BEARYS INSTITUTE OF TECHNOLOGY, MANGALORE

DEPARTMENT OF CIVIL ENGINEERING

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CONCRETE TECHNOLOGY LABORATORY MANUAL (BCV503)

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EXPERIMENT 1

(a) CONSISTENCY OF CEMENT

AIM:

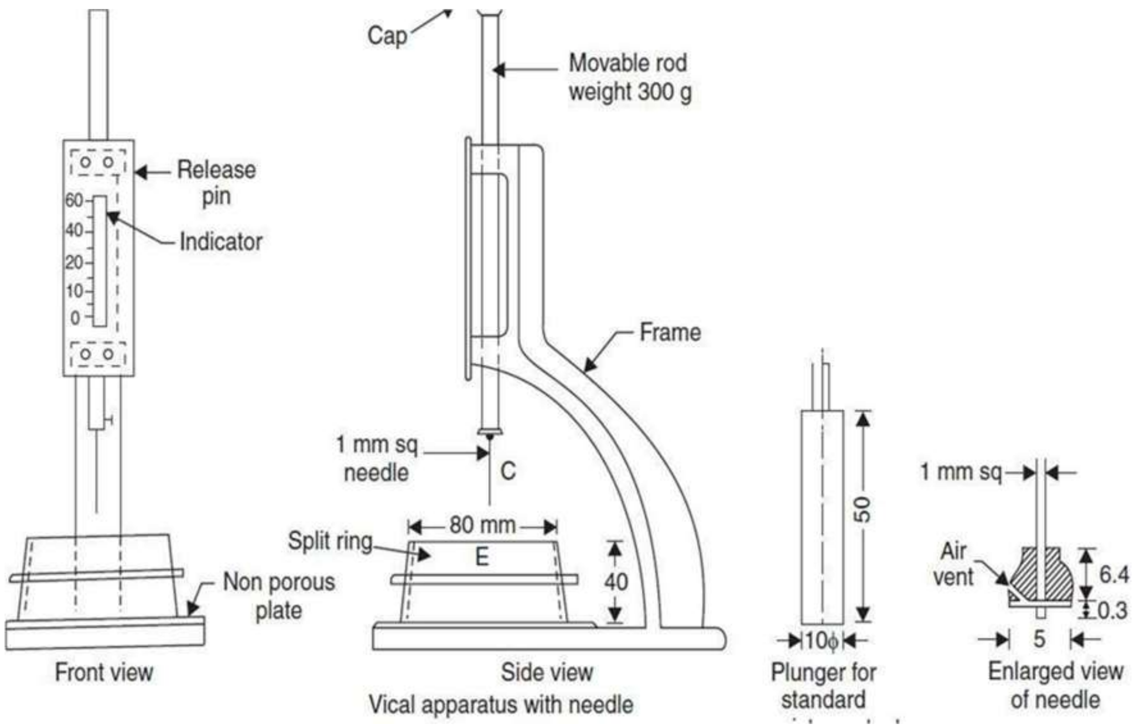
Normal consistency test is used to optimum percentage of water content required for a cementpaste.

APPARATUS:

1. Vicat apparatus (conforming to IS: 5513 - 1976) with plunger (10 mm in diameter)
2. Vicat mould
3. Gauging trowel
4. Measuring jar
5. Balance
6. Tray.

INTRODUCTION

The standard consistency of a cement paste is defined as that consistency which will permit the Vi-cat plunger to penetrate to a point 5 to 7 mm from the bottom of the Vicat mould. For finding out initial setting time, final setting time, soundness of cement and compressive strength of cement, it is necessary to fix the quantity of water to be mixed in cement in each case. This experiment is intended to find out the quantity of water to be mixed for a given cement to give a cement paste of normal consistency and can be done with the help of Vi-cat apparatus.



PROCEDURE:

1. Prepare a paste of weighed quantity of cement (300 grams) with a weighed quantity of potable or distilled water, starting with 28% water of 250g of cement.
2. The percentage of water to be taken according to the room temperature 27 ± 50C.
3. Take care that the time of gauging is not less than 3 minutes, not more than 5 minutes and the gauging shall be completed before setting occurs.
4. The gauging time shall be counted from the time of adding the water to the dry cement until commencing to fill the mould.
5. Fill the Vicat mould with this paste, the mould resting upon a non-porous plate.
6. After completely filling the mould, trim off the surface of the paste, making it in level with the top of the mould. The mould may slightly be shaken to expel the air.
7. Place the test block with the mould, together with the non-porous resting plate, under the rod bearing the plunger (10mm diameter), lower the plunger gently to touch the surface of the test block and quickly release, allowing it to penetrate into the paste.

