



**SRM VALLIAMMAI ENGINEERING COLLEGE**

*(AN AUTONOMOUS INSTITUTION)*

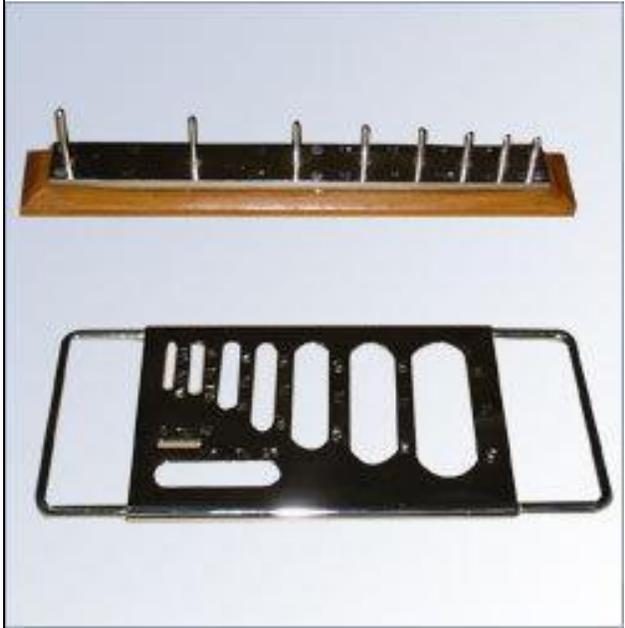
**SRM NAGAR, KATTANKULATHUR – 603 203**



**CE3367 -CONSTRUCTION MATERIALS LABORATORY**

**LAB INSTRUCTION MANUAL**

**(THIRD SEMESTER)**



**DEPARTMENT OF CIVIL ENGINEERING**

**REGULATION 2023**

**ACADEMIC YEAR (2025-2026)**

## **PREFACE**

This instruction manual has been prepared by the department of Civil Engineering to facilitate instructions doing practical classes and further to be used as a reference manual by the third semester Civil Engineering students of this college. This manual cover explanation of experiments included in the syllabus according to Regulation 2023 Construction Materials Laboratory (CE3367) for the B.E Civil Engineering degree course.

**Ms.K.Suganya Devi**

Assistant Professor (O.G)

## **Specific Rules and Hazards Associated with this Lab Include**

**Capacity**-Normal Occupancy during teaching labs is 34

- Students should enter the lab with proper uniform and ID card.
- Always keep work areas clean and tidy.
- Observe safety alerts in the laboratory.
- Always wear shoes that completely cover your feet. No sandals or opened toed shoes are allowed.
- Follow all written and verbal instructions carefully.
- Observe the safety alerts in the laboratory.
- Don't forget to bring Lab manual, Record, observation, calculator, graph sheet and other accessories when you come to lab.
- In the absence of Instructor, no student shall be allowed to work in the laboratory.
- Don't use mobile phones during lab hours.
- Place tools and equipment in proper place after use.
- Turn off the power switches of weighing balance and equipment's after used.
- Report to the staff if any injuries.
- Don't try to repair any faulty instruments.

**COURSE OBJECTIVES:****To impart knowledge on the following topics**

- To facilitate the understanding of the behavior cement.
- To know about the various test procedures on Fine aggregates
- To know about the various test procedures on Coarse aggregates
- To know about the various test procedures on Bricks.
- To understand applications various construction materials.

**LIST OF EXPERIMENTS:****I. TESTS ON CEMENT**

- a. Determination of fineness of cement
- b. Determination of consistency of cement
- c. Determination of specific gravity of cement
- d. Determination of setting time of cement

**II. TESTS ON FINE AGGREGATE**

- a. Determination of specific gravity of fine aggregate
- b. Determination of grading of fine aggregate
- c. Determination of water absorption for fine aggregate

**III. TESTS ON COARSE AGGREGATE**

- a. Determination of compacted and loose bulk density of coarse aggregate
- b. Determination of impact value of coarse aggregate
- c. Determination of elongation index and flakiness index of coarse aggregate
- d. Determination of aggregate crushing value of coarse aggregate
- e. Determination of specific gravity and water absorption of coarse aggregate

**IV. TESTS ON BRICKS**

- a. Determination of compressive strength of bricks.
- b. Determination of water absorption and efflorescence of bricks.

**TOTAL: 45 PERIODS**

## LIST OF EQUIPMENTS FOR A BATCH OF 30 STUDENTS

Sl.No.	Description of Equipment	Quantity
1.	Vicat Appratus	1
2.	Le chatelier Appratus	1
3.	Pycnometer	1
4.	Weighing Balance	1
5.	Compression testing machine	1
6.	Aggregate impact testing machine	1
7.	Length Gauge	1
8.	Thickness Gauge	1
9.	Aggregate Crushing Value Apparatus	1
10.	Trovels and planers	1 Set
11.	Sieves	1 Set

### **COURSE OUTCOMES:**

1. The students will have the required knowledge in the area of testing of construction Materials.
2. Will be able to test the quality of cement.
3. Will be analyze the properties of fine aggregate.
4. Will be analyze the properties of coarse aggregate.
5. Will be able to test brick's quality.

### **REFERENCES:**

1. Construction Materials Laboratory Manual, Anna University, Chennai-600 025.
2. IS 4031 (Part 1) – 1996 – Indian Standard Method for determination of fineness by dry sieving.
3. IS 2386 (Part 1 to Part 6) – 1963 – Indian Standard methods for test for aggregate
4. for concrete.
5. IS 383 – 1970 Indian Standard specification for coarse and fine aggregates from natural sources for concrete.

CE3367	PROGRAM OUTCOMES												PSO			
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
CO1	3	-	-	-	-	-	2	1	2	2	0	2	2	-	1	3
CO2	3	-	-	-	-	-	2	1	2	0	0	2	2	-	1	3
CO3	3	2	-	-	-	-	0	1	2	0	2	0	2	-	1	3
CO4	3	2	-	-	-	-	2	1	2	0	0	2	2	-	1	3
CO5	3	-	-	-	-	-	2	1	2	2	0	2	2	-	1	3
<b>Average</b>	<b>3.0</b>	<b>2.0</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>1.6</b>	<b>1.0</b>	<b>2.0</b>	<b>0.8</b>	<b>0.4</b>	<b>1.6</b>	<b>2.0</b>	<b>-</b>	<b>1.0</b>	<b>3.0</b>

### PROGRAMME OUTCOMES (POs):

After going through the four years of study, our Civil Engineering Graduates will exhibit ability to:

PO	Graduate Attribute	Programme Outcome
1	Engineering knowledge	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization for the solution of complex engineering problems.
2	Problem analysis	Identify, formulate, research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
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 public health and safety, and cultural, societal, and environmental considerations.
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
5	Modern tool usage	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling to complex engineering activities, with an understanding of the limitations.
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
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.

8	Ethics	Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice
9	Individual and team work	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings
10	Communication	Communicate effectively on complex engineering activities with the engineering community and with the society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions
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
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

**PROGRAM SPECIFIC OUTCOMES (PSOs):**

By the completion of Civil Engineering program, the student will have following Program specific outcomes

1. Establish a Civil Engineering career in industry, government or academic field and achieve professional expertise as appropriate.
2. Execute innovation and excellence in Civil engineering problem solving and design in global and societal contexts.
3. Commit to lifelong learning and professional development in the Civil Engineering field to stay updated in technology, research topics and contemporary issues.
4. Understand the fundamentals of Civil Engineering in commercial contexts and in expeditin construction projects.

