MUZAFFARPUR INSTITUTE OF TECHNOLOGY

Muzaffarpur

LAB MANUAL

Branch: Civil Engineering
Year & Semester: 2nd Year/ 3rd Sem

BUILDING SCIENCE LABORATORY

(01 1X03 P)

Prepared By:

Niraj Kumar
Assistant Professor
Department of Civil Engineering

Introduction:

The behavior and properties of structural materials, e.g. concrete, asphalt and steel can be better understood by detailed, well-designed, firsthand experience with these materials. The students will become familiar with the nature and properties of these materials by conducting laboratory tests.
These tests have been selected to illustrate the basic properties and methods of testing of cement, aggregates, paste, mortar, concrete, asphalt and steel. Test procedures, sometimes simplified because of time limitation, are mostly those outlined by the Indian Standards.

Course Objectives:

1. To prepare the students to effectively link theory with practice and application and to demonstrate background of the theoretical aspects.
2. To prepare the students to generate and analyze data using experiments and to apply elements of data statistics.
3. To prepare the students to have hands on experiments and to have exposure to equipment and machines
4. To prepare the students to solve problems including design elements and related to their course work.
5. To encourage the students to use computers in analyzing the data.
6. To emphasize the knowledge and application of safety regulations.

List of Experiments

Tests on Cement:

1. Standard consistency of cement.
2. Setting Time of Standard Cement Paste.
3. Fineness of cement.

Tests on Bricks:

1. Shape and size of supplied brick.
2. Water absorption of brick.
3. Compressive strength of bricks.

Test on Cement Mortar:

1. Compressive strength of cement mortar.

Tests on Fine aggregates:

