Vision of the Institute	Mission of the Institute
"To become a leading institute of providing professionally competent and socially responsive technocrats with high moral values."	⇨ To create an eco-system for the dissemination of technical knowledge, to achieve academic excellence. ⇨ To develop technocrats with creative skills and leadership qualities, to solve local and global challenges. ⇨ To impart human values and ethics in students, to make them socially and Eco-friendly responsible.

LAB MANUAL

OF

Material Testing Lab

[BCE 451]

B.TECH, 2nd.Year, 4th.Semester -

Dr. A.P.J. Abdul Kalam Tech. University
Uttar Pradesh

2025-26

Department of Civil Engineering

Faculty Name: Ms Kajal Singh

(Assistant Professor)

Approved by: (Head of the Department)

Vision of the Institute	Mission of the Institute
"To become a leading institute of providing professionally competent and socially responsive technocrats with high moral values."	⇨ To create an eco-system for the dissemination of technical knowledge, to achieve academic excellence. ⇨ To develop technocrats with creative skills and leadership qualities, to solve local and global challenges. ⇨ To impart human values and ethics in students, to make them socially and Eco-friendly responsible.

MANUAL CONTENTS

This manual is intended for the 2nd year students of Civil Engineering in the subject of Material Testing Lab. This manual typically contains practical/lab sessions related to Material Testing and construction Practices, covering various aspects to enhance understanding of cement behavior, strengthof concrete , and field applications.

Students are advised to thoroughly go through this manual rather than only the topics mentioned in the syllabus, as practical exposure is essential for understanding and visualizing the theoretical concepts related to material testing , site investigation.

Good luck, and we wish you an engaging and insightful laboratory experience.

PREFACE

This practical manual will be helpful for students of Civil Engineering for understanding the course from the point of view of applied aspects. Though all the efforts have been made to make this manual error free, yet some errors might have crept in inadvertently. Suggestions from the readers for the improvement of the manual are most welcomed.

VISION OF THE INSTITUTE

"To become a leading institute of providing professionally competent and socially responsive technocrats with high moral values."

MISSION OF THE INSTITUTE

- To create an eco-system for the dissemination of technical knowledge, to achieve academic excellence.
- To develop technocrats with creative skills and leadership qualities, to solve local and global challenges.
- To impart human values and ethics in students, to make them socially and Eco-friendly responsible

Vision of the Institute	Mission of the Institute
"To become a leading institute of providing professionally competent and socially responsive technocrats with high moral values."	⇨ To create an eco-system for the dissemination of technical knowledge, to achieve academic excellence. ⇨ To develop technocrats with creative skills and leadership qualities, to solve local and global challenges. ⇨ To impart human values and ethics in students, to make them socially and Eco-friendly responsible.

VISION OF THE DEPARTMENT

To impart academic excellence in civil engineering field with emphasis on holistic development of the professional, while inculcating ethics, socially and professionally responsive technocrats.

MISSION OF THE DEPARTMENT

M1: To provide a comprehensive platform for academic expertise and proficiency

M2: To develop civil engineering professionals with creative skills and leadership qualities in order to face regional and global challenges.

M3: To develop ethics in students in order to promote socially responsible environmental awareness with innovative thinking.

Vision of the Institute	Mission of the Institute
"To become a leading institute of providing professionally competent and socially responsive technocrats with high moral values."	⇨ To create an eco-system for the dissemination of technical knowledge, to achieve academic excellence. ⇨ To develop technocrats with creative skills and leadership qualities, to solve local and global challenges. ⇨ To impart human values and ethics in students, to make them socially and Eco-friendly responsible.

Program Educational Objectives (PEOs) of Department

PEO 1: To enhance skill and expertise in field of civil engineering with aim of boosting employability and entrepreneurship.

PEO 2: To develop multidisciplinary approach of civil engineering system with lifelong learning solutions.

PEO 3: To develop the potential to pursue higher education and research in field of civil engineerin

Vision of the Institute	Mission of the Institute
"To become a leading institute of providing professionally competent and socially responsive technocrats with high moral values."	⇨ To create an eco-system for the dissemination of technical knowledge, to achieve academic excellence. ⇨ To develop technocrats with creative skills and leadership qualities, to solve local and global challenges. ⇨ To impart human values and ethics in students, to make them socially and Eco-friendly responsible.

Program Outcomes:(PO)

Graduates will be able to achieve

PO 1.Engineering knowledge: Apply the knowledge of mathematics, science, engineering Fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO 2.Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO 3. Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO 4. Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO 5. Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO 6. The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO 7. Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO 8. Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 9. Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO 10. Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear.

PO 11.Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO 12. Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change

Vision of the Institute	Mission of the Institute
"To become a leading institute of providing professionally competent and socially responsive technocrats with high moral values."	⇨ To create an eco-system for the dissemination of technical knowledge, to achieve academic excellence. ⇨ To develop technocrats with creative skills and leadership qualities, to solve local and global challenges. ⇨ To impart human values and ethics in students, to make them socially and Eco-friendly responsible.

PSO 1: Graduates shall be able to apply critical thinking in research ,design ,analysis and implementation of civil engineering problems

PSO 2: Graduates shall be able to inculcate the idea of sustainability in engineering solution to meet real world challenges.

Course Evaluation Scheme

Sr No	Subject Code	Subject Name	Periods			Evauation Scheme				Total	Credit
						Sessional Assessment			PE		
			L	T	P	CT	TA	PS			
1.	BCE451	Material Testing Lab	0	0	2	-	-	50	50	100	1

Vision of the Institute	Mission of the Institute
"To become a leading institute of providing professionally competent and socially responsive technocrats with high moral values."	⇨ To create an eco-system for the dissemination of technical knowledge, to achieve academic excellence. ⇨ To develop technocrats with creative skills and leadership qualities, to solve local and global challenges. ⇨ To impart human values and ethics in students, to make them socially and Eco-friendly responsible.