## LIST OF EXPERIMENTS

EX.NO	EXPERIMENT NAME
<b>I. TESTS ON CEMENT</b>	
1.	Determination of fineness of cement
2.	Determination of consistency of cement
3.	Determination of specific gravity of cement
4.	Determination of setting time of cement
<b>II. TEST ON FINE AGGREGATES</b>	
5.	Determination of specific gravity of fine aggregate
6.	Determination of grading of fine aggregate
7.	Determination of compacted and loose bulk density of fine aggregate
<b>III. TEST ON COARSE AGGREGATE</b>	
8.	Determination of impact value of coarse aggregate
9.	Determination of elongation index and flakiness index of coarse aggregate
10.	Determination of aggregate crushing value of coarse aggregate
11.	Determination of specific gravity of coarse aggregate
12.	Determination of water absorption for coarse aggregate
<b>IV. TEST ON BRICKS</b>	
13.	Test for compressive strength of bricks
14.	Test for Water absorption of bricks
15.	Determination of Efflorescence of bricks

# I. TESTS ON CEMENT

## 1. DETERMINATION OF FINENESS OF CEMENT BY SIEVING

**Aim:** 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.)	Percentage 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.

## 2. CONSISTENCY TEST ON CEMENT

**Aim:** 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 \_\_\_\_

### 3. DETERMINATION OF SPECIFIC GRAVITY OF CEMENT

**Aim:** Determination of specific gravity of cement using Le-Chatelier flask.

**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. (W1) : \_\_\_\_\_
- Initial reading of flask in ml (V1) : \_\_\_\_\_
- Final reading of flask in ml (V2) : \_\_\_\_\_
- Volume of cement particle (V2 - V1) : \_\_\_\_\_
- Weight of equal volume of water in g. (W2) : \_\_\_\_\_
- Specific gravity of cement (W1/ W2) : \_\_\_\_\_

#### Result and conclusion:

Specific gravity of the given cement obtained as \_\_\_\_\_.

## 4. DETERMINATION OF SETTING TIMES OF CEMENT

**Aim:** 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  $1 \text{ mm}^2$ ); 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  $5.0 \pm 0.5 \text{ mm}$  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	

**Result :**

Initial setting time of cement (in min): \_\_\_\_\_

Final setting time (in min): \_\_\_\_\_

**Conclusion:**

1. 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.

## VIVA QUESTIONS

### **Fineness of cement & Normal consistency**

1. What do you mean by fineness?
2. Which type of sieve used in fineness test?
3. According to IS, How much fineness of cement is preferred?
4. According to IS, How much residue of cement is preferred?
5. What is the key role of fineness of cement in strength?
6. What is the advantage of fineness?
7. What you mean by normal consistency?
8. Which type of apparatus used in consistency test?
9. Based on which principle vicat apparatus worked?
10. Which type of needle used in consistency test?
11. What is the diameter of Plunger?
12. How many needles present in vicat apparatus?
13. According to IS, How much consistency of cement is preferred?

### **Initial & Final setting time of cement**

1. What do you mean by setting time?
2. What do you mean by initial setting time?
3. What do you mean by final setting time?
4. Which type of apparatus used in cement setting test?
5. Which type of needle used in initial setting test?
6. Which type of needle used in final setting test?
7. What is the diameter of initial setting time needle?
8. What is the diameter of final setting time needle?

9. How much of water added to cement in setting time of cement test?
10. According to IS, how much of initial setting time of cement is preferred?
11. According to IS, how much of final setting time of cement is preferred?
12. How can you determined intial setting time as per experiment?
13. How can you determine final setting time as per experiment?

### **Specific gravity of cement & Soundness of cement**

1. What do you mean by specific gravity?
2. Why we have to done specific gravity experiment of cement by using kerosene?
3. Which type of apparatus used in specific gravity of cement test?
4. What is the capacity of pycnometer?
5. According to IS, How much of specific gravity of cement is preferred?

## II. TEST ON FINE AGGREGATES

### 5. DETERMINATION OF SPECIFIC GRAVITY OF FINE AGGREGATE

**Aim:**

To determine specific gravity of fine aggregate

**Apparatus Required:**

1. Pycnometer (either a Pycnometer jar with conical top or a stoppered bottle having a capacity of at least 50ml)
2. 4.75mmsieve
3. Weighing balance
4. Oven
5. Glass rod
6. Distilled water

**Procedure:**

1. Clean and dry the Pycnometer
2. Weigh the empty Pycnometer with its cap(W1)
3. Take about 200gm of oven dried soil passing through 4.75mm sieve into the Pycnometer and weigh again(W2)
4. Add sufficient de-aired water to cover the soil and screw on the cap
5. Shake the Pycnometer well and remove entrapped air if any
6. Fill the Pycnometer with water completely
7. Dry the Pycnometer from outside and weigh it(W3)
8. Clean the Pycnometer by washing thoroughly
9. Fill the cleaned Pycnometer completely with water up to its top with cap screw on
10. Weigh the Pycnometer after drying it on the outside thoroughly(W4)
11. Repeat the procedure for three samples and obtain the average value of specific gravity.

**Observation and Calculation**

Weight of empty Pyconometer, W1=

Weight of Pyconometer +soil sample, W2=

Weight of Pyconometer + soil sample + water, W3 =

Weight of Pyconometer+water, W4=

Calculate the specific gravity of the soil, as follows,

$$\text{Specific gravity} = G_s = (W_2 - W_1) / (W_2 - W_1) - (W_3 - W_4)$$

**Result:**

The specific gravity of the test sample =

## VIVA QUESTIONS

- 1. What is the significance of specific gravity test of sand?**  
Specific Gravity is the ratio of the weight of a given volume of aggregate to the weight of an equal volume of water. Water, at a temperature of 73.4°F (23°C) has a specific gravity of 1. Specific Gravity is important for several reasons. Some deleterious particles are lighter than the "good" aggregates.
- 2. What is the specific gravity of fine aggregate range as per IS code**  
Specific gravity of fine aggregate (sand) is the ratio of the weight of given volume of aggregates to the weight of equal volume of water. The specific gravity of sands is considered to be around 2.65.
- 3. What is the density of M Sand?**  
The Fineness modulus of river sand is 5.24. Manufactured Sand: M-Sand was used as partial replacement of fine aggregate. The bulk density of Manufactured sand was 1.75 kg/m<sup>3</sup>, specific gravity and fineness modulus was found to be 2.73 and 4.66, respectively.
- 4. Why specific gravity test is done?**  
It is used to define the weight or density of a liquid as compared to the density of an equal volume of water at a specified temperature. The temperature used for measurement is usually 39.2° F (4° C), because this temperature allows water to assume its maximum density.
- 5. How heavy is 1m<sup>3</sup> of sand?**  
Sand, dry weighs 1.631 gram per cubic centimetre or 1 631 kilogram per cubic meter, i.e. density of sand, dry is equal to 1 631 kg/m<sup>3</sup>. In Imperial or US customary measurement system, the density is equal to 101.8 pound per cubic foot [lb/ft<sup>3</sup>], or 0.9428 ounce per cubic inch [oz/inch<sup>3</sup>].
- 6. What is M Sand and P sand?**  
If i am not mistaken, P sand stands for Plastering sand. Other types are manufactured sand (m sand), sharp sands, buildings sands etc ..... The difference is in the size of the particles. Plastering sand will have fine grained particles, whereas manufactured sand will have little coarser particles may be
- 7. What is the weight of 1 CFT sand?**  
1 cft of sand would weigh around 45 kgs.
- 8. What is one unit of sand?**  
Equals: 35.31 **cubic feet** (cu ft - ft<sup>3</sup>) in volume. Converting **cubic foot** to cubic meters value in the beach sand units scale.

## 6. DETERMINATION OF GRADING (FINENESS MODULUS) OF FINE AGGREGATE

### Aim:

To determine fineness modulus of fine aggregate and classifications based on IS: 383-1970.

### Apparatus Required:

1. Test Sieves conforming to IS:460-1962.
2. Specification of 4.75 mm, 2.36 mm, 1.18 mm, 600 micron, 300micron, 150micron.
3. Weigh Balance
4. Gauging Trowel
5. Stop Watch

### Procedure:

1. The sample shall be brought to an air-dry condition before weighing and sieving.
2. The air-dry sample shall be weighed and sieved successively on the appropriate sieves starting with the largest.
3. Material shall not be forced through the sieve by hand pressure.
4. Lumps of fine material, if present, may be broken by gentle pressure with fingers against the side of the sieve.
5. Light brushing with a fine camel hair brush may be used on the 150-micron and 75-micron IS Sieves to prevent aggregation of powder and blinding of apertures.
6. On completion of sieving, the material retained on sieve, together with any material cleaned from the mesh, shall be weighed.