8. This operation shall be carried out immediately after filling the mould.
9. Prepare trial pastes with varying percentages of water and test as described above until the amount of water necessary for making the standard consistency as defined above is obtained.
10. Express the amount of water as a percentage by weight of the dry cement.

OBSERVATIONS:

S.No	**Weight of cement taken in gms(a)**	**Water taken in % (b)**	**Water taken in ml (c)**	**Plunger penetration(mm)**
1	250	28		
2	250	30		
3	250	32		
4	250	34		
5	250	36		

CALCULATIONS:

1 gm per cc = 1 ml of water

P = $\frac{W}{C}$ x 100

Where P = percentage of water (b)

W = water required in ml (c)

C = weight of cement required (a).

RESULT:

Normal consistency for the given sample of cement is = ……………………….

(b) FINENESS OF CEMENT

AIM:

To determine the fineness of the given sample of cement by sieving.

APPARATUS:

1. IS-90-micron sieve conforming to IS:460-1965
2. Standard balance
3. Weights
4. Brush.

INTRODUCTION:

The fineness of cement has an important bearing on the rate of hydration and hence on the rate of gain of strength and on the rate of evolution of heat. Finer cement offers a greater surface area for hydration and hence the faster and greater the development of strength. Increase in fineness of cement is also found to increase the drying shrinkage of concrete. Fineness of cement is tested either by sieving or by determination of specific surface by air-permeability apparatus. Specific surface is the total surface area of all the particles in one gram of cement.

PROCEDURE:

1. Weigh accurately 100 g of cement and place it on a standard 90 microns IS sieve.
2. Break down any air-set lumps in the cement sample with fingers.
3. Continuously sieve the sample giving circular and vertical motion for a period of 15 minutes.
4. Weigh the residue left on the sieve. As per IS code the percentage residue should not exceed 10%.

OBSERVATIONS:

S. No	Weight of sample taken, W (g)	Weight of cement retained, W_1 (g)	Fineness (%)
	Average		

CALCULATIONS:

Fineness (%) = $\frac{W_1}{W}$ x 100

RESULT:

Fineness of given sample of cement is ……………………….

(c) SETTING TIME OF CEMENT

AIM:

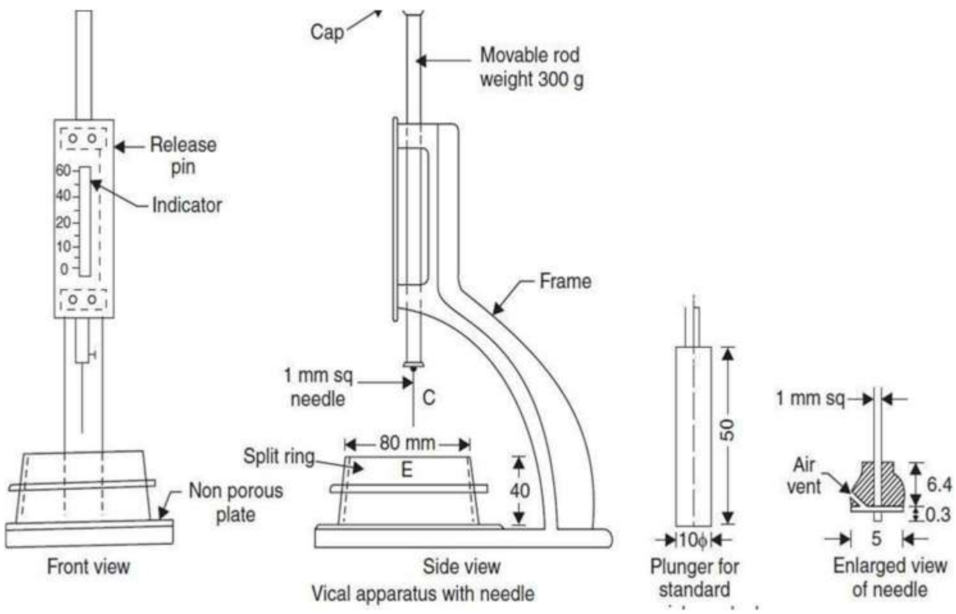
To determine the initial and final setting times for the given sample of cement.