Course Objectives:

The teacher will explain:

1.	**I. Cement** 1. Normal Consistency of cement. 2. Initial & final setting time of cement 3. Compressive strength of cement.
2.	**II Course Aggregates** 1. Water absorption of aggregate 2. Sieve Analysis of Aggregate 3. Specific gravity &bulk density 4. Grading of aggregates
3.	**III Fine Aggregates** 1. Sieve analysis of sand 2. Silt content of sand 3. Bulking of sand
4.	**IV Bricks** 1. Water absorption. 2. Compressive strength

Vision of the Institute	Mission of the Institute
"To become a leading institute of providing professionally competent and socially responsive technocrats with high moral values."	⇨ To create an eco-system for the dissemination of technical knowledge, to achieve academic excellence. ⇨ To develop technocrats with creative skills and leadership qualities, to solve local and global challenges. ⇨ To impart human values and ethics in students, to make them socially and Eco-friendly responsible.

Course Outcomes (COs)

Course Outcomes: The students should be able to:		**Bloom's Level**
CO1	**I. Cement** 1. Normal Consistency of cement. 2. Initial & final setting time of cement 3. Compressive strength of cement	L3
CO2	**II Course Aggregates** 1. Water absorption of aggregate 2. Sieve Analysis of Aggregate 3. Specific gravity &bulk density 4. Grading of aggregates	L4
CO3	**III Fine Aggregates** 1. Sieve analysis of sand 2. Silt content of sand 3. Bulking of sand	L5
CO4	**IV Bricks** 1. Water absorption. 2. Dimension Tolerances 3. Compressive strength	L5

CO-PO-PSO Mapping

COs /POs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO 1	3	2	1	2	2	1	1	–	–	–	–	1	3	2
CO 2	3	2	1	2	2	1	1	–	–	–	–	1	3	2
CO 3	3	2	1	2	2	1	1	–	–	–	–	1	3	2
CO 4	3	2	1	2	2	1	1	–	–	–	–	1	3	2

The extent of mapping is as follows: 1 for low, 2 for moderate, 3 for high &"-" for No correlation between CO & PO.

List of Experiments

S. No.	Experiment
1	Determination of normal consistency of cement.
2	Determination of initial and final setting time of cement.
3	Determination of compressive strength of cement.
4	Determination of water absorption of coarse aggregate.
5	Determination of sieve analysis of coarse aggregate.
6	Determination of specific gravity and bulk density of coarse aggregate.
7	Determination of grading of coarse aggregates.
8	Determination of sieve analysis of fine aggregate (sand).
09	Determination of silt content of sand.
10	Determination of bulking of sand.
11	Determination of water absorption of bricks.
12	Determination of compressive strength of bricks.

Beyond Syllabus:

1- TO DETERMINE OF AGGREGATE OF CONCRETE SAMPLE IMPACT VALUE

2- TO DETERMINE THE WORKABILITY OF CONCRETE SAMPLE BY SLUMP TEST

Vision of the Institute	Mission of the Institute
“To become a leading institute of providing professionally competent and socially responsive technocrats with high moral values."	⇨ To create an eco-system for the dissemination of technical knowledge, to achieve academic excellence. ⇨ To develop technocrats with creative skills and leadership qualities, to solve local and global challenges. ⇨ To impart human values and ethics in students, to make them socially and Eco-friendly responsible.

INDEX

S.No.	Name of the Experiment	CO	BTL	Lab Conduction Date	Remark/ Grade/ Marks	Faculty Signature with Date

Softwares & Hardwares Required:

Hardware:

Peripherals/Lab Equipment:

I . Cement Tests

- Vicat Apparatus (with plunger & needles)
- Le-Chatelier Apparatus
- Compression Testing Machine (CTM)
- Tensile Strength Testing Machine (Briquette apparatus)

II. Coarse Aggregate Tests

- Set of standard sieves (IS sieves)
- Sieve shaker
- Weighing balance
- Oven (for drying aggregates)

Vision of the Institute	Mission of the Institute
"To become a leading institute of providing professionally competent and socially responsive technocrats with high moral values."	⇨ To create an eco-system for the dissemination of technical knowledge, to achieve academic excellence. ⇨ To develop technocrats with creative skills and leadership qualities, to solve local and global challenges. ⇨ To impart human values and ethics in students, to make them socially and Eco-friendly responsible.

DO's

- Follow all lab safety instructions and wear proper PPE (lab coat, gloves, safety shoes if required).
- Read the experiment procedure carefully before starting.
- Ensure all equipment is clean, calibrated, and in working condition before use.
- Handle cement samples carefully to avoid contamination or moisture loss.
- Take accurate measurements and record observations neatly in the lab record.
- Maintain proper labeling of samples and test data.
- Use equipment like oven, sieve shaker, and testing machines as per guidelines.
- Work in coordination with your lab partners/team members.
- Switch off equipment after use and maintain cleanliness of the workspace.
- Report any faulty equipment or unusual results to the lab instructor immediately.

Don'ts

- Do not operate any equipment without proper instruction or supervision.
- Do not disturb soil samples during preparation or testing.
- Avoid guessing or fabricating readings—always use actual observations.
- Do not overload or misuse testing machines (e.g., compressive testing machine, shear apparatus).
- Do not leave equipment running unattended.
- Avoid spilling water or cement or material near electrical equipment.
- Do not mix up different soil samples or test results.
- Do not ignore safety precautions, especially with hot ovens and heavy equipment.
- Avoid careless handling of delicate instruments like balances and glassware.
- Do not leave the lab untidy after completing experiments.

EXPERIMENT NO.: 1

Normal Consistency of Cement

Object: This test method cover the determination of the normal consistency of cement. That is by determining the amount of water required to prepare Cement pastes for Initial and final time of setting test.