Observation and Calculation		
Weight of empty tray	=	kg
Weight of tray + fine aggregate	=	kg
Weight of fine aggregate	=	kg

IS Sieve	Weight Retained on Sieve	Percentage of Weight Retained (%)	Percentage of Weight Passing (%)	Cumulative Percentage of Passing (%)
4.75 mm				
2.36 mm				
1.18 mm				
600 micron				
300 micron				
<b>Total</b>				

Fineness modulus =  $F/100$

**Result:**

The fineness modulus of fine aggregate is \_\_\_\_\_.

## VIVA QUESTIONS

1. Fine Aggregates should pass through which IS sieve?  
4.75mm IS sieve is the aggregate size deciding sieve. Anything retained on sieve is coarse aggregate and the ones that pass through sieve are fine aggregates.
2. How many types of fine aggregates are there based on source?  
Three types are natural sand (river banks), crushed stone sand (hard stone) and crushed gravel sand (gravel).
3. What is the use of fineness modulus of fine aggregate?  
Fineness modulus is generally used to get an idea of how coarse or fine the aggregate is. More fineness modulus value indicates that the aggregate is coarser and small value of fineness modulus indicates that the aggregate is finer.
4. What is the percentage of fine aggregate of fineness modulus?  
 $Z =$  Economical value of fineness modulus for combined aggregate. The above formula will fix the proportion of fine aggregate to coarse aggregate. The percentage of the coarse aggregate is equal to 100 minus the percentage of fine aggregate.
5. Why is the fineness modulus important?  
Fineness modulus offers a way to quantify the average size of the aggregate particles in the concrete mix. The size of the particles, in turn, will greatly affect how easily the concrete pours and spreads, as well as its strength and durability once cured.
6. How do you calculate fine modulus?  
Fineness modulus of sand (fine aggregate) is an index number which represents the mean size of the particles in sand. The cumulative percentage retained on each sieve is added and subtracted by 100 gives the value of fineness modulus.
7. Is code for fineness modulus of sand?  
The larger the value, the coarser is the material. Fine aggregate is classified as coarse sand, medium sand and fine sand based on the fineness modulus (IS 2386 - PART III 1963) as shown in Table 3.6. Sand having a fineness modulus more than 3.2 will be unsuitable for making satisfactory concrete.
8. Which sand is used for plastering?  
Basically river sand are used for any plastering work. Generally, in any plastering work plasterers are used natural sand, crushed stone sand or crushed gravel sand. Though, there is a grading limit of sand which are used in plastering work. Other types of sand will also work, but it could be more expensive to use.
9. Is M Sand good for plastering?  
Plastering M Sand is used for Wall plastering and brickwork purposes. The granule thickness is 150 microns to 4.75 mm and is suitable for concrete preparations required for construction purposes. The granule thickness is 150 microns to 2.38 mm is ideal for block masonry and plastering purposes.

## **7. DETERMINATION OF COMPACTED AND LOOSE BULK DENSITY OF FINE AGGREGATES**

### **Aim:**

To determine compacted and loose bulk density of fine aggregate.

### **Apparatus Required:**

1. Weighing balance
2. Cylindrical metal measure
3. Tamping rod

### **1 Procedure for Compacted Bulk Density**

1. Measure the volume of the cylindrical metal measure by pouring water into the metal measure and record the volume "V" in litre.
2. Fill the cylindrical metal measure about one-third full with thoroughly mixed aggregate and tamp it 25 times using tamping bar.
3. Add another layer of one-third volume of aggregate in the metal measure and give another 25 strokes of tamping bar.
4. Finally fill aggregate in the metal measure to over-flowing and tamp it 25 times.
5. Remove the surplus aggregate using the tamping rod as a straight edge.
6. Determine the weight of the aggregate in the measure and record that weight "W" in kg.

### **Procedure for Loose Bulk Density**

1. Measure the volume of the cylindrical metal measure by pouring water into the metal measure and record the volume "V" in litre.
2. Fill the cylindrical measure to over flowing by means of a shovel or scoop, the aggregate being discharged from a height not exceeding 5 cm above the top of the measure
3. Level the top surface of the aggregate in the metal measure, with a straightedge or tamping bar.
4. Determine the weight of the aggregate in the measure and record the weight "W" in kg.

## **Observation and Calculation**

### **Calculation for Compacted Bulk Density**

Compacted unit weight or bulk density =  $W/V$

Where,

$W$  = Weight of compacted aggregate in cylindrical metal measure, kg

$V$  = Volume of cylindrical metal measure, litre

### **Calculation For Loose Bulk Density**

Loose unit weight or bulk density =  $W/V$

Where,

$W$  = Weight of loose aggregate in cylindrical metal measure, kg

$V$  = Volume of cylindrical metal measure, litre

### **Result:**

The compacted bulk density of the given sample =

The loose bulk density of the given sample =

## VIVA QUESTIONS

1. What is bulk density of fine aggregate?  
If the volume is unit then, Bulk Density= Mass. Unit in  $\text{kg/m}^3$  or  $\text{lb/ft}^3$ . In this definition, the volume is that contain both the aggregates and the voids between aggregates particles. The approximate bulk density of aggregate that is commonly used in normal-weight concrete is between 1200-1750  $\text{kg/m}^3$  (75-110  $\text{lb/ft}^3$ ).
2. Are sieves fine aggregates?  
Size of sieves to be used: For fine aggregate- 4.75mm, 2.36mm, 1.18mm, 600 microns, 300 microns, 150 microns. For coarse aggregate-25mm,20mm 12.5mm, 10mm, 4.75mm.
3. Why Bulk density is important?  
High bulk density is an indicator of low soil porosity and soil compaction.
4. What factors affect bulk density?  
Inherent factors that affect bulk density such as soil texture cannot be changed. Bulk density is dependent on soil organic matter, soil texture, the density of soil mineral (sand, silt, and clay) and their packing arrangement.
5. How Bulk density is measured?  
Bulk Density. Bulk density is the volume of powder per gram of weight in a cylinder, after 50 mechanical taps. Tap density is measured in a tapping machine containing a graduated cylinder that moves up and down. Powdered material is introduced into the cylinder.
6. What is bulk density of sand?  
The bulk density or unit weight of sand is the mass or weight of the sand that required to fill a container of a specified unit volume. Bulk Density of sand =  $\frac{\text{Mass of sand}}{\text{volume}}$ .  
Key Features: If the volume is unit then, Bulk Density= Mass. Unit in  $\text{kg/m}^3$  or  $\text{lb/ft}^3$ .
7. What is dry bulk density?  
Background. The soil bulk density (BD), also known as dry bulk density, is the weight of dry soil ( $M_{\text{solids}}$ ) divided by the total soil volume ( $V_{\text{soil}}$ ). The total soil volume is the combined volume of solids and pores which may contain air ( $V_{\text{air}}$ ) or water ( $V_{\text{water}}$ ), or both
8. What is the mass of sand?  
A grain of sand has a mass of approximately . 00000003 grams.
9. What does 1 yard of sand weigh?  
The approximate weight of 1 cubic yard of sand is 2,600 to 3,000 pounds. This amount is also roughly equal to 1 1/2 tons. A cubic yard of gravel will weigh slightly less, at roughly 2,400 to 2,900 pounds, or roughly still 1 1/2 tons.
10. Will 2 yards of sand fit in a pickup truck?  
A regular size pick-up will hold three cubic yards of mulch (a full load). Two cubic yards is about body level full. When picking up soils, sands and gravels, one cubic yard is all that is recommended on a pick-up truck. Below is an outline of what your truck may be able to handle.