APPARATUS:

1. Vicat apparatus (conforming to IS: 5513-1976) with attachments
2. Balance
3. Weights
4. Gauging trowel.

INTRODUCTION:

In actual construction dealing with cement, mortar or concrete, certain time is required for mixing, transporting and placing. During this time cement paste, mortar, or concrete should be in plastic condition. The time interval for which the cement products remain in plastic condition is known as the setting time. Initial setting time is regarded as the time elapsed between the moment 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 pressure. The constituents and fineness of cement is maintained in such a way that the concrete remains in plastic condition for certain minimum time. Once the concrete is placed in the final position, compacted and finished it should lose its plasticity in the earliest possible time so that it is least vulnerable to damages from external destructive agencies. This time should not be more than 10 hours which is referred to as final setting time. Initial setting time should not be less than 30 minutes.



PROCEDURE:

Preparation of Test Block:

1. Prepare a neat cement paste by gauging 300 grams of cement with 0.85 times the water required to give a paste of standard consistency (0.85P).
2. Potable or distilled water shall be used in preparing the paste.
3. The paste shall be gauged in the manner and under the conditions prescribed in determination of consistency of standard cement paste.
4. Start a stop-watch at the instant when water is added to the cement.
5. Fill the mould with the cement paste gauged as above the mould resting on a non-porous plate. Fill the mould completely and smooth off the surface of the paste making it level with the top of the mould. The cement block thus prepared in the mould is the test block.

Determination of Initial Setting time:

1. Place the test blocks confined in the mould and rest it on the non-porous plate, under the rod bearing initial setting needle, lower the needle gently in contact with the surface of the test block and quickly release, allowing it to penetrate into the test block.

2. In the beginning, the needle will completely pierce the test block.

3. Repeat this procedure until the needle, when brought in contact with the test block and released as described above, fails to pierce the block to a point 5 to 7 mm measured from the bottom of the mould shall be the initial setting time.

Determination of final setting time:

1. Replace the needle of the Vicat apparatus by the needle with an annular attachment.

2. 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 there on, while the attachment fails to do so.

3. The period elapsed 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.

OBSERVATIONS:

Quantity of cement =

Quantity of water = 0.85P =

Time in minutes					
Height in mm fails to penetrate					

Initial setting time =

Final setting time =

RESULT:

Initial setting time for the given sample of cement = …………………………….

Final setting time for the given sample of cement = ……………………………

EXPERIMENT 2

(a) SPECIFIC GRAVITY

AIM:

To determine the specific gravity of given sample of hydraulic cement.

APPARATUS:

1. Physical balance
2. Specific gravity bottle of 50ml capacity
3. Clean kerosene.

INTRODUCTION:

Specific gravity is defined as the ratio between weight of a given volume of material and weight of an equal volume of water. To determine the specific gravity of cement, kerosene is used which does not react with cement.

PROCEDURE:

1. Clean and dry the specific gravity bottle and weigh it with the stopper (W1).
2. Fill the specific gravity bottle with cement sample at least half of the bottle and weigh with stopper (W2).

3. Fill the specific gravity bottle containing the cement, with kerosene (free of water) placing the stopper and weigh it (W3).
4. While doing the above do not allow any air bubbles to remain in the specific gravity bottle.
5. After weighing the bottle, the bottle shall be cleaned and dried again.
6. Then fill it with fresh kerosene and weigh it with stopper (W4).
7. Remove the kerosene from the bottle and fill it with full of water and weigh it with stopper (W5).
8. All the above weighing should be done at the room temperature of 27c + 10 c.

OBSERVATIONS:

Description of item	Trial 1	Trial 2	Trial 3
Weight of empty bottle W1 g			
Weight of bottle + Cement W2 g			
Weight of bottle + Cement + Kerosene W3 g			
Weight of bottle + Full Kerosene W4 g			
Weight of bottle + Full Water W5 g			

CALCULATIONS

Specific gravity of kerosene $S_k = \frac{W_4 - W_1}{W_5 - W_1}$

Specific gravity of cement $S_c = \frac{(W_2 - W_1)}{(W_4 - W_1) - (W_3 - W_2)} X \frac{W_4 - W_1}{W_5 - W_1}$

RESULT:

Average specific gravity of given sample of cement = ………………………

(b) SOUNDNESS OF CEMENT

AIM:

To determine the soundness of the given sample of cement by "Le Chatelier" Method.

APPARATUS:

1. Le Chatelier apparatus conforming to IS 5514-1969
2. Balance
3. Weights
4. Water bath.

INTRODUCTION:

It is essential that the cement concrete shall not undergo appreciable change in volume after setting. This is ensured by limiting the quantities of free lime, magnesia and sulphates in cement which are the causes of the change in volume known as unsoundness. Unsoundness in cement does not come to surface for a considerable period of time. This test is designed to accelerate the slaking process by the application of heat and discovering the defects in a short time. Unsoundness produces cracks, distortion and disintegration there by giving passage to water and atmospheric gases which may have injurious effects on concrete and reinforcement. The apparatus for conducting the test consists of small split cylinder of spring brass or other suitable metal of 0.5mm thickness forming a mould 30 mm internal diameter and 30mm high. On either side of the split mould are attached to indicators with pointed ends, the distance from these ends to the centre of the cylinder being 165 mm. The mould shall be kept in good condition with the jaws not more than 50mm apart.