Apparatus:

1. Weight and weighing devices.
2. Glass graduates (200 or 250) ml capacity.
3. Vicat apparatus with the plunger end, 10 mm in diameter.
4. Electrical mixer, trowel and containers.
5. Mixing glass plate 30cm x 30cm.

Procedure:

1- Weigh 400g of cement and prepare the weight of water to be between 24% to 30% of the cement then places the dry paddle and the dry bowl in the mixing position in the mixer.

2- Place all the mixing water in the bowl.

3- Add the cement to the water and allow 30 s for absorption of the water.

4- Start the mixer at low speed for 30 s

5- Stop for (15 s) and make sure no materials have collected on the sides of the bowel.

6- Start mixing at medium speed for (1 min).

7- Quickly form the cement paste into the approximate shape of a ball with gloved hands

8- Putting hand at (15cm) distance, throw the cement paste ball from hand to hand six times.

9- Press the ball into the larger end of the conical ring; completely fill the ring with paste.

10- Remove the excess at the larger end by a single movement of the palm of the hand. Place the ring on its larger end on the base of the plate of Vicat apparatus.

11- Slice off the excess paste at the smaller end at the top of the ring by a single sharp-ended trowel and smooth the top. (Take care not to compress the paste).

12- Center the paste under the plunger end which shall be brought in contact with the surface of the paste, and tighten the set-screw.

13- Set the movable indicator to the upper zero mark of the scale or take an initial reading, and release the rod immediately. This must not exceed 30 seconds after completion of mixing.

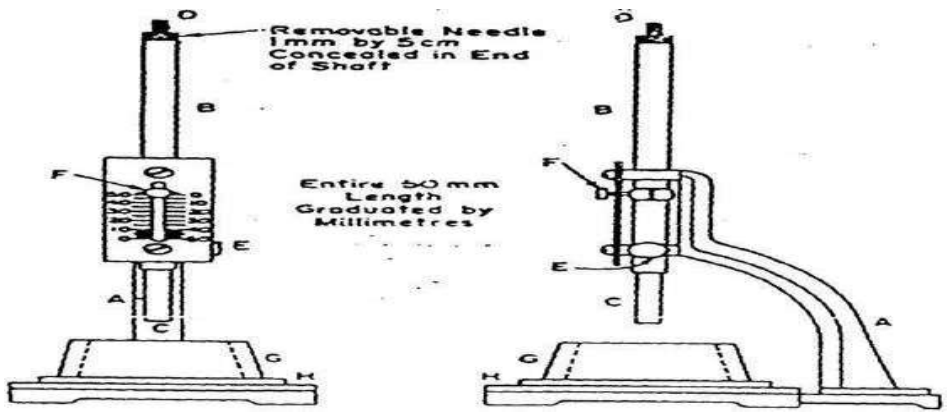
14- The paste shall be of normal consistency when the rod settles to a point 10±1mm below the original surface in 30 seconds after being released.

15- . Make trial paste with varying percentages of water until the normal consistency is obtained. Make each trial with fresh cement.

16- Prepare a table in the form:

W/c	Weight of cement (gm)	Water Volume (ml)	Penetration (mm)
24%			
26%			
28%			
30%			

17. From the curve state the w/c% which will give (10mm) that is the percentage for Normal Consistency



VICAT APPARATUS

Result "Initial and Final Time of Setting of Cement"

Experiment 2

Objective:

To determine initial and final setting time of cement.

Equipment's/Machines:

a) Vicat apparatus

b) Stopwatch

c) Weighing balance

Principle:

Initial setting time is when cement starts losing plasticity, and final setting time is when it completely loses plasticity.

1. Weight (400) gm cement.
2. Prepare amount of water as to that calculated in normal consistency test.
3. Prepare a cement paste following same steps mentioned in the previous test. Place in Vicat conical ring like test No. 9. Don't forget to record the time since the cement is added to the water.
4. Allow the time of setting specimen to remain in the moist cabinet for 30 minutes after molding without being disturbed. Determine the Penetration of the 1mm needle at this time and every (15) minutes until a penetration of 25mm or less is obtained
5. To read the penetration, lower the needle of Vicat Apparatus until it touches the surface of the cement paste. Tighten the screw and take an initial reading. Release the set screw and allow the needle to settle for 30 seconds, and then take the

reading to determine the penetration.

6. Note that no penetration shall be made closer than (6mm) from any previous penetration and no penetration shall be made closer than (9.5mm) from the inside of the mold. Record the results of all penetration, then by drawing a curve determine the time when a penetration of 25 mm is obtained. This is the initial setting time
7. The final setting time is when the needle dose not sinks visible into the paste.
8. Draw a graph for (penetration — time). Show the time which gives penetration of (25 mm) this will be the initial setting time.

Note: According to I.S

1. Initial time of setting, not less than 30 min.
2. Final time of setting, not less than 10 hours

1. TABULATION AND RESULTS:

SI NO	Time (min)	Penetration (mm)	Remarks
1			
2			
3			
4			
5			

Vision of the Institute	Mission of the Institute
"To become a leading institute of providing professionally competent and socially responsive technocrats with high moral values."	⇨ To create an eco-system for the dissemination of technical knowledge, to achieve academic excellence. ⇨ To develop technocrats with creative skills and leadership qualities, to solve local and global challenges. ⇨ To impart human values and ethics in students, to make them socially and Eco-friendly responsible.

Experiment No. 3

Compressive Strength of Cement Mortars Using 50 mm Cube Specimens

Object: This test method covers determination of the compressive strength of cement mortars, using 2 in(50 mm) cube specimens.

Apparatus:

1- Weights and weighing device.2- Glass Graduate. Specimens molds: three cubes of (50mm) side. Mixer (electrically driven mechanical mixer of the type equipped with paddle and mixing bowl) .5- Testing machine. 6- Tamper and trowel.