### III TEST ON COARSE AGGREGATES

#### 8. DETERMINATION OF IMPACT VALUE OF COARSE AGGREGATE

**Aim:**

To determine the aggregate impact value of given aggregate

**Apparatus Required:**

1. Impact testing machine: The machine consists of a metal base. A detachable cylindrical steel cup of internal diameter 10.2 cm and depth 5 cm. A metal hammer of weight between 13.5 to 14 kg, 10 cm in diameter and 5 cm long. An arrangement for raising the hammer and allow it to fall freely between vertical guides from a height of 38cm on the test sample in the cup.
2. A cylindrical metal measure having 7.5cm diameter and depth of 5cm for measuring aggregates
3. A tamping rod of circular cross section, 1cm in diameter and 23cm long, rounded at one end.
4. IS sieve of sizes 12.5 mm, 10 mm and 2.36mm
5. Balance of capacity not less than 500gm to weigh accurate upto 0.01gm

**Procedure:**

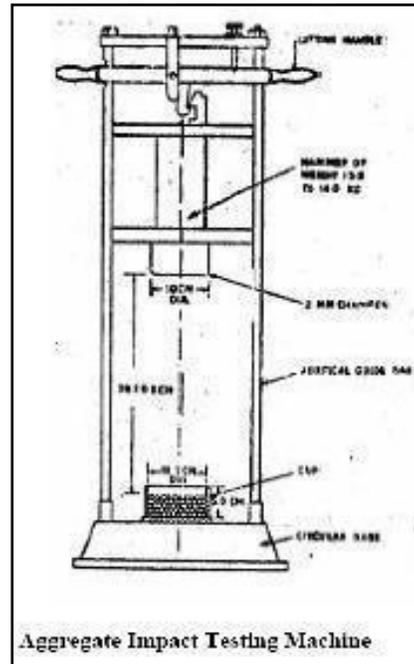
1. The test sample consists of aggregates passing 12.5mm sieve and retained on 10mm sieve and dried in an oven for 4 hours at a temperature of 1000 °C to 1100 °C.
2. The aggregates are filled upto about 1/3 full in the cylindrical measure and tamped 25 times with rounded end of the tamping rod.
3. The rest of the cylindrical measure is filled by two layers and each layer being tamped 25 times.
4. The overflow of aggregates in cylindrical measure is cut off by tamping rod using its straight edge.
5. Then the entire aggregate sample in a measuring cylinder is weighted nearing to 0.01gm.
6. The aggregates from the cylindrical measure are carefully transferred into the cup which is firmly fixed in position on the baseplate of machine. Then it is tamped 25 times.
7. The hammer is raised until its lower face is 38cm above the upper surface of

aggregates in the cup and allowed to fall freely on the aggregates. The test sample is subjected to a total of 15 such blows each being delivered at an interval of not less than one second. The crushed aggregate is then removed from the cup and the whole of it is sieved on 2.36mm sieve until no significant amount passes. The fraction passing the sieve is weighed accurate to 0.1gm

8. Repeat the above steps with other fresh sample
9. Let the original weight of the oven dry sample be  $w_1$  gm and the weight of fraction passing 2.36 mm IS sieve below 2gm. Then aggregate impact value is expressed as the % of fines formed in terms of the total weight of the sample.

### Observation and Calculation

	Details of Sample	Trail 1	Trail 2	Average
1	Total Weight of aggregate sample filling the cylinder measure = $W_1$ g			
2	Weight of aggregate passing 2.36mm sieve after the test = $W_2$ g			
3	Weight of aggregate retained 2.36mm sieve after the test = $W_3$ g			
4	$(W_1 - W_2 + W_3)$			
5	Aggregate Impact Value = $(W_2 / W_1) * 100$ Percent			



**Result:**

The mean aggregate impact value is % =

## VIVA QUESTIONS

1. Why aggregate impact value test is done?  
The aim of aggregate impact test is to determine the relative measure of the resistance of aggregate to sudden shock or impact in which in some aggregate differs from its resistance to a slowly applies compressive load. The property of a material to resist impact is known as toughness.
2. What are the uses of determining impact value?  
To determine the impact value of the aggregates used in pavement construction(Road); To assess their suitability in road layers (base course, surface course ) construction on the basis of impact value.
3. What is impact value?  
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.
4. Why do we do impact test?  
Impact test determines the amount of energy absorbed by a material during fracture. This absorbed energy is a measure of a given material's toughness and acts as a tool to study temperature-dependent brittle-ductile transition. It is to determine whether the material is brittle or ductile in nature.
5. What is aggregate toughness?  
Toughness. Resistance of the aggregates to impact is termed as toughness. Aggregates used in the pavement should be able to resist the effect caused by the jumping of the steel tyred wheels from one particle to another at different levels causes severe impact on the aggregates
6. What are the types of aggregate?  
The Different Types Of Aggregate. The categories of aggregates include gravel, sand, recycled concrete, slag, topsoil, ballast, Type 1 MOT, and geosynthetic aggregates (synthetic products commonly used in civil engineering projects used to stabilise terrain).
7. What are the advantages of aggregate impact test?  
The advantages of aggregates impact test are that the test equipment and procedure are simple, and it can obtain the resistance and impact of stones even in field condition. The test can be done in brief period whether it is at construction site.
8. What are the test for coarse aggregate?  
Crushing test.  
Abrasion test.  
Impact test.  
Soundness test.  
Shape test.  
Specific gravity and water absorption test.  
Bitumen adhesion test.
9. What is grading of coarse aggregate?  
Grading of aggregates is determining the average grain size of the aggregates before they are used in construction. This is applied to both coarse and fine aggregates. The aggregate sample is sieved through a set of sieves and weights retained on each sieve in percentage terms are summed up.
10. What is 20mm aggregate?  
It is the aggregate composed of both fine aggregate and coarse aggregate. ... For example, all in aggregate of nominal size of 20mm means an aggregate most of which passes through 20 mm IS sieve and contains fine aggregates also.

## 9.a. DETERMINATION OF ELONGATION INDEX

### Aim:

To determine the Elongation index of the given aggregate sample

### Apparatus Required:

1. Length gauge
2. IS sieve

### Procedure:

1. The sample is sieved through IS Sieve specified in the table. A minimum of 200 aggregate pieces of each fraction is taken and weighed
2. Each fraction is thus gauged individually for length in length gauge. The gauge length is used should be those specified in the table for the appropriate material
3. The pieces of aggregate from each fraction tested which could not pass through the specified gauge length with its long side are elongated particles and they are collected separately to find the total weight of aggregate retained on the length gauge from each fraction.
4. The total amount of elongated material retained by the length gauge is weighed to an accuracy of at least 0.1% of the weight of the test sample.
5. The weight of each fraction of aggregate passing and retained on specified sieves sizes are found –  $W_1, W_2, W_3, \dots$  and the total weight of sample determined =  $W_1 + W_2 + W_3 + \dots = W$  gm. Also the weights of the material from each fraction retained on the specified gauge length are found =  $x_1, x_2, x_3, \dots$  and the total weight retained determined =  $x_1 + x_2 + x_3 + \dots = X$  gm
6. The elongation index is the total weight of the material retained on the various length gauges, expressed as a percentage of the total weight of the sample gauged

### Observation and Calculation

Size of aggregate		Length gauge	Weight of the fraction consisting of atleast 200 pieces in gm	Weight of aggregates in each fraction retained on length gauge gm
Passing through IS sieve mm	Retained on IS sieve mm			
63	50	-		
50	40	81		
40	25	58.50		
31.5	25	-		
25	20	40.5		
20	16	32.4		
16	12.5	25.6		
12.5	10	20.2		
10	6.3	14.7		