1. Specific gravity of fine aggregates.
2. Particle size distribution of fine aggregates

INDEX

Experiment No: 1 **Date:**

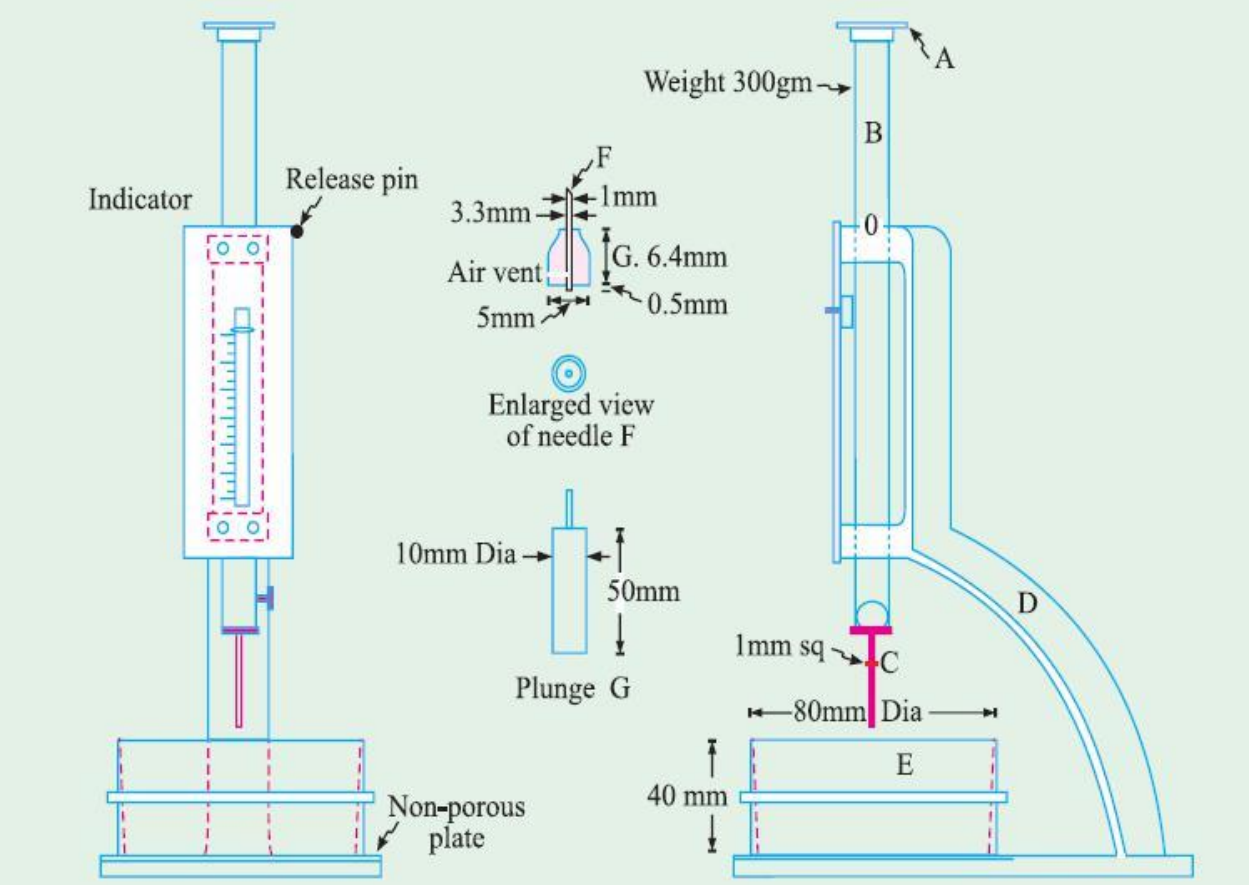
Title: Standard consistency of cement

Objective: To determine the normal consistency of a given sample of cement.

Reference: IS : 4031 (Pat 4) - 1988, IS : 5513-1976

Theory: For finding out initial setting time, final setting time and soundness of cement, and strength a parameter known as standard consistency has to be used. The standard consistency of a cement paste is defined as that consistency which will permit a Vicat plunger having 10 mm diameter and 50 mm length to penetrate to a depth of 33-35 mm from the top of the mould.

Figure:



Apparatus: Vicat apparatus conforming to IS : 5513-1976, Balance, Gauging Trowel, Stop Watch, etc.

Procedure:

1. The standard consistency of a cement paste is defined as that consistency which will permit the Vicat plunger to penetrate to a point 5 to 7 mm from the bottom of the Vicat mould.
2. Initially a cement sample of about 300 g is taken in a tray and is mixed with a known percentage of water by weight of cement, say starting from 26% and then it is increased by every 2% until the normal consistency is achieved.
3. Prepare a paste of 300 g of Cement with a weighed quantity of potable or distilled water, taking care that the time of gauging is not less than 3 minutes, nor more than 5 min, and the gauging shall be completed before any sign of setting occurs. The gauging time shall be counted from the time of adding water to the dry cement until commencing to fill the mould.
4. Fill the Vicat mould (E) with this paste, the mould resting upon a non-porous plate. After completely filling the mould, smoothen the surface of the paste, making it level with the top of the mould. The mould may be slightly shaken to expel the air.
5. Place the test block in the mould, together with the non-porous resting plate, under the rod bearing the plunger; lower the plunger gently to touch the surface of the test block, and quickly release, allowing it to sink into the paste. This operation shall be carried out immediately after filling the mould.
6. Prepare trial pastes with varying percentages of water and test as described above until the amount of water necessary for making up the standard consistency as defined in Step 1 is found.

Observation: Express the amount of water as a percentage by mass of the dry cement to the first place of decimal.

Sl. No.	Weight of cement (gm)	Percentage by weight of dry Cement (%)	Amount of water added (ml)	Penetration (mm)
1				
2				
3				
4				

Conclusion/Result: The normal consistency of a given sample of cement is _ _ _ _ %