Materials: Graded standard sand should be used (C778). With cement in the proportion 1 cement: 2.75 Sand by weight. Use water – cement ratio of 0.485 for all Portland cements and 0.460 for all air- entraining Portland cements.

Note: For other than Portland and air- entraining Portland cements do flow table test, to determine the amount of mixing water.

Procedure:

A. Preparation of Mortar:

Weigh (300) gm of cement and Prepare the corresponding weights of standard sand and water.

1. Place the dry paddle and the dry bowl in the mixing position in the mixer. Then introduce the materials for a batch into the bowl and mix in the following manner:

i- Place all the mixing water in the bowl.

ii- Add the cement to the water, then start the mixer and mix at the low speed (140 ± 5 r/ min) for (30s).

iii- Add the entire quantity of sand slowly over a (30 s) period, while mixing at slow speed.

iv- Stop the mixer, change to medium speed (285 +10 r/min) and mix for 30 s.

v- Stop the mixer and let the mortar stand for 1.5 min. During the first (15 s) of this interval, quickly scrape down into the batch any mortar that may have collected on the side of the bowl.

vi- Finish by mixing for (1min) at medium speed.

B-Molding test specimens

(i) Thinly cover the interior faces of the specimen molds with oil.

(ii) Start molding the specimens within a total time of not more than 2.5 min after completion of mixing.

(iii) Place a layer of mortar about 25 mm (half the depth of the mold) in all the cube specimens.

(iv) Tamp the mortar in each cube 32 times (4x8), about 4 rounds, each round to be at right angles to the other. The tamping pressure shall be just sufficient to insure uniform filling of the molds.

(v) The 4 rounds of taming shall be completed in one cube before going to the next.

(vi) When the tamping of the first layer in all cubes is completed, fill the molds with the remaining mortar and tamp as specified for the first layer.

(vii) Cut off the mortar to a plane surface with a straight edge.

(viii) Keep the molds in a moist room for 20-24 hours then open them and keep the Specimens in a water basin for a week.

C-Testing specimens:

1- After 7 days (+ 3 hours), take the specimens out of the basin, dry them with a clean cloth, put them, one after the other, in the testing machine.

2- The cubes must be put on one side, using extra steel plates up and down the specimen.

3- Start loading in a speed of 1.4 KN /sec or (350 kg /cm2) in a minute

4- When failure, record load and the compressive strength.

Calculations:

1- Table the results:

Cube No.	Load(kN)	Compressive strength(MPa)

2- Compare with [$\sigma c \geq 19.3$MPa [For type I cement] age 7 days.

Result: "Fineness of Cement by No.100 or No. 200 Sieve"

Experiment No. 4

Water Absorption Test of Coarse Aggregate

Objective:

To determine the percentage of water absorbed by a given sample of coarse aggregate.

Apparatus:

- Weighing balance (accuracy 0.1 g)
- Drying oven (100–110°C)
- Wire basket
- Water tank/container
- Absorbent cloth
- Tray

Theory/Principle:

Water absorption of aggregate is a measure of the amount of water absorbed by the aggregate under specified conditions. It indicates the porosity and permeability of the aggregate.
Aggregates having higher water absorption are generally more porous and may affect the strength and durability of concrete. According to IS specifications, water absorption should generally be less than 2% for good quality aggregates.

Procedure:

(i) Take a representative sample of coarse aggregate (about 2 kg).

(ii) Wash the sample thoroughly to remove dust and impurities.

(iii) Dry the sample in an oven at a temperature of 100–110°C for 24 hours.

(iv) Remove the sample and allow it to cool to room temperature.

(v) Weigh the dry sample and record it as W_1 (Dry weight).

(vi) Immerse the sample completely in water for 24 hours.

(vii) After 24 hours, remove the sample from water.

(viii) Wipe off surface moisture using a damp cloth.

(ix) Weigh the saturated sample and record it as W_2 (Wet weight).

Observations:

S. No.	Dry Weight W_1 (kg)	Wet Weight W_2 (kg)	Water Absorption (%)	Remarks
1				
2				
3				

Calculation:

Water Absorption (%) $= \frac{W_2 - W_1}{W_1} \times 100$

Result:

The water absorption of the given aggregate sample is found to be ______ **%**.

Conclusion:

- The tested aggregate shows **(low/moderate/high)** water absorption.
- If water absorption is **less than 2%**, the aggregate is considered suitable for concrete works.
- Higher absorption indicates **porous aggregate**, which may reduce strength and durability.

Precautions:

- Ensure complete drying before initial weighing.
- Remove only surface moisture, not internal water.
- Use accurate weighing instruments.
- Avoid loss of aggregate during handling.

Experiment No. 5 & 8

(Sieve Analysis of fine and coarse aggregates)

Object: This method covers the determination of the particle size distribution the fine and coarse aggregate by sieving.

Materials:

1. The weight of test sample of fine aggregate shall be, after drying, approximately (500 gm).
2. The weight of test sample of coarse aggregate shall conform to the following:

N.M.S (mm)	Minimum Weight (kg)
9.5	1
12.5	2
19	5
25	10
37.5	15

Apparatus:

1. Balance: For fine aggregate accurate for 0.5gm.For coarse aggregate accurate for 0.5gm.
2. Containers to carry the sample.
3. Oven.
4. Mechanical Sieve shaker.
5. Two sets of sieve:-For fine aggregate [No.4 , No.8, No.16 , No.30 , No.50, No.100] For coarse aggregate [37.5mm , 19mm ,9.5mm, No.4 , No.8] In addition to a pan and a cover for each set.

Procedure:

1. Put the sample in the oven at 110°C.
2. Determine the empty weight for each sieve and record.
3. Nest the sieve in order of decreasing size of opening from top to bottom place the sample on the top sieve.
4. Agitate (shake) the sieve by placing the set on the mechanical shaker for 10min.
5. Open the set of sieve carefully so that no loosing of materials is expected.
6. Weigh each sieves with the residue record its weight.