Elongation Index Test in Progress

### Result:

The elongation index of a given sample of aggregate is \_\_\_\_\_ %

## VIVA QUESTIONS

1. What do you infer from elongation index?  
Flakiness Index is the percentage by weight of particles in it, whose least dimension (i.e. thickness) is less than three-fifths of its mean dimension. Elongation Index is the percentage by weight of particles in it, whose largest dimension (i.e. length) is greater than one and four-fifths times its mean dimension.
2. Why elongation index test is conducted?  
This test is used to determine the particle shape of the aggregate and each particle shape being preferred under specific conditions. The significance of flakiness & elongation index is as follows; ... Due to high surface area to volume ratio, the flaky and elongated particles lower the workability of concrete mixes.
3. What is elongation index?  
Elongation index of an aggregate is the percentage by weight of particles whose greatest dimension (length) is greater than one and four-fifth times (1.8 times or 9/5 times) their mean dimension. It is measured on particles passing through mesh size of 63mm and retained on mesh size of 6.3mm.
4. What is combined flakiness and elongation index?  
Flakiness index is weight of flaky stone metal divided by. weight of stone sample. Only the elongated particles be separated out from the remaining (non-flaky) stone metal. Elongation index is weight of elongated particles divided by total non-flaky particles.
5. Is code for elongation index?  
The Elongation index of an aggregate is the percentage by weight of particles whose greatest dimension (length) is greater than nine-fifths (1.8times) their mean dimension. This test is not applicable for sizes smaller than 6.3mm.
6. Coarse aggregates are classified into how many groups?  
The two main groups of coarse aggregates are single-sized aggregates and graded aggregates.
7. Graded aggregate contains particles of size:  
It consists of aggregates of more than one single grade. It ideally contains particles of size 4.75mm and above in a proportionate amount.
8. Which size coarse aggregate is ideal for use in a concrete mix?  
Using the largest size will result in a reduction of cement, water and shrinkage in the concrete mix.
9. Gravel is a type of?  
All gravel particles have an irregular shape and sharp edge. Sand has a rounded shape. Laminated rocks have flaky shape and crushed rocks have an angular shape.
10. How is percentage retained on each sieve calculated?  
The percentage retained is calculated by dividing weight of sample retained by the weight of the total sample, taken in beginning of test.

## 9.b DETERMINATION OF FLAKINESS INDEX

### Aim:

To determine the flakiness index of the given aggregate sample

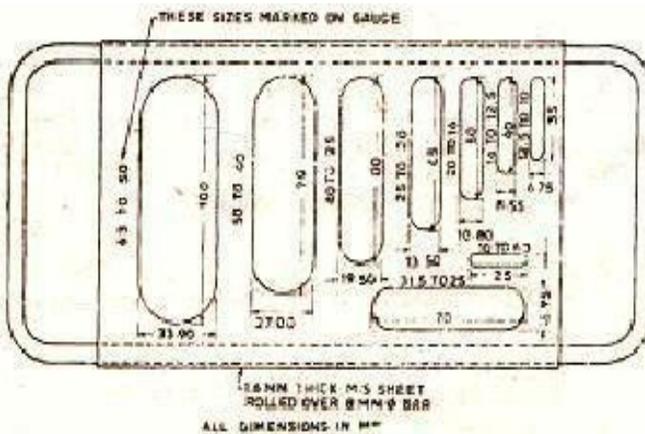
### Apparatus Required:

1. The apparatus consist of a standard thickness gauge
2. IS Sieve of size 63, 50, 40, 31.5, 25, 20, 16, 12.5, 10 and 6.3
3. Balance to weight the samples

### Procedure:

1. The sample is sieved with the sieves mentioned in the table
2. A minimum of 200 pieces of each fraction to be tested are taken and weighed ( $W_1$ gm)
3. In order to separate flaky materials, each fraction is then gauged for thickness on thickness gauge, or in bulk on sieve having elongated slots as specified in the table.
4. Then the amount of flaky materials passing the gauge is weighed to an accuracy of at least 0.1% of test sample.
5. Let the weight of the flaky materials passing the gauge be  $W_1$ gm. Similarly the weights of the fractions passing and retained on the specified sieves be  $W_1, W_2, W_3$ , etc, are weighed and the total weight  $W_1+W_2+W_3+\dots = W$  gm is found. Also the weights of the materials passing each of the specified thickness gauge are found =  $W_1, W_2, W_3, \dots$ . And the total weight of the material passing the different thickness gauges =  $W_1+W_2+W_3+\dots = W$  gm is found
6. Then the flakiness index is the total weight of the flaky material passing the various thickness gauges expressed as a percentage of the total weight of the sample gauged.

$$\text{Flakiness index} = \frac{(w_1 + w_2 + w_3 + \dots)}{(W_1 + W_2 + W_3 + \dots)} \times 100$$



Flakiness Index Test in Progress

Size of aggregate		Thickness gauge (0.6 times the mean sieve) mm	Weight of the fraction consisting of at least 200 pieces in gm	Weight of aggregates in each fraction passing on thickness gauge gm
Passing through IS sieve mm	Retained on IS sieve mm			
63	50	33.90		
50	40	27.00		
40	25	19.50		
31.5	25	16.50		
25	20	13.50		
20	16	10.80		
16	12.5	8.55		
12.5	10	6.75		
10	6.3	4.89		

**Result:**

The flakiness index of a given sample of aggregate is \_\_\_\_\_ %

## VIVA QUESTIONS

1. How do you find the flakiness index?  
The flakiness index of an aggregate sample is found by separating the flaky particles and expressing their mass as a percentage of the mass of the sample tested. The test is not applicable to materials passing the 6.30 mm test sieve or retained on the 63.00 mm test sieve.
2. What is flakiness and elongation test?  
Theory of Flakiness Index and Elongation Index Tests  
The Flakiness index of aggregates is the percentage by weight of particles whose least dimension (thickness) is less than three-fifths (0.6times) of their mean dimension. This test is not applicable to sizes smaller than 6.3mm.
3. What is flakiness index test?  
The Flakiness Index is the total weight of the material passing the various thickness gauges or sieves, expressed as a percentage of the total weight of the sample gauged. ... The total amount retained by the length gauge shall be weighed to an accuracy of at least 0.1 percent of the weight of the test sample.
4. Is code for flakiness index?  
Aggregate Flakiness Index Value (Is:2386-Part 1-1963)
5. Why do we do flakiness index?  
This test is used to determine the particle shape of the aggregate and each particle shape being preferred under specific conditions. The significance of flakiness & elongation index is as follows; ... Due to high surface area to volume ratio, the flaky and elongated particles lower the workability of concrete mixes.
6. What is the use of flakiness index and elongation index?  
Flakiness Index is the percentage by weight of particles in it, whose least dimension (i.e. thickness) is less than three-fifths of its mean dimension. Elongation Index is the percentage by weight of particles in it, whose largest dimension (i.e. length) is greater than one and four-fifths times its mean dimension.
7. Flaky particles have:  
Flaky particles have a small thickness compared to the dimensions of other parameters that is width and length.
8. Which of the below is a limitation of performing sieve analysis?  
The shape of particles is assumed to be nearly round or spherical so that they pass through the square opening. For elongated, flaky particles it will be difficult.

## 10. DETERMINATION OF AGGREGATE CRUSHING VALUE OF COARSE AGGREGATE

### AIM

To determine the **Aggregate Crushing Value** by compression testing machine.