Experiment No: 2 **Date:**

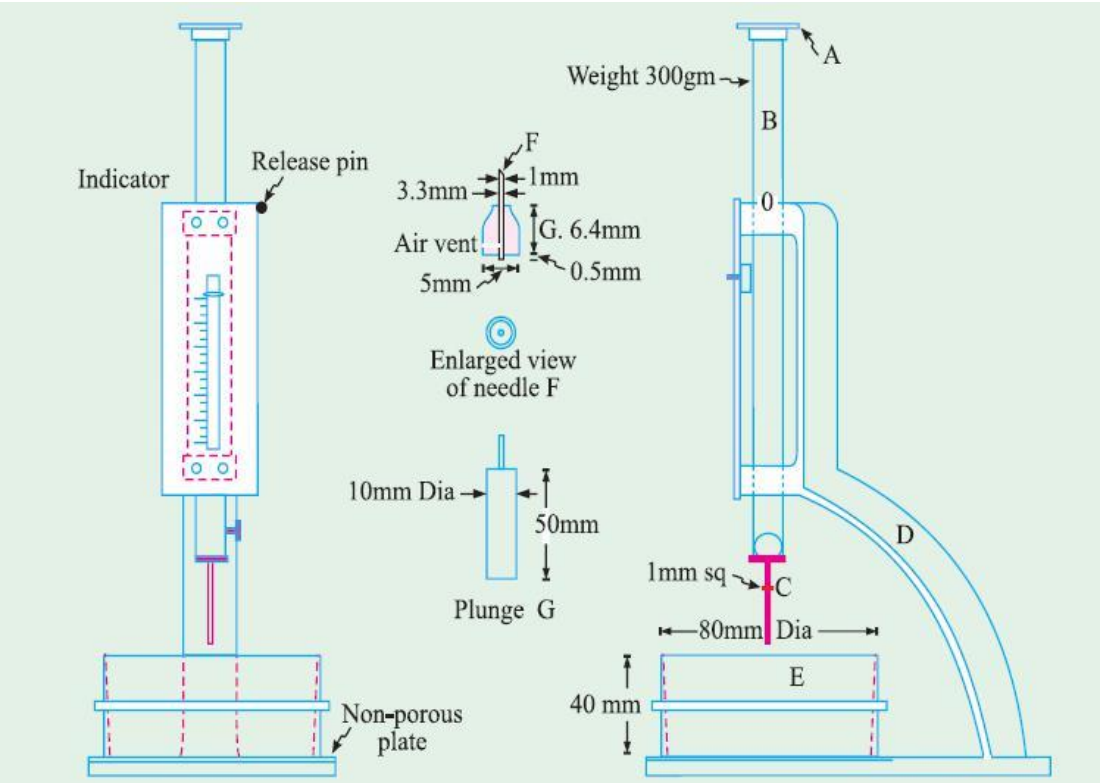
Title: Setting Time of Standard Cement Paste

Objective: To determine the initial and final setting time of a given sample of cement.

Reference: IS: 4031 (Part 4) - 1988, IS: 4031 (Part 5) – 1988, IS : 5513-1976

Theory: For convenience, initial setting time is regarded as the time elapsed between the moments that the water is added to the cement, to the time that the paste starts losing its plasticity. The final setting time is the time elapsed between the moment the water is added to the cement, and the time when the paste has completely lost its plasticity and has attained sufficient firmness to resist certain definite pressure.

Figure:



Apparatus: Vicat apparatus conforming to IS : 5513-1976, Balance, Gauging Trowel, Stop Watch, etc.

Procedure:

1. **Preparation of Test Block -** Prepare a neat 300 gms cement paste by gauging the cement with 0.85 times the water required to give a paste of standard consistency. Potable or distilled water shall be used in preparing the paste.

2. Start a stop-watch at the instant when water is added to the cement. Fill the Vicat mould with a cement paste gauged as above, the mould resting on a nonporous plate. Fill the mould completely and smooth off the surface of the paste making it level with the top of the mould.
3. Immediately after moulding, place the test block in the moist closet or moist room and allow it to remain there except when determinations of time of setting are being made.

4. **Determination of Initial Setting Time** - Place the test block confined in the mould and resting on the non-porous plate, under the rod bearing the needle (C); 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
5. Repeat this procedure until the needle, when brought in contact with the test block and released as described above, fails to pierce the block beyond 5.0 ± 0.5 mm measured from the bottom of the mould shall be the initial setting time.

6. **Determination of Final Setting Time -** Replace the needle (C) of the Vicat apparatus by the needle with an annular attachment (F).
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 period elapsing between the time when water is added to the cement and the time at which the needle makes an impression on the surface of test block while the attachment fails to do so shall be the final setting time.

Observation :

1. Weight of given sample of cement is _ _ _ _ gms
2. The normal consistency of a given sample of cement is _ _ _ _ %
3. Volume of water addend (0.85 times the water required to give a paste of standard consistency) for preparation of test block _ _ _ _ ml

Sr. No.	Setting Time(Sec)	Penetration (mm)	Remark
1			
2			
3			

Conclusion / Result : i) The initial setting time of the cement sample is found to be …..
ii) The final setting time of the cement sample is found to be …..

