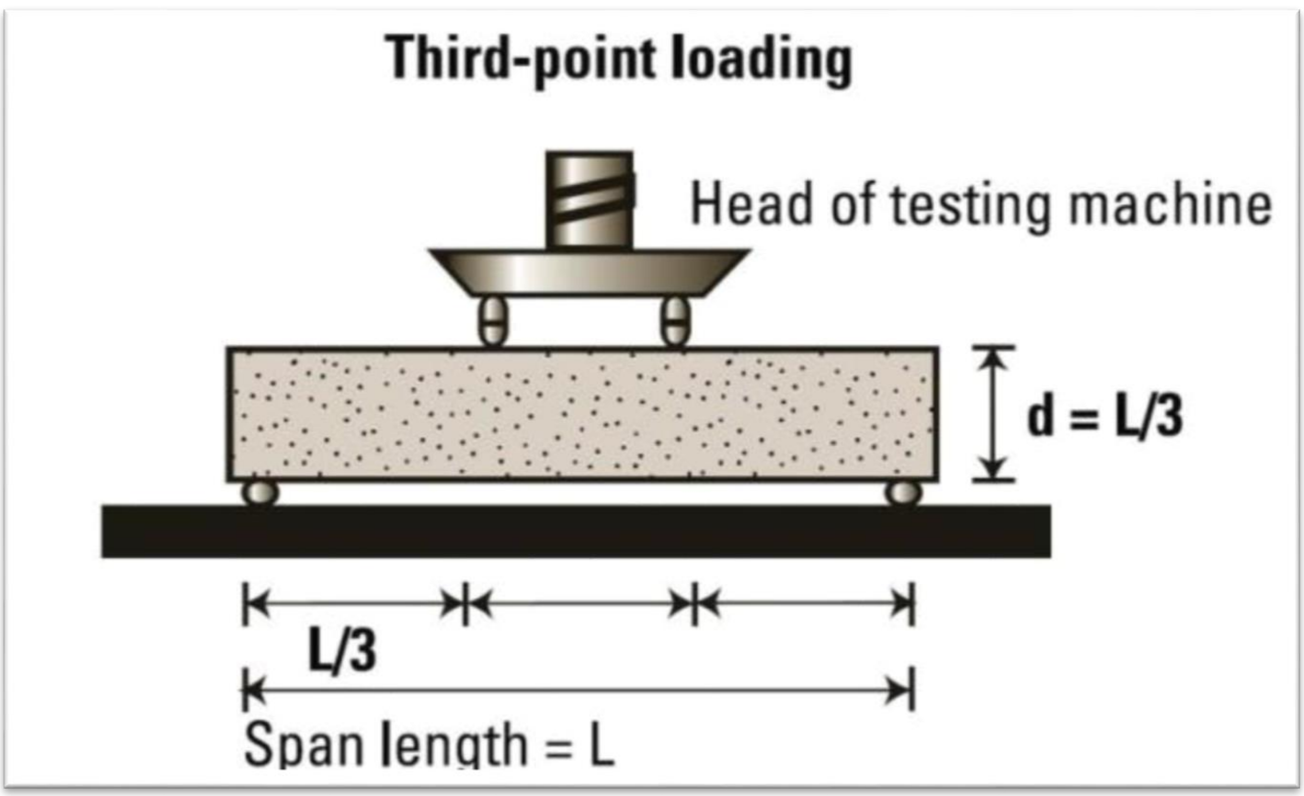
AIM:

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.

EX.NO:

DATE:

COMPRESSIVE STRENGTH OF BRICK

AIM:

To determine the Compressive Strength of brick

APPARATUS :

Bricks, Oven Venire Caliper, Scale,Etc.

THEORY:

Bricks are used in construction of either load bearing walls or in portion walls incase of frame structure. In bad bearing walls total weight from slab and upper floor comes directly through brick and then it is transversed to the foundation. In case the bricks are loaded with compressive nature of force on other hand in case of frame structure bricks are used only for construction of portion walls, layers comes directly on the lower layers or wall. In this case bricks are loaded with compressive nature of force. Hence for safely measures before using the bricks in actual practice they have to be tested in laboratory for their compressive strength.

PROCEDURE:

1. Select some brick with uniform shape and size.

2. Measure its all dimensions. (LXBXH)

3. Now fill the frog of the brick with fine sand. And

4. Place the brick on the lower platform of compression testing machine and lower the spindle till the upper motion of ramis offered by a specimen the oil pressure start incrising the pointer start returning to zero leaving the drug pointer that is maximum reading which can be noted down.

FORMULA:

Compressive Strength = (Max. Load at failure / Loaded Area of brick) in N/mm^2

OBSERVATION TABLE:

S.I No	L x B x H	Area	Compressive Strength	Avg. Compressive Strength
1				
2				
3				

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

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:

- Apply a load either at the centre of the simply supported span or at the free end of the beam, the deflected form can be obtained.
- Measure the height of the beam at certain distance by means of a dial gauge before and after loading and determine the deflection before and after at each point separately.
- Now move a load along the beam at certain distance and for each positions of the load, the deflection of the point was noted where the load was applied in step1.This deflection should be measured at each such point before and after the loading, separately.
- Plot the graph between deflection as ordinate and position of point on abssica the plot for graph drawn in step2 and 3.These are the influence line ordinates for deflection of the beam.

Observation Table :

Distance from the pinned end	**Load at central point/ cantilever end**		**Deflection of various points (mm) 2-3**	**Load moving along beam**		**Deflection of various points (mm) 5-6**
	Beam unloaded Dial gauge reading (mm)^2	**Beam loaded Dial gauge reading (mm)^3**	**Beam unloaded Dial gauge reading (mm)^5**	**Beam unloaded Dial gauge reading (mm)^5**	**Beam loaded Dial gauge reading (mm)^6**	

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

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