### APPARATUS REQUIRED:

1. Cylindrical measure and plunger,
2. Compression testing machine,
3. IS Sieves of sizes – 12.5mm, 10mm and 2.36mm



### PROCEDURE

1. The aggregates passing through 12.5mm and retained on 10mm IS Sieve are oven-dried at a temperature of 100 to 110°C for 3 to 4hrs.
2. The cylinder of the apparatus is filled in 3 layers, each layer tamped with 25 strokes of a tamping rod.
3. The weight of aggregates is measured (Weight 'A').
4. The surface of the aggregates is then leveled and the plunger inserted. The apparatus is then placed
5. in the compression testing machine and loaded at a uniform rate so as to achieve 40t load in 10 minutes. After this, the load is released.
6. The sample is then sieved through a 2.36mm IS Sieve and the fraction passing through the sieve is weighed (Weight 'B').
7. Two tests should be conducted.

$$\text{Aggregate crushing value} = (B/A) \times 100\%.$$

### Result:

The Aggregate Crushing Value of coarse aggregate is \_\_\_\_\_

## VIVA QUESTIONS

1. What is purpose of crushing test coarse aggregate?  
Resistance of an aggregate to crushing under gradually applied compressive load.
2. What is the limit for aggregate crushing vale for cement concrete pavement  
Aggregate crushing vale for cement concrete pavement shall not exceed 30%
3. What is the limit for aggregate crushing vale for wearing surfaces  
Aggregate crushing vale for wearing surfaces shall not exceed 45%
4. What are the mechanical properties required in aggregate
  - i. Satisfactory resistance crushing under the roller during construction
  - ii. Adequate resistance to surface abrasion under traffic.
5. What is the significance of crushing strength of aggregate  
The aggregate crushing value provides a relative measure of resistance to crushing under a gradually applied load. To achieve a high quality of pavement, aggregate possessing low aggregate crushing value should be preferred.
6. List the apparatus required for aggregate crushing test
  - a) Steel cylinder with open ends, and internal diameter 152mm, square base plate, plunger having a piston of diameter 150mm, with a hole provided across the stem of the plunger so that a rod could be inserted for lifting or placing the plunger in the cylinder.
  - b) Cylindrical measure having internal diameter of 115mm and height 180mm.
  - c) Steel tamping rod with one rounded end, having a diameter of 16mm and length 450 to 600mm.
  - d) Balance of capacity 3 kg with accuracy up to 1gm.
  - e) Compressive testing machine capable of applying load of 40 tonnes, at a uniform rate of loading of 4 tonnes per minute.
7. What is crushing strength  
The capacity of a material or structure to withstand loads tending to reduce size

## 11. SPECIFIC GRAVITY ON COARSE AGGREGATE

### AIM

To determine the specific gravity on Coarse Aggregate.

### APPARATUS REQUIRED

- Balance
- Sample Container
- 5mm Sieve
- Suitable oven or stove for drying sample
- Sample splitter
- Large Absorbant Cloth

### PROCEDURE

1. After thoroughly washing to remove dust or other coatings from the surface of the particles, dry the sample to constant weight at a temperature of 100 to 110° C, cool in air at room temperature for 1 to 3 hours and then immerse in water at room temperature for a period of  $24 \pm 4$  hours.
2. Note: Where the absorption and specific gravity values are to be used in pro-portioning concrete mixtures in which the aggregates will be in their naturally moisture condition, the requirement for initial drying to constant weight may be eliminated.
3. Remove the specimen from the water and roll it in a large absorbent cloth until all visible films of water are removed. Wipe the larger particles individually. Take care to avoid evaporation of water from aggregate pores during the operation of surface-drying. Weigh the specimen in the saturated surface-dry condition. Record this and all subsequent weights to the nearest 0.5 g or 0.0001 times the sample weight, whichever is greater.
4. After weighing, immediately place the saturated surface-dry specimen in the sample container and determine its weight in water at  $23 \pm 1.7^\circ$  C, having a density of  $0.997 \pm 0.002$  g/cm<sup>3</sup>. Take care to remove all entrapped air before weighing by shaking the container while immersed.
5. Dry the specimen to constant weight at a temperature of 100 to 110° C. Cool in air at room temperature 1 to 3 hours and weigh.

## RESULTS AND CALCULATIONS

### 1. Bulk Specific Gravity

Calculate the bulk specific gravity, 23/23<sup>o</sup> C,

$$\text{Bulk Specific Gravity} = A/(B-C)$$

Where A = weight of oven-dry specimen in Air, g

B = weight of saturated surface-dry specimen in air, g

C = weight of saturated specimen in water, g

### 2. Bulk Specific Gravity (Saturated Surface-Dry Basis)

Calculate the bulk specific gravity, 23/23<sup>o</sup> C, on the basis of weight of saturated surface-dry aggregate as follows:

$$\text{Bulk Specific Gravity (saturated surface-dry basis)} = B/(B-C)$$

Where: B = weight of saturated surface-dry specimen in air, g

C = weight of saturated specimen in water, g

### 3. Apparent Specific Gravity

Calculate the apparent specific gravity, 23/23<sup>o</sup> C, as defined in Definitions E12 as follows:

$$\text{Apparent Specific Gravity} = A/(A-C)$$

Where: A = weight of oven-dry specimen in air, g

C = weight of saturated specimen in water, g

### 4. Absorption

Calculate the percentage of absorption, as defined in Definitions C125, as follows:

$$\text{Absorption \%} = [(B-A)/A] \times 100$$

Where A = weight of oven-dry specimen in air, g

B = weight of saturated surface-dry specimen in air, g

## RESULTS

1. Bulk Specific Gravity =

2. Bulk Specific Gravity (saturated surface-dry basis) =

3. Apparent Specific Gravity =

4. Absorption % =

## 12. WATER ABSORPTION TEST ON COARSE AGGREGATE

**AIM:**

To determine the water absorption of given coarse aggregate

**APPARATUS REQUIRED:**

Container, Balance, Electric Oven

**PROCEDURE:**

- 1) The coarse aggregate passing through IS 10mm sieve is taken about 200g.
- 2) They are dried in an oven at a temperature of  $110^{\circ} \pm 5^{\circ}\text{C}$  for 24 hours.
- 3) The coarse aggregate is cooled to room temperature.
- 4) Its weight is taken as ( $W_1\text{g}$ )
  
- 5) The dried coarse aggregate is immersed in clean water at a temperature  $27^{\circ} \pm 2^{\circ}\text{C}$  for 24 hours.
  
- 6) The coarse aggregate is removed from water and wiped out of traces of water with a cloth
- 7) Within three minutes from the removal of water, the weight of coarse aggregate  $W_2$  is found out
- 8) The above procedure is repeated for various samples.

**Observation and Calculation:**

Sample No.	Weight of oven dired specimen ( $W_1$ ) g	Weight of saturated specimen ( $W_2$ ) g	Weight of water absorbed $W_3=(W_2-W_1)$ g	% of water absorption $=(W_3/W_1) \times 100$

Weight of dry sample of coarse aggregate  $W_1$  =

Weight of saturated specimen  $W_2$  =

Weight of water absorbed  $W = W_2 - W_1$  =

Percentage of water absorption  $\frac{(W_2 - W_1)}{W_1} \times 100$  =

**Result:**

Water absorption of the coarse aggregate is \_\_\_\_\_

## VIVA QUESTIONS

### SPECIFIC GRAVITY ON AGGREGATE

1. **Specific Gravity/Relative Density**  
It is the ratio of the density of the aggregate material to the density of the gas free distilled water at a standard temperature (i.e. 4 °C). The relative density is a dimensionless quantity and is expressed as oven dried, saturated surface dry and apparent
2. **Oven Dried Specific Gravity**  
It is the ratio of the oven dried density of the aggregate to the density of the gas free distilled water at a standard temperature (i.e. 4 °C).
3. **Saturated Surface Dry Specific Gravity**  
It is the ratio of the saturated surface dry density of the aggregate to the density of the gas free distilled water at a standard temperature (i.e. 4 °C).
4. **Apparent Specific Gravity**  
It is the ratio of the apparent density of the aggregate to the density of the gas free distilled water at a standard temperature (i.e. 4 °C).
5. **Application of this test**  
This method determines (after 24 hours in water) the bulk specific gravity and the apparent specific gravity, the bulk specific gravity on the basis of weight of saturated surface dry aggregate and the absorption.
6. **What is the recommended value of specific gravity as per codes?**  
The specific gravity of aggregates normally used in road construction ranges from about 2.5 to 3.0 with an average of about 2.68.
7. **What is the formula to calculate Specific gravity**  
Specific gravity = (dry weight of the aggregate /Weight of equal volume of water)
8. **What is the formula to Apparent specific gravity**  
Apparent specific gravity = (dry weight of the aggregate/Weight of equal volume of water excluding air voids in aggregate)

### WATER ABSORPTION TEST ON AGGREGATES

1. **What is Absorption?**  
It is the increase in the mass of the aggregate due to the penetration of water into the pores of the particles during a prescribed period of time. The term absorption does not include the amount of water adhering to the surface of the particles. Water absorption is expressed as percentage of the dry mass.
2. **What is Apparent Density?**  
It is the mass per unit volume of the impermeable portion of the aggregate particles.  
OR  
It is the mass per unit volume of the solid portion of the particles excluding the voids.
3. **What is the purpose of this test?**
  - i. To find out the porous of aggregate.
  - ii. Durability of aggregate/concrete.
4. **What is the limitations of this test?**  
The standard limitations for 0.5 – 1%.
5. **What is meant by water absorption?**  
The ratio between wet aggregate and dry aggregate for same weights.If presents by percentage.
6. **What apparatus is required for water absorption test**  
Wire basket – perforated, electroplated or plastic coated with wire hangers for suspending it from the balance, Water-tight container for suspending the basket, Dry soft absorbent cloth – 75cm x 45cm (2 nos.), Shallow tray of minimum 650 sq.cm area, Air-tight container of a capacity similar to the basket and Oven.
7. **How long the aggregate should be placed in water for conducting this test.**  
The basket and sample should remain immersed for a period of 24 + ½ hrs afterwards.