7. Tabulate your data in a suitable shape.
8. Make sure that the summation of the residue weights equals to the original sample weight with a difference not more than 1% of the original weight.

The table should contain:

10 Fineness Modulus for fine aggregate can be determined as: -

F.M. = Σ Cumulative residue percentage

No. of sieve	Sieve empty Wt	Sieve +residue Wt	Residue Wt	Residue %	%Cum Residue	% Passing

- It must be within-(2.6 - 3.1) for sand.

Notes:

1-The sieves dimensions are

No. of Sieve	100	50	30	16	8	4	3/8"	1/2"	3/4"	1"	1.5"
Size of Opening (mm)	0.150	0.3	0.6	1.18	2.36	4.75	9.5	12.5	19	25.4	37.5

Sieve No.	Sieve size	% Passing
3/4"	1.9mm	100
No.4	4.75mm	95-100
No.8	2.36mm	80-100
No.16	1.18mm	50-85
No.30	0.600mm	25-60
No.50	0.3mm	10-30
No.100	0.15mm	2-10

b- For Coarse aggregate: See table (1).

Calculation:

Result:

Vision of the Institute	Mission of the Institute
"To become a leading institute of providing professionally competent and socially responsive technocrats with high moral values."	⇨ To create an eco-system for the dissemination of technical knowledge, to achieve academic excellence. ⇨ To develop technocrats with creative skills and leadership qualities, to solve local and global challenges. ⇨ To impart human values and ethics in students, to make them socially and Eco-friendly responsible.

Experiment No. 6

(Specific Gravity, Bulk Density and Absorption of fine Aggregate)

Object: This test method covers the determination of Bulk and Apparent Specific Gravity and Absorption of fine aggregate.

Materials: - l kg of sand is used using sample splitter.

Apparatus:

1. A balance having capacity of 1kg or more sensitive to 0.1gm
2. Pycnometer a flask or other suitable container into which the fine aggregate sample can be introduced It is usually of 500cm3 capacity.
3. Mould: a metal mould in the form of a frustum of a cone with dimensions as follows: 37mm inside diameter at the top, 90mm inside diameter at the bottom and 75mm in height.
4. Tamper: A metal tamper weighing 340±15gm and having a flat circular tamping face 25mm in diameter.
5. Electrical Oven.
6. A container suitable to submerge the sample with water.

Preparation of the test Specimen:-

1- Obtain approximately 1kg of the fine aggregate using sample splitter.

2- Dry it in a suitable pan or vessel to constant weight at 110°C. Allow it to cool to a comfortable handling temperature, cover with water by immersion and permit to stand for 24 hours.

3- Decant excess water with care to avoid loss of fines, spread the sample on a flat non absorbent surface exposed to a gently moving current of warm air.

4- Stir frequently to get homogeneous drying until achieving the saturated surface dry condition. Use cone test for surface moisture.

5- Hold the mould firmly on a smooth nonabsorbent surface with the large diameter down. Place a portion of partially dried fine aggregate loosely in the mould by filling it to over following and heaping additional materials above the top of the mould.

6- Lightly tamp the sand into the mould with 25 light drops of the tamper. Each drop should start about 5mm above the top surface of the sand. Permit the tamper to fall freely under gravitational attraction on each drop.

7- Adjust the surface, remove loose sand from the base and lift the mold vertically. If surface moisture is still present the sand will retain the moulded shape. When the sand slumps slightly, it indicates that it has reached S.S.D condition.

Procedure:-

1. Weigh 500gm of the S.S.D sample.
2. Partially fill the Pycnometer with water. Immediately put into the Pycnometer 500gm saturated surfacedry aggregate.
3. Then fill with additional water to approximately 90%of capacity.
4. Roll; invert the Pycnometer to eliminate all air bubbles.
5. Adjust its temperature to 23±1.7 °C by putting the Pycnometer in a water bath for an hour.
6. Bring the water level in the Pycnometer to its calibrated capacity.
7. Determine the total weight of the Pycnometer, specimen and water.
8. Remove the fine aggregate from the Pycnometer, dry to constant weight at temp. 110±5 C, cool in air atroom temperature for one hour, and weigh.
9. Determine the weight of the Pycnometer filled to its capacity with water at 23 o C

Calculations:-

1- Calculate the bulk specific gravity as follows:-Bulk sp. gr. = A / (B + S – C)

Where:

A: Weight of oven —dry specimen in air, (gm).

B: Weight of Pycnometer filled with water, (gm)

S: Weight of the saturated surface-dry specimen. (500 gm)

C: Weight of Pycnometer with specimen and water to calibration mark, (gm).

1. **Calculat the bulk specific gravity (SSD) as follows:**

   Bulk specific gravity (SSD) = S / (B + S – C)

2. **Calculate the apparent Specific Gravity as follows:-**

   Apparent specific gravity=. A / (B + A - C)

3. **Calculate the percentage of absorption as follows:-**

   Absorption = [(S – A) / A x] 100

Result:

Experiment 7

Determination of Grading of Coarse Aggregate (Sieve Analysis)

Objective:

To determine the grading (particle size distribution) of a given sample of coarse aggregate using sieve analysis and to classify it as per IS specifications.

Apparatus:

- Set of IS standard sieves (e.g., 80 mm, 40 mm, 20 mm, 10 mm, 4.75 mm, etc.)
- Sieve shaker (mechanical or manual)
- Weighing balance (accuracy 0.1 g or suitable range)
- Oven (100–110°C)
- Brushes
- Tray or pan
- Sample container

Theory/Principle:

Grading of aggregates refers to the distribution of particle sizes within a given sample. It is determined by passing the aggregate through a series of standard sieves and recording the amount retained on each sieve.