PROCEDURE:

1. Place the lightly oiled mould on a lightly oiled glass sheet and fill it with cement paste formed by gauging cement with 0.78 times the water required to give a paste of standard consistency.
2. The paste shall be gauged in the manner and under the conditions prescribed in determination of consistency of standard cement paste, taking care to keep the edges of the mould gently together.
3. While this operation is being performed cover the mould with another piece of glass sheet. Place a small weight on this covering glass sheet and immediately submerge the whole assembly in water at a temperature of 27^0C- 20^0C and keep there for 24 hours.
4. Measure the distance separating the indicator points.
5. Submerge the moulds again in water at the temperature prescribed above.
6. Bring the water to boiling, with the mould kept submerged for 25 to 30 minutes, and keep it boiling for three hours.
7. Remove the mould from the water allow it to cool and measure the distance between the indicator points.
8. The difference between these two measurements represents the expansion of the cement.
9. For good quality cement this expansion should not be more than 10mm.

OBSERVATIONS:

Initial distance between the indicator points (mm)	
Final distance between the indicator points (mm)	
Final length – Initial Lnegth	

CALCULATIONS:

Quantity of cement =

Quantity of water = 0.78P =

RESULT:

Expansion in mm = …………………………..

Therefore, the given sample of OPC is sound/ unsound.

EXPERIMENT 3

(a) SPECIFIC GRAVITY

AIM:

To determine the specific gravity of the fine aggregate.

APPARATUS:

Balance, Pycnometer, metal tray, conical mould.

THEORY:

Specific gravity of an aggregate is defined as the ratio of the mass of a given volume of a sample to the mass of a equal volume of water at the same temperature. The specific gravity of fine aggregate is generally required for calculations of volume yield of concrete. The specific gravity also gives information on quality and properties of aggregates. Apecific gravity also gives information on quality and properties of aggregates.

PROCEDURE:

- Take the empty weight of the pycnometer, let the weight be W_1.
- Take the sample of fine aggregate for which the specific gravity has to be found out and transfer that to the empty flask and then it is weighed. Let the weight be W_2.
- The pycnometer with the sample is filled with water up to a mark (made on the flask) and its weight is taken. The flask should be completely dry on the outer surface W_3.
- Fill the flask witht water to the top cone, roll the flask in an inclined position to eliminate the air bubble and replace with water by means of wash bottle W_4.
- Calculate the specific gravity of the fine aggregate by using the formula
- Specific gravity = $\frac{Dry\ weight\ of\ aggregate}{Weight\ of\ equal\ volume\ of\ water}$

OBSERVATIONS:

Description of item	Trial 1	Trial 2	Trial 3
Weight of empty pycnometer (W_1) g			
Weight of pycnometer + 1/3 volume of fine aggregate (W_2) g			
Weight of pycnometer + 1/3 volume of fine aggregate + 2/3 volume of water (W_3) g			
Weight of pycnometer + Full water (W_4)g			

CALCULATIONS:

Specific gravity = $\frac{W_2 - W_1}{(W_4 - W_1) - (W_3 - W_2)}$

RESULTS:

The specific gravity of given fine aggregates =

(b) SIEVE ANALYSIS

AIM:

To determine the fineness modulus and grain size distribution of the given fine aggregates.

APPARATUS:

I.S. Seive set (4.75 mm, 2.36 mm, 1.18 mm, 600 mm, 300 mm, 1150 mm), Seive shaker, balance.

THEORY:

The sieve analysis is a simple test consisting of sieving a measured quantity of material through successively smaller sieves. The weight retained on each sieve is expressed as a percentage of the total sample. The commonly used properties for classification are the grain size distribution. Grain size analysis also known as mechanical analysis. It determines the percentages of individual grain size present in the sample. The result of the test is of great value in soil classification. In mechanical stabilization of soil and for designing soil aggregate mixture the result of the gradation tests are used. Conclusions have also been made between the grain size distribution of soil and the general soil behaviors as sub grade material and the performance such as susceptibility to frost action. Pumping of rigid pavements etc. Sand is the fine aggregate used in mortar. Coarse aggregate that is the broken stone or gravel and the mixed aggregate which is the combination of coarse and fine aggregates are used in concrete. The coarse aggregate unless mixed with fine aggregates does not produce good quality concrete for construction works.