## IV. TEST ON BRICKS

### 13. TEST FOR COMPRESSIVE STRENGTH OF BRICKS

**Aim:**

To determine the compressive strength of the bricks.

**Apparatus Required:**

1. Compressive testing machine of capacity 100T
2. Measuring scale
3. Tamping rod
4. Water bath
5. Trowel

**Procedure:**

1. Eight bricks are taken for the compressive strength testing.
2. The bricks are then immersed in water at room temperature for 24hours.
3. Then these are taken out of water and surplus water on the surfaces is wiped off with a moist cloth.
4. The frog of the bricks is flushed level with cement mortar (1:3)
5. The bricks are stored under damp jute bags for 24 hours followed by its immersion in water at room temperature for three days.
6. The bricks are placed in the compression testing machine with flat faces horizontal and mortar filled face being upwards.
7. Load is applied at a uniform rate of  $14 \text{ N/ m}^2$  per minute till failure.

**Observations:**

Sl No	Load at Failure (N)	Average area of back faces (mm <sup>2</sup> )	Compressive Strength. (N/mm <sup>2</sup> )	Remarks

**Calculation:**

$$\begin{aligned} \text{Ultimate Compressive Strength} &= \frac{\text{Ultimate load}}{\text{Area of Cross section}} \\ &= \text{N/mm}^2 \end{aligned}$$

**Result:**

Ultimate compressive strength of Brick = \_\_\_\_\_ N/mm<sup>2</sup>

## VIVA QUESTIONS

1. Is code for compressive strength of brick?  
Compressive Strength Of Brick (IS:3495-Part 1-1992)
2. Why compressive strength of brick is important?  
Compressive strength test on bricks are carried out to determine the load carrying capacity of bricks under compression with the help of compression testing machine. ... Thus, it is important to know the compressive strength of bricks to check for its suitability for construction.
3. What is the compressive strength of first class brick?  
[common burnt clay building bricks- specification (5th revision)]. hence minimum acceptable compressive strength of any class of burnt clay bricks in dry state is 3.5 MPa. First class bricks should not be less than 10 N/mm<sup>2</sup>.
4. What is the range of compressive strength for common bricks?  
Compressive strength of bricks are very variable, and may vary from 30 kg/sq. cm to 150 kg/sq. cm for hand-made burnt bricks, while compressive strength of heavy duty bricks machine pressed (also called engineering bricks) may have compressive strength as high as 450 kg/sq. cm, and even 500 kg/sq.
5. What is brick code?  
The resulting common business language is clear and instantly understandable. The building block of GPC is a product code known as a brick. There are bricks for everything from a car to a bottle of milk. The highest level of the classification is a segment, which is defined as a particular industry.
6. What is the compressive strength of brick in n mm<sup>2</sup>?  
Minimum crushing strength of brick is 3.50N/mm<sup>2</sup>.
7. How do you check the strength of fly ash bricks?  
Each brick may give different strength. Hence, average of three bricks was taken. Fly ash Bricks should not absorb water more than 12%. The bricks to be tested should be dried in an oven at a temperature of 105 to 115o C till attains constant weight cool the bricks to room temperature and weight (W1).
8. Which brick is good for construction?  
There are various types of bricks such as Common Burnt Clay Bricks, Sand Lime Bricks (Calcium Silicate Bricks), Concrete Bricks, Fly ash Clay Bricks, Fire Clay Bricks and the Hollow Brick, the latest technology in bricks segment.
9. Is Brick a code test?  
The Indian Standard IS 5454 : 1976 'Method for sampling of clay building bricks( first revision )' is a necessary adjunct to this standard.
10. Why bricks are tested for compressive strength?  
Compressive strength test on bricks are carried out to determine the load carrying capacity of bricks under compression with the help of compression testing machine. ... These load bearing masonry structures experiences mostly the compressive loads.

## 14. TEST FOR WATER ABSORPTION OF BRICKS

### Aim:

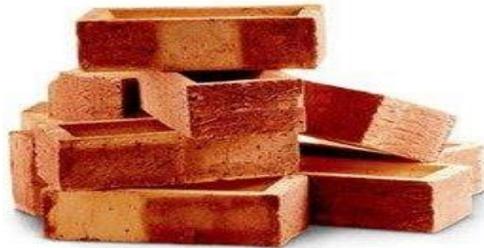
To determine the water absorption of the bricks.

### Apparatus Required:

1. A sensitive balance capable of weighing within 0.1% of the mass of the specimen
2. Ventilated oven.

### Procedure:

1. Dry the specimen in a ventilated oven at a temperature of 105°C to 115°C till it attains substantially constant mass.
2. Cool the specimen to room temperature and obtain its weight ( $M_1$ ) specimen too warm to touch shall not be used for this purpose.
3. Immerse completely dried specimen in clean water at a temperature of  $27 \pm 2^\circ\text{C}$  for 24 hours.
4. Remove the specimen and wipe out any traces of water with damp cloth and weigh the specimen after it has been removed from water ( $M_2$ ).



### Calculation:

$$W = \frac{M_2 - M_1}{M_1} \times 100$$

Water absorption, % by mass, after 24 hours immersion in cold water is given by the formula

### Result:

Water absorption of the given bricks = .....%

## VIVA QUESTIONS

1. What is the water absorption of brick?  
The acceptable water absorption for clay bricks are between 12% and 20%.
2. Why is water absorption of bricks important?  
Porosity is the ability to release and absorb moisture, and it is important and useful properties of brick.
3. What are the limits of water absorption of burnt clay bricks?  
Water absorption (IS 3495 (2): 1992) of bricks should not be more than 20% by weight up to class 12.5 and 15% for higher classes when bricks are immersed in cold water for 24 hours. Efflorescence (IS 3495 (3): 1992) should not be more than 'moderate' for class up to 12.5 and 'slight' for higher classes.
4. What are the types of bricks?  
Sun-Dried or Unburnt Clay Bricks. Sun-dried or unburnt bricks are less durable and these are used for temporary structures.  
Burnt Clay Bricks, Fly Ash Bricks, Concrete Bricks, Engineering Bricks and Sand Lime or Calcium Silicate Bricks.
5. How many bricks can bricklayer lay in a day?  
An average experienced bricklayer can lay 4–5 bricks a minute. That's roughly 240 bricks an hour. That's about 1900 bricks a day.
6. How many courses of bricks can you lay in a day?  
Working at average speeds one good bricklayer might lay 600 bricks in the day. So 1200 bricks between the gang will amount to 20m<sup>2</sup> of single skin face brickwork (60 bricks per m<sup>2</sup>).
7. Why bricks are soaked in water before use?  
When brick is soaked in water, the brick absorbs water and release air so that when it is used in masonry and placed over the wet mortar, it will no more absorb any water from the wet mortar. ... Thus, it will fail to make a strong bond between bricks and mortar. Ultimately, it will make the bonding of masonry wall weak.
8. What is the weight of a hollow concrete block?  
Concrete masonry Hollow Blocks are manufactured with 2150 Kg/m<sup>3</sup> concrete density for normal weight blocks and 1100 Kg/m<sup>3</sup> concrete density for light-weight concrete blocks. Hollow blocks are the most commonly used masonry unit.
9. Is code for hollow concrete block?  
Description of item: Hollow Concrete Blocks Confirms to IS: 2185 (Part 1): 2005. This hollow Concrete Block have open or closed cavity and can be used in the construction of load-bearing and non-load bearing partition walls.
10. How do you calculate hollow blocks?  
Once you have the wall measurements, calculate the square footage by multiplying the width times the height. wall sq. ft. = width × height , block sq. ft. = (16 × 8) ÷ 144 = . 89 sq. ft. blocks = wall sq. ft. ÷ block sq. ft.