Proper grading is essential because it:

- Improves workability of concrete
- Reduces voids and cement consumption
- Enhances strength and durability

Aggregates are classified as well-graded, poorly graded, or uniformly graded based on their particle size distribution.

Procedure:

i. Take a representative sample of coarse aggregate (about 2–5 kg depending on size).
ii. Dry the sample in an oven at 100–110°C and allow it to cool.
iii. Weigh the total sample and record as W.
iv. Arrange the IS sieves in descending order (largest size at top).
v. Place the aggregate sample on the top sieve.
vi. Fix the sieve set in a sieve shaker and shake for 10–15 minutes.
vii. Remove the sieves and weigh the material retained on each sieve.
viii. Record the weight retained on each sieve.
ix. Calculate the percentage retained and cumulative percentage retained.
x. Determine the percentage passing for each sieve.
xi. Plot a grading curve (optional) with sieve size vs % passing.

Observations:

Sieve Size (mm)	Weight Retained (kg)	% Retained	Cumulative % Retained	% Passing	Remarks
40 mm					
20 mm					
10 mm					
4.75 mm					
Pan					

Calculations:

1. $\% \text{ Retained} = \frac{\text{Weight retained on sieve}}{\text{Total weight}} \times \mathbf{100}$

2. Cumulative% Retained = Sum of % retained up to that sieve

3. % Passing = 100 - \text{Cumulative % Retained}

Result:

- The aggregate grading is found to be (well-graded / poorly graded / uniformly graded).
- The sample conforms / does not conform to IS grading requirements.

Conclusion:

- Properly graded aggregates improve strength, durability, and economy of concrete.
- Poor grading leads to more voids and higher cement consumption.
- The tested aggregate is suitable / not suitable for construction work based on grading.

Experiment 9

(Determination of Silt Content of Sand)

Objective:

To determine the percentage of silt (fine particles) present in a given sample of sand.

Apparatus:

- Measuring cylinder (100 ml or 250 ml capacity)
- Graduated glass jar
- Clean water
- Sand sample
- Stirring rod
- Scale

Theory/Principle:

Silt consists of very fine particles (smaller than 75 microns) present in sand. Excessive silt content affects the bond between cement and sand, thereby reducing the strength and durability of concrete. When sand is mixed with water and allowed to settle, heavier sand particles settle at the bottom while lighter silt particles form a layer above it. The thickness of the silt layer helps determine the percentage of silt.

As per IS standards, the permissible silt content in sand should generally not exceed 8% for most construction works.

Procedure:

i. Take a clean measuring cylinder.
ii. Fill sand in the cylinder up to 50 ml mark.
iii. Add clean water up to 100 ml mark.
iv. Add a pinch of common salt (optional, helps settlement).
v. Close the cylinder and shake it vigorously for 2–3 minutes.
vi. Place the cylinder on a level surface and allow it to stand undisturbed for 3 hours.

vii. After settlement, observe two layers:
   - Lower layer: Sand
   - Upper layer: Silt

viii. Measure the height of sand layer (H_1) and total height (H_2).

ix. Calculate the percentage of silt.

Observations:

S. No.	Height of Sand Layer H_1 (mm)	Height of Silt Layer (mm)	Total Height H_2 (mm)	Silt Content (%)	Remarks
1					
2					
3					

Calculation:

$$\text{Silt Content (\%)} = \frac{\text{Height of silt layer}}{\text{Total height}} \times \mathbf{100}$$

OR

$$\frac{H_2 - H_1}{H_2} \times \mathbf{100}$$

Result:

The silt content of the given sand sample is found to be ______ %.

Conclusion:

- If silt content is ≤ 8%, sand is suitable for construction.
- If silt content is > 8%, sand should be washed before use.
- Excess silt reduces bonding, strength, and durability of concrete.

Experiment No.10

Object- To ascertain the bulking phenomena of given sample of sand.

Apparatus- 1000ml measuring jar, brush. etc

Introduction- Increase in volume of sand due to presence of moisture is known as bulking of sand. Bulking is due to the formation of thin film of water around the sand grains and the interlocking of air in between the sand grains and the film of water. When more water is added sand particles get submerged and volume again becomes equal to dry volume of sand. To compensate the bulking effect extra sand is added in the concrete so that the ratio of coarse to fine aggregate will not change from the specified value. Maximum increase in volume may be 20% to 40% when moisture content is 5% to 10% by weight. Fine sands show greater percentage of bulking than coarse sands with equal percentage of moisture.

Procedure-

1. Take 1000 ml measuring jar.
2. Fill it with loose dry sand up to 500ml without tamping at any stage of filling.
3. Then pour that sand on a pan and mix it thoroughly with water whose volume is equal to 2% of that of dry loose sand.
4. Fill the wet loose sand in the container and find the volume of the sand which is in excess of the dry volume of the sand.
5. Repeat the procedure for moisture content of 4%, 6%, 8%, etc, and note down the readings.
6. Continue the procedure till the sand gets completely saturated i.e., till it reaches the original volume of 500 ml.

Observations-

S.No.	Volume of Dry loose sand V_1	% moisture content Added	Volume of wet loose sand V_2	% Bulking V_2-V_1/V_1
1	500 ml	2%		
2		4%		
3		6%		
4		8%		

Graph- Draw a graph between percentage moisture content on X-axis and percentage bulking on Y-axis. The points on the graph should be added as a smooth curve. Then from the graph, determine maximum percentage of buling and the corresponding moisture content.

Precautions-

1. While mixing water with sand grains, mixing should be through and uniform.
2. The sample should not be compressed while being filled in jar.
3. The sample must be slowly and gradually poured into measuring jar from its top.
4. Increase in volume of san due to bulking should be measured accurately.

Result- The maximum bulking of the given sand is ……….at % of moisture content

EXPERIMENT NO.: 11

Objective: To determines water absorption of brick.