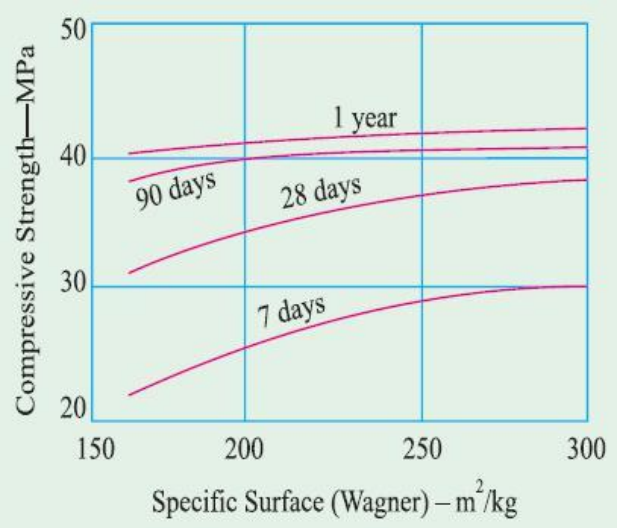
Experiment No: 3 **Date:**

Title: Fineness of cement

Objective: To determination of fineness of cement by dry sieving.

Reference: IS: 4031 (Part 1) – 1988

Theory: The fineness of cement has an important bearing on the rate of hydration and hence on the rate of gain of strength and also on the rate of evolution of heat. Finer cement offers a greater surface area for hydration and hence faster the development of strength, (Fig. 3). The fineness of grinding has increased over the years. But now it has got nearly stabilized. Different cements are ground to different fineness. The particle size fraction below 3 microns has been found to have the predominant effect on the strength at one day while 3-25 micron fraction has a major influence on the 28 days strength. Increase in fineness of cement is also found to increase the drying shrinkage of concrete.



Fineness of cement is tested in two ways :

(a) By sieving.

(b) By determination of specific surface (total surface area of all the particles in one gram of cement) by air-permeability apparatus. Expressed as cm^2/gm or m^2/kg. Generally Blaine Air permeability apparatus is used.

Apparatus: Test Sieve 90 microns, Balance, Gauging Trowel, Brush, etc.

Procedure:

1. Fit the tray under the sieve, weigh approximately 10 g of cement to the nearest 0.01 g and place it on the sieve, being careful to avoid loss. Fit the lid over the sieve. Agitate the

sieve by swirling, planetary and linear movement until no more fine material passes through it.

2. Remove and weigh the residue. Express its mass as a percentage, R1, of the quantity first placed in the sieve to the nearest 0.1 percent. Gently brush all the fine material off the base of the sieve into the tray.
3. Repeat the whole procedure using a fresh 10 g sample to obtain R2. Then calculate the residue of the cement R as the mean of R1, and R2, as a percentage, expressed to the nearest 0.1 percent.
4. When the results differ by more than 1 percent absolute, carry out a third sieving and calculate the mean of the three values.

Conclusion / Result : The fineness of a given sample of cement is _ _ _ _ %

Experiment No: 4 **Date:**

Title: Shape and size of supplied brick

Objective: To determine the shape and size of the supplied brick.

Apparatus: Scale

Material required: Bricks

Procedure:

(i) 20 bricks are taken randomly from a stack. The bricks should be rectangular in shape with sharp edges and smooth surface.

(ii) Dimension i.e. length, breadth, &height of the bricks are measured by scale and recorded.

(iii) For good quality bricks, the dimension of 20 bricks should be within the following limits.

Length 3680 mm to 3920 mm
Width 1740 mm to 1860 mm
Height 1740 mm to 1860 mm

Observation:

SL NO	Length (mm)	Breath(mm)	Height(mm)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			

19			
20			

Calculation:

Sum of the length of 20 bricks = mm
Sum of the breadth of 20 bricks = mm
Sum of the height of 20 bricks = mm

Conclusion/ Result :

Experiment No: 5 **Date:**

Title: Water absorption of brick

Objective: To determines water absorption of brick.

Apparatus:

a) Dry bricks
b) Weighing machine

Material required: Bricks

Theory: 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.

Procedure:

(i) 20 bricks are taken randomly from a stack.
(ii) The bricks are put in an oven at a temperature of 105^0C for drying.
(iii) Bricks are weighed in a digital weighing machine and is record as W_1
(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 W_2.
(vii) Calculate water absorption of brick

Observation:

Sl No	Weight W_1(Kg)	Weight W_2 (Kg)	Water absorption in %	Remarks
1				
2				
3				

Conclusion/Result: Water absorption in % is calculated as.....

Experiment No: 6 **Date:**

Title: Compressive Strength of Bricks

Objective: To determine the compressive strength of bricks.