## 15. DETERMINATION OF EFFLORESCENCE OF BRICKS

### Aim:

To determine the efflorescence of the bricks.

### Apparatus Required:

1. A shallow flat bottom dish containing sufficient distilled water to completely saturate the specimens. The dish shall be made of glass, porcelain or glazed stoneware and of size 180 mm x 150 mm X 40 mm depth for square shaped and 200 mm diameter X 40 mm depth for cylindrical shaped.
2. Distilled water
3. Brick specimens

### Procedure:

1. Fill distilled water in shallow dish and place one end of brick in dish. Water should fill in dish such that bricks should immersed in water up to 25 mm depth.
2. Place this whole arrangement in a warm ventilated room such that whole water is absorbed by the specimen and the surplus water will get evaporated.
3. Cover the dish containing brick with suitable glass cylinder so that there will not excessive evaporation from dish.
4. When whole water get absorbed and brick appears to be dry, place a similar quantity of water in the dish and allow it to evaporate as before.
5. After this process examine the bricks for efflorescence and report results.



**Result:**

Results of efflorescence test shall be reported as nil, slight, moderate, heavy or serious.

1. Nil- If there is no noticeable deposit of efflorescence.
2. Slight- when less than 10% of exposed area of brick is covered by a thin layer of salt.
3. Moderate-When there is a heavier deposit than under 'slight' and covering upto50 percent of the exposed area of the brick surface but unaccompanied by powdering or flaking of the surface.
4. Heavy – When there is a heavy deposit of salts covering 50 percent or more of the exposed area of the brick surface but unaccompanied by powdering or flaking of the surface.
5. Serious-when there is heavy deposit of salt acquired by powdering and /or flaking of exposed surface.

## VIVA QUESTIONS

1. What is efflorescence test in Brick?  
Testing Of Bricks: Efflorescence Test (IS: 3495 (Part III)): The ends of the brick are kept in a 150 mm diameter porcelain or glass dish containing 25 mm depth of water at room temperature (20 ° - 30 ° C) till the entire water is absorbed or evaporated.... When the deposit of efflorescence is imperceptible
2. Method of Efflorescence test?  
A shallow flat bottom dish containing sufficient distilled water to completely saturate the specimens. ...  
Distilled water.  
Brick specimens.
3. Does efflorescence go away?  
In many cases, efflorescence will disappear on its own over time (usually after the first year of a paver or retaining wall installation). Efflorescence can also be removed with special cleaners like the Gator Efflorescence Cleaner. On average, you should wait about 60 days before applying efflorescence cleaner.
4. What does efflorescence look like?  
Efflorescence is a crystalline deposit of salts that can form when water is present in or on brick, concrete, stone, stucco or other building surfaces. It has a white or greyish tint and consists of salt deposits left behind when water evaporates.
5. How is efflorescence caused?  
There are many mechanisms of efflorescence, often complicated. Simply stated, efflorescence occurs when water containing dissolved salts is brought to the surface of masonry, the water evaporates and the salts are left on the surface.
6. Does vinegar remove efflorescence?  
Vinegar and water solution—Efflorescence can be removed by using a dilute solution of household white vinegar and water. ... Dilution ratio is 20–50% vinegar in water by volume. For most cases of efflorescence a 25% solution works well.
7. Is efflorescence a problem?  
Efflorescence alone does not pose a major problem, but it can be an indication of moisture intrusion, which may compromise the structural material.
8. Should I worry about efflorescence?  
Ultimately, efflorescence itself isn't dangerous. However, it can lead to potential moisture problems that can cause structural damage to building materials. That means if you notice efflorescence in the basement or on concrete and other structures, it's important to take action.
9. How do you stop efflorescence?  
Clear water repellents, silicone and acrylic coatings also may help you remove efflorescence as well. The coating will absorb water across a masonry surface and prevent efflorescence from recurring. Plus, the combination of warm water and white wine vinegar has been shown to eliminate efflorescence
10. How long does it take for efflorescence to disappear?  
Efflorescence can also be removed with special cleaners like the Gator Efflorescence Cleaner. On average, you should wait about 60 days before applying an efflorescence cleaner.

## TOPIC BEYOND SYLLABUS

### 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.  $0.78 \times P$ ).
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  $27 \pm 20CC$ .
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 (D1) in mm	
Distance between pointers after boiling (D2) in mm	
Expansion of the cement = $E1 = (D2 - D1)$ in mm	
Average expansion of the cement in mm	

**Result:**

Average expansion of the cement is obtained is \_\_\_\_\_mm.

## TEST ON TILES

### Aim:

To determine the water absorption and bulk density of tiles.

### Apparatus Required:

1. Oven – capable of maintaining temp of about 110°C
2. Balance – accurate to 0.01% of the mass of test specimen
3. Waterbath
4. Desiccators
5. Chamois leather
6. Wirebasket

### Preparation of Sample

1. A test sample consists of 10 numbers of whole tiles. If the surface area of individual tile specimen is greater than  $0.04\text{m}^2$ , then the numbers of tile specimens in a sample can be reduced to 5.
2. When the mass of each individual tile is below 50g, then take sufficient number of tiles, so that each test specimen weighs 50g to 100g.
3. If the dimension of tile is longer than 200 mm, then it may be cut up, but include the cut pieces in the measurement.

### Test Procedure

1. Dry the tiles in the oven at  $110 \pm 5^\circ\text{C}$ , until it attains constant mass, i.e. when the difference between two successive weighing at intervals of 24 h is less than 0.1%.
2. Cool the tiles in the desiccators over silica gel, until cooled to room temperature.
3. Weigh each tile specimen and record the weight of individual test specimen (i.e. **m<sub>1</sub>**) in the observation sheet.
4. Place the tiles vertically, with no contact between them, in water in the water bath so that there is a depth of 50 mm water above and below the tiles. Maintain the water level 50 mm above the tiles throughout the test.
5. Heat the water until boiling and continue to boil for 2h. After 2h, switch off the source of heat and allow the tiles to cool, still completely immersed in this water, overnight.

6. Remove the tiles from the water bath and remove the surface water from the tiles pieces by chamois leather.
7. Immediately weigh each tile and record the weight (i.e. **m2**) in the observation sheet.
8. Now place the specimens in the wire basket that is immersed in water and determine the weight of each specimen to the nearest 0.01g.

## Calculation

### 1. Water Absorption

For each tile, calculate the water absorption in percentage (to the first decimal place) of the dry mass using the following formula.

$$\text{Water absorption (\%)} = [(m2 - m1) / m1] * 100$$

Where,

m1 = mass of the dry tile, in g m2 = mass of the wet tile, in g

Calculate the average water absorption of the sample as the average of the individual result.

### 2. Bulk Density

Bulk density (B), in g/cm<sup>3</sup>, of a specimen is the ratio of its dry mass divided by the exterior volume, including pores. Calculate bulk density of tile as follow.

$$B = m1 / V$$

Where,

B = bulk density of tile, g/cm<sup>3</sup> m1 = mass of dry tile, g

V = exterior volume, in cm<sup>3</sup>: = (**m2 - m3**)

m3 = mass of suspended tile impregnated by boiling water method, in g

Calculate the average bulk density of the sample as the average of the individual result.

### Result:

Water absorption of the giventiles =..... %

Bulk density of the given sample =