Equipments/ Machines

a) Dry bricks

b) Weighing machine

Principle

Brick for external use must be capable of preventing rain water from passing through them to the inside of walls of reasonable thickness. A good brick should aborb water maximum 1/7 th of the weight of the brick

Methods/Procedures

(i) 20 bricks are taken randomly from a stack.

(ii) The bricks are put in an oven at a temperature of 1050C for drying.

(iii) Bricks are weighed in a digital weighing machine and is record asW1

(iv) The bricks are immersed in water at room temperature for 24 hours.

(v) After 24 hours immersion, the bricks are taken out of water and wiped with a damp cloth for 3 minutes

(vi) The bricks are weight again and recorded as W2.

(vii) Water absorption in % is calculated as $(W2-W1)/W1\times100$

Vision of the Institute	Mission of the Institute
"To become a leading institute of providing professionally competent and socially responsive technocrats with high moral values."	⇨ To create an eco-system for the dissemination of technical knowledge, to achieve academic excellence. ⇨ To develop technocrats with creative skills and leadership qualities, to solve local and global challenges. ⇨ To impart human values and ethics in students, to make them socially and Eco-friendly responsible.

Observations

SI NO	Weight W_1 (Kg)	Weight W_2 (Kg)	Water absorption in%	Remarks
1				
2				
3				
4				
5				

Calculation

Conclusion : water absorption value of brick =

EXPERIMENT NO.: 12

Objective To determines the compressive strength of bricks

Equipments/Machines

Compressive strength testing machine, Bricks, Water, Sand, Cement, Trowel

Principle

Bricks are mostly subjected to compression and tension. The usual crushing strength of common hand moulded well burnt bricks is about 5 to 10 N/mm2 (50 to 100/kg/cm2) varying according to the nature of preparation of the clay. Pressed and machine moulded bricks made of thoroughly plugged clay are strongerthan common hand moulded bricks from carelessly prepared clay.

Methods/Procedures

i. Eight bricks are taken for the compressive strength testing.

ii. The bricks are then immersed in water at room temperature for 24 hours.

iii. Then these are taken out of water and surplus water on the surfaces is wiped off with a moist cloth.

iv. The frog of the bricks is flushed level with cement mortar (1:3)

v. The bricks are stored under damp jute bags for 24 hours followed by its immersion in water at room temperature for three days.

vi. The bricks are placed in the compression testing machine with flat faces horizontal and mortar filled face being upwards.

vii. Load is applied at a uniform rate of 14 N/ m2 per minute till failure.

Vision of the Institute	Mission of the Institute
"To become a leading institute of providing professionally competent and socially responsive technocrats with high moral values."	⇨ To create an eco-system for the dissemination of technical knowledge, to achieve academic excellence. ⇨ To develop technocrats with creative skills and leadership qualities, to solve local and global challenges. ⇨ To impart human values and ethics in students, to make them socially and Eco-friendly responsible.

Observations

SL NO	Load at Failure (N)	Average area of back faces (mm2	Compressive Strength. (N/mm2	Remarks
1				
2				
3				
4				
5				

Calculation :

Average strength of bricks =

Conclusion : Compressive strength of brick =

COURSE BEYOND SYLLABUS

Experiment No. 1

DETERMINATION OF AGGREGATE IMPACT VALUE

1. OBJECTIVE

1) To determine the impact value of the road aggregates
2) To assess suitability of aggregates for use in different types of road pavement

2. PRINCIPLE

The property of a material to resist impact is known as toughness. Due to movement of vehicles on the road the aggregates are subjected to impact resulting in their breaking down into smaller pieces. The aggregates should therefore have sufficient toughness to resist their disintegration due to impact. This characteristic is measured by impact value test. The aggregate impact value is a measure of resistance to sudden impact or shock, which may differ from its resistance to gradually applied compressive load.

3. APPARATUS

The apparatus of the aggregate impact value test as per IS: 2386 (Part IV) – 1963 consists of:

1) A testing machine weighing 45 to 60 kg and having a metal base with a plane lower surface of not less than 30 cm in diameter. It is supported on level and plane concrete floor of minimum 45 cm thickness. The machine should also have provisions for fixing its base.

2) A cylindrical steel cup of internal diameter 102 mm, depth 50 mm and minimum thickness 6.3 mm.

3) A metal hammer p weighing 13.5 to 14.0 kg the lower end is cylindrical in shape, is 50 mm long, 100.0 mm in diameter, with a 2 mm chamfer at the lower edge and case hardened. The hammer should slide freely between vertical guides and be concentric with the cup. The free fall of the hammer should be within 380 ± 5 mm.

4) A cylindrical metal measure having internal diameter of 75 mm and depth 50 mm for measuring aggregates.

5) Tamping rod 10 mm in diameter and 230 mm long, rounded at one end.

6) A balance of capacity not less than 500 g, readable and accurate up to 0.1 g.

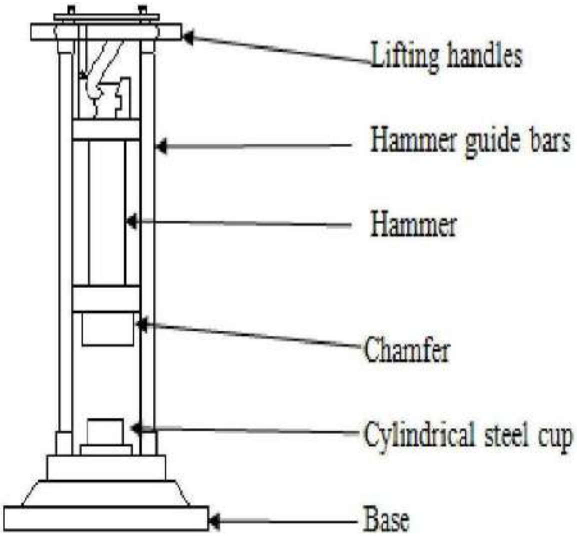


Fig 2 AGGREGATE IMPACT TESTING MACHINE

4. PROCEDURE

The test sample: It consists of aggregates sized 12.5 mm - 10.0 mm. The aggregates should be dried by h eating at 10 0-110^{o} C for a period of 4 hours and cooled.