Apparatus: Compressive strength testing machine

Material required: Bricks, Water, Sand, Cement, Trowel

Theory: 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 pugged clay are stronger than common hand moulded bricks from carelessly prepared clay.

Procedure:

1. Eight bricks are taken for the compressive strength testing.
2. The bricks are then immersed in water at room temperature for 24 hours.
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 N/ m^2 per minute till failure.

Observation:

Sl No	Load at Failure (N)	Average area of back faces (mm^2)	Compressive Strength. (N/mm^2)	Remarks
1				
2				
3				
4				
5				

Conclusion/Result: Average strength of bricks.....

Experiment No: 7 **Date:**

Title: Compressive strength of cement mortar

Objective: To determine the compressive strength of a given sample of cement.

Reference: IS : 4031 (Pat 6) - 1988, IS : 10080-1982, IS : 650-1966, IS: 269-1976

Apparatus: The standard sand to be used in the test shall conform to IS : 650-1966, Vibration Machine, Poking Rod, Cube Mould of 70.6 mm size conforming to IS : 10080-1982, Balance, Gauging Trowel, Stop Watch, Graduated Glass Cylinders, etc.

Theory: The compressive strength of hardened cement is the most important of all the properties. Therefore, it is not surprising that the cement is always tested for its strength at the laboratory before the cement is used in important works. Strength tests are not made on neat cement paste because of difficulties of excessive shrinkage and subsequent cracking of neat cement.

Procedure:

1. Preparation of test specimens - Clean appliances shall be used for mixing and the temperature of water and that of the test room at the time when the above operations are being performed shall be 27 ± 2°C. Potable/distilled water shall be used in preparing the cubes.
2. The material for each cube shall be mixed separately and the quantity of cement, standard sand and water shall be as follows:
3. Cement 200 g and Standard Sand 600 g water P/4+ 0.3 percent of combined mass of cement and sand, where P is the percentage of water required to produce a paste of standard consistency determined as described in IS : 4031 (Part 4)-1988 or Experiment No.1.
4. Place on a nonporous plate, a mixture of cement and standard sand. Mix it dry with a trowel for one minute and then with water until the mixture is of uniform colour. The quantity of water to be used shall be as specified in step 2. The time of mixing shall in any event be not less than 3 min and should the time taken to obtain a uniform colour exceed 4 min, the mixture shall be rejected and the operation repeated with a fresh quantity of cement, sand and water.
5. Moulding Specimens - In assembling the moulds ready for use, treat the interior faces of the mould with a thin coating of mould oil.
6. Place the assembled mould on the table of the vibration machine and hold it firmly in position by means of a suitable clamp. Attach a hopper of suitable size and shape securely at the top of the mould to facilitate filling and this hopper shall not be removed until the completion of the vibration period.

7. Immediately after mixing the mortar in accordance with step 1 & 2, place the mortar in the cube mould and prod with the rod. Place the mortar in the hopper of the cube mould and prod again as specified for the first layer and then compact the mortar by vibration.
8. The period of vibration shall be two minutes at the specified speed of 12 000 ± 400 vibration per minute.
9. At the end of vibration, remove the mould together with the base plate from the machine and finish the top surface of the cube in the mould by smoothing the surface with the blade of a trowel.
10. Curing Specimens - keep the filled moulds in moist closet or moist room for 24 ± 1 hour after completion of vibration. At the end of that period, remove them from the moulds and immediately submerge in clean fresh water and keep there until taken out just prior to breaking.
11. The water in which the cubes are submerged shall be renewed every 7 days and shall be maintained at a temperature of 27 ± 2°C. After they have been taken out and until they are broken, the cubes shall not be allowed to become dry.
12. Test three cubes for compressive strength for each period of curing mentioned under the relevant specifications (i.e. 3 days, 7 days, 28 days)
13. The cubes shall be tested on their sides without any packing between the cube and the steel plattens of the testing machine. One of the plattens shall be carried on a base and shall be self-adjusting, and the load shall be steadily and uniformly applied, starting from zero at a rate of 35 N/mm^2/min.

Figure:

Observation :

Sr. No.	Age of Cube	Weight of Cement Cube (gms)	Cross-Sectional area (mm^2)	Load (N)	Compressive strength (N/mm^2)	Average Compressive strength (MPa)
1	7 Days					
2						
3						
4	28 Days					
5			`			
6						

Calculation: The measured compressive strength of the cubes shall be calculated by dividing the maximum load applied to the cubes during the test by the cross-sectional area, calculated from the mean dimensions of the section and shall be expressed to the nearest 0.5 N/mm^2. In determining the compressive strength, do not consider specimens that are manifestly faulty, or that give strengths differing by more than 10 percent from the average value of all the test specimens.

Conclusion / Result:

i) The average 3 Days Compressive Strength of given cement sample is found to be …..…..

ii) The average 7 Days Compressive Strength of given cement sample is found to be …..…..

iii) The average 28 Days Compressive Strength of given cement sample is found to be …..…..

Table 2.5. Physical Characteristics of Various Types of Cement.

Sl.No.	Type of Cement	Fineness	Soundness By		Setting Time		Compressive Strength			
		(m^2/kg) Min.	Le chatelier (mm) Max.	Autoclave (%) Max.	Initial (mts) min.	Final (mts) max.	1 Day min. MPa	3 Days min. MPa	7 Days min. MPa	28 Days min. MPa
1.	33 Grade OPC (IS 269-1989)	225	10	0.8	30	600	N S	16	22	33
2.	43 Grade OPC (IS 8112-1989)	225	10	0.8	30	600	N S	23	33	43
3.	53 Grade OPC (IS 12269-1987)	225	10	0.8	30	600	N S	27	37	53
4.	SRC (IS 12330-1988)	225	10	0.8	30	600	N S	10	16	33
5.	PPC (IS 1489-1991) Part I	300	10	0.8	30	600	N S	16	22	33
6.	Rapid Hardening (IS 8041-1990)	325	10	0.8	30	600	16	27	N S	N S
7.	Slag Cement (IS 445-1989)	225	10	0.8	30	600	N S	16	22	33
8.	High Alumina Cement (IS 6452-1989)	225	5	N S	30	600	30	35	N S	N S
9.	Super Sulphated Cement (IS 6909-1990)	400	5	N S	30	600	N S	15	22	30
10.	Low Heat Cement (IS 12600-1989)	320	10	0.8	60	600	N S	10	16	35
11.	Masonry Cement (IS 3466-1988)	*	10	1	90	1440	N S	N S	2.5	5
12.	IRS-T-40	370	5	0.8	60	600	N S	N S	37.5	N S

Experiment No: 8 **Date:**

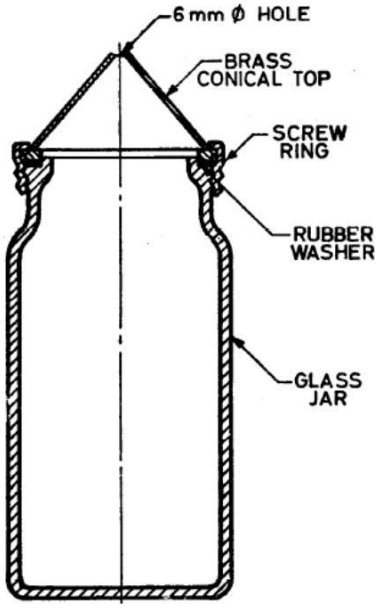
Title: Specific gravity of fine aggregates

Objective: To determine specific gravity of a given sample of fine aggregate.

Reference : IS : 2386 (Part III) – 1963

Apparatus: Pycnometer, A 1 000-ml measuring cylinder, well-ventilated oven, Taping rod, Filter papers and funnel, etc.

Figure:



Procedure:

1. A sample of about 500 g shall be placed in the tray and covered with distilled water at a temperature of 22 to 32°C. Soon after immersion, air entrapped in or bubbles on the surface of the aggregate shall be removed by gentle agitation with a rod. The sample shall remain immersed for 24 ± l/2 hours.
2. The water shall then be carefully drained from the sample, by decantation through a filter paper, any material retained being return& to the sample. The fine aggregate including any solid matter retained on the filter paper shall be exposed to a gentle current of warm air to evaporate surface moisture and the material just attains a _free-running‘ condition. The saturated and surface-dry sample shall be weighed (weight A).
3. The aggregate shall then be placed in the pycnometer which shall be filled with distilled water. Any trapped air shall be eliminated by rotating the pycnometer on its side, the hole

in the apex of the cone being covered with a finger. The pycnometer shall be dried on the outside and weighed (weight B).