1) Sieve the material through 12.5 mm and 10.0 mm IS sieve. The aggregates passing through 12.5 mm sieve and retained on 10.0 mm sieve comprises the test material.
2) Pour the aggregates to fill about 1/3rd depth of measuring cylinder.
3) Compact the material by giving 25 gentle blows with the rounded end of the tamping rod.
4) Add two more layers in similar manner, so that cylinder is full.
5) Strike off the surplus aggregates.
6) Determine the net weight of the aggregates to the nearest gram (W).
7) Bring the impact machine to rest without wedging or packing up on the level plate, block or floor, so that it is rigid and the hammer guide columns are vertical.
8) Fix the cup firmly in position on the base of machine and place whole of the test sample in it and compact by giving 25 gentle strokes with tamping rod.
9) Raise the hammer until its lower face is 380 mm above the surface of the aggregate sample in the cup and allow it to fall freely on the aggregate sample. Give 15 such blows at an

interval of not less than one second between successive falls.

10) Remove the crushed aggregate from the cup and sieve it through 2.36 mm IS sieves until no further significant amount passes in one minute. Weigh the fraction passing the sieve to an accuracy of 1 gm (W_2). Also weigh the fraction retained in the sieve.

11) Note down the observations in the Performa and compute the aggregate impact value.

The mean of two observations, rounded to nearest whole number is reported as the Aggregate Impact Value.

5. PRECAUTIONS

1) Place the plunger centrally so that it falls directly on the aggregate sample and does not touch the walls of the cylinder in order to ensure that the entire load is transmitted on to the aggregates.
2) In the operation of sieving the aggregates through 2.36 mm sieve the sum of weights of fractions retained and passing the sieve should not differ from the original weight of the specimen by more than 1 gm.
3) The tamping is to be done properly by gently dropping the tamping rod and not by hammering action. Also the tampering should be uniform over the surface of the aggregate taking care that the tamping rod does not frequently strike against the walls of the mould.

6. REPORTING OF RESULTS

The mean of the two results shall be reported to the nearest whole number as the aggregate impact value of the tested material.

Aggregate impact value is used to classify the stones in respect of their toughness property as indicated below in Table 1.

Table 1: Classification of aggregate based on aggregate impact value

Aggregate impact value (%)	**Quality of aggregate**
< 10	Exceptionally strong
10 – 20	Strong
20 – 30	Satisfactory for road surfacing

>35	Weak for road surfacing

Table 2: Maximum allowable impact values of aggregate in different types of Pavement material/ layers

Sl. No	Types of pavement material /layer	Aggregate impact value (%)
1	Water bound macadam, sub-base course	50
2	Cement concrete, base course	45
3	i) WBM base coarse with bitumen surfacing ii) Built-up spray grout, base course	40
4	Bituminous macadam, base course	35
5	i) WBM, surfacing course ii) Built-up spray grout, surfacing course iii) Bituminous penetration macadam iv) Bituminous surface dressing v) Bituminous macadam, binder course vi) Bituminous carpet vii) Bituminous/Asphaltic concrete viii) Cement concrete, surface course	30

7. CONCLUSION

Record of Observation	**Sample I**	**Sample II**
Total weight of dry sample taken= W_1 gm		
Weight of portion passing 2.36 mm sieve = W_2 gm		
Aggregate impact = $(W_2/W_1)*100$ Value (per cent)		

Aggregate Impact Mean Value =

Experiment 2

TO DETERMINE THE WORKABILITY BY SLUMP TEST OF CONCRETE SAMPLE

Objective

To determine the workability and consistency of fresh concrete by conducting the slump test.

Apparatus Required

1. Slump cone (Abrams cone): Top diameter = 100 mm, Bottom diameter = 200 mm, Height = 300 mm
2. Tamping rod: Diameter = 16 mm, Length = 600 mm
3. Base plate
4. Scale or measuring tape
5. Fresh concrete sample
6. Trowel
7. Scoop
8. Cleaning cloth

Principle

The workability of concrete refers to the ease with which concrete can be mixed, transported, placed, compacted and finished without segregation. Slump test is the simplest method used for measuring workability.

Procedure

1. Clean the slump cone and place it on a rigid, level, and non-absorbent surface.
2. Hold the cone firmly in position using footrests.
3. Fill the cone with fresh concrete in **three equal layers**.
4. Compact each layer with **25 blows** using the tamping rod.
5. Ensure the tamping rod penetrates slightly into the underlying layer.
6. Fill the top layer slightly above the mould and strike off excess concrete using a trowel.
7. Remove any spilled concrete around the base.
8. Lift the cone vertically upward slowly within **5–10 seconds** without disturbing the concrete.
9. Allow the concrete to subside freely.
10. Measure the difference between the height of the mould and the highest point of slumped concrete.
11. Record the slump value.

Observation Table

Height of cone = 300 mm
Initial concrete height = 300 mm
Height after slump = 240 mm

Slump value = 60 mm
Type of slump = True slump

Calculation

Slump Value = Original Height − Height after Slump
= 300 − 240
= 60 mm

Result

The slump value of the concrete sample was found to be 60 mm. Hence the concrete possesses medium workability.

Conclusion

The slump test was successfully performed and the concrete showed medium workability with true slump.

Precautions

1. Use rigid surface.
2. Fill equal layers.
3. Give exactly 25 blows.
4. Lift cone vertically.
5. Measure immediately.