4. The contents of the pycnometer shall be emptied into the tray, care being taken to ensure that all the aggregate is transferred. The pycnometer shall be refilled with distilled water to the same level as before, dried on the outside and weighed (weight C).
5. The water shall then be carefully drained from the sample by decantation through a filter paper and any material retained returned to the sample. The sample shall be placed in the oven in the tray at a temperature of 100 to 110°C for 24 f l/2 hours, during which period it shall be stirred occasionally to facilitate drying. It shall be cooled in the air-tight container and weighed (weight D).

Calculations:

Specific gravity, apparent specific gravity shall be calculated as follows:

Specific gravity = [D/{A-(B-C)}];

Apparent Specific gravity = [D/{D-(B-C)}]

A = weight in g of saturated surface - dry sample,

B = weight in g of pycnometer or gas jar containing sample and filled with distilled water,

C = weight in g of pycnometer or gas jar filled with distilled water only, and

D = weight in g of oven - dried sample.

Conclusion / Result: The Specific Gravity of a given sample of fine aggregate is found to be …….

Experiment No: 9 **Date:**

Title: Particle size distribution of fine aggregates

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

Reference: IS : 2386 (Part I) – 1963, IS: 383-1970, IS : 460-1962

Theory: This is the name given to the operation of dividing a sample of aggregate into various fractions each consisting of particles of the same size. The sieve analysis is conducted to determine the particle size distribution in a sample of aggregate, which we call gradation. Many a time, fine aggregates are designated as coarse sand, medium sand and fine sand. These classifications do not give any precise meaning. What the supplier terms as fine sand may be really medium or even coarse sand. To avoid this ambiguity fineness modulus could be used as a yard stick to indicate the fineness of sand.
The following limits may be taken as guidance: Fine sand : Fineness Modulus : 2.2 - 2.6, Medium sand :

F.M. : 2.6 - 2.9, Coarse sand : F.M. : 2.9 - 3.2

Sand having a fineness modulus more than 3.2 will be unsuitable for making satisfactory concrete.

Apparatus: Test Sieves conforming to IS : 460-1962 Specification of 4.75 mm, 2.36 mm, 1.18 mm, 600 micron, 300 micron, 150 micron, Balance, Gauging Trowel, Stop Watch, etc.

Procedure:

1. The sample shall be brought to an air-dry condition before weighing and sieving. The air-dry sample shall be weighed and sieved successively on the appropriate sieves starting with the largest. Care shall be taken to ensure that the sieves are clean before use.
2. The shaking shall be done with a varied motion, backward sand forwards, left to right, circular clockwise and anti-clockwise, and with frequent jarring, so that the material is kept moving over the sieve surface in frequently changing directions.
3. Material shall not be forced through the sieve by hand pressure. Lumps of fine material, if present, may be broken by gentle pressure with fingers against the side of the sieve.
4. 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.

5. On completion of sieving, the material retained on each sieve, together with any material cleaned from the mesh, shall be weighed.

Observation :

I S Sieve	Weight Retained on Sieve (gms)	Percentage of Weight Retained (%)	Percentage of Weight Passing (%)	Cumulative Percentage of Passing (%)	Remark
4.75 mm					
2.36 mm					
1.18 mm					
600 micron					
300 micron					
150 micron					
Total					

Calculation: Fineness modulus is an empirical factor obtained by adding the cumulative percentages of aggregate retained on each of the standard sieves ranging from 4.75 mm to 150 micron and dividing this sum by an arbitrary number 100.
Fineness Modulus, FM = Total of Cumulative Percentage of Passing (%)/100

Conclusion / Result:
i) Fineness modulus of a given sample of fine aggregate is …….. that indicate Coarse sand/ Medium sand/ Fine sand.
ii) The given sample of fine aggregate is belong to Grading Zones I / II / III / IV

Table 3.15. Grading limits of fine aggregates IS: 383-1970

I.S. Sieve Designation	Percentage passing by weight for			
	Grading Zone I	Grading Zone II	Grading Zone III	Grading Zone IV
10 mm	100	100	100	100
4.75 mm	90–100	90–100	90–100	95–100
2.36 mm	60–95	75–100	85–100	95–100
1.18 mm	30–70	55–90	75–100	90–100
600 micron	15–34	35–59	60–79	80–100
300 micron	5–20	8–30	12–40	15–50
150 micron	0–10	0–10	0–10	0–15