PROCEDURE:

1. Take 1Kg of sand in a clean dry plate. from a sample of 10Kg, by quartering & breaking clay lamps if any.
2. Arrange the sieves in order of IS Sieve No: 4.75mm, 2.36mm, 1.18mm, 600micron, 300mm,150micron.Fix them in a Sieve Shaking machine with a pan at the bottom &Cover at the top.
3. Keep the sand in the top Sieve Carry out the Sieving in the set of Sieves as arranged before for not less than 10minutes.

4. Find mass retained on each Sieve & tabulate the reading in the observation sheet.
5. The grain size greater than 75 micron is determined by sieving set of sieves of decreasing order. Sieve opening place one below the other and separating out the different size ranges.

OBSERVATION:

Weight of fine aggregates for sieving =

Sl No	Seive size	Wt. of sand retained	Wt. of sand passing	% Wt. of sand retained	% Wt of sand passing	Cumulative % Wt of sand retained
1						
2						
3						
4						
5						
6						
7						
8						
9						

RESULT:

Fineness modulus of fine aggregate =

(c) BULKING OF FINE AGGREGATE

AIM:

To determine the bulking of fine aggregates and to draw curve between water content and bulking.

APPARATUS:

Balance, Cylindrical container, graduated cylinder, Beaker, Metal tray, Steel rule and Oven

THEORY:

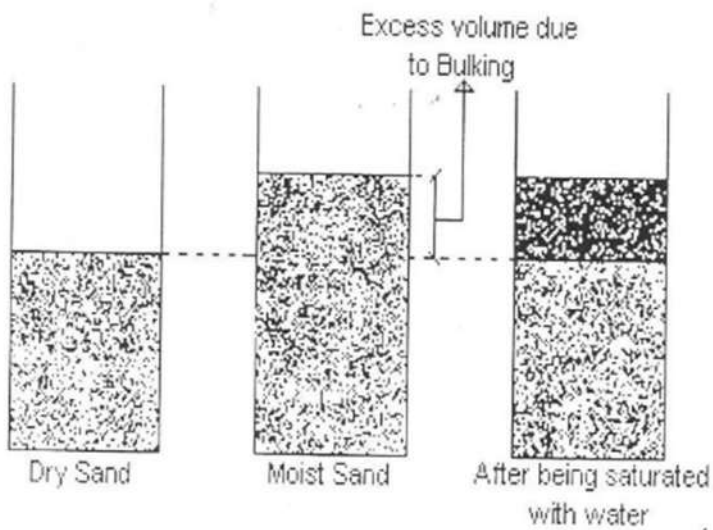
In concrete mix design, the quantity of fine aggregates used in each batch should be related to know the volume of cement. The difficulty with measurement of fine aggregate by volume is the tendency of sand to vary s in bulk according to moisture content. The extent of this variation is given by this test. If sand is measured by volume and no allowance is made for bulking the mix will be richer than specified because for given mass, moist sand occupies a considerable larger volume than the same mass of dry sand, as the particles are less closely packed when the sand is moist. If as usual the sand is measured by loose volume, it is necessary in such a case to increase the measured volume of the sand, in order that the amount of sand put into concrete may be the amount intended for the nominal mix used (based on the dry sand). It will be necessary to increase the volume of sand by the best, but a correction of the right order can easily be determined and should be applied in order to keep the concrete uniform. This experiment is intended to cover the field method of determining the necessary adjustment for bulking of the aggregate.

PROCEDURE:

1. Put sufficient of the oven dry sand loosely into the container until it is about two third full. Level off the top of sand and weigh the container. Calculate the mass of sand by deducting the mass of container.
2. Push a steel rule vertically down through the sand at the middle to the bottom and measure the height of the sand. Let it beV1mm3
3. Empty the sand out into a clean metal tray without any loss.
4. Add 1 percent of water by mass of sand. Mix the sand and water thoroughly by hand (1)

5. Put the wet sand loosely into the container without tamping it.
6. Smooth and level the top surface of the moist sand and measure its depth at the middle with the steel rule. Let it beV2 mm (2)
7. Repeat the steps (1) and (2) of the above procedure with 1% of water by mass .

   Go on increasing the percentage by one till bulking is maximum and a start falling down ultimately bulking is Zero. i.e. saturated sand occupies the same volume as dry sand



OBSERVATIONS:

Mass of sand (ml)	% of water added	Initial volume, V_1	Final volume, V_2	% bulking

CALCULATIONS:

% bulking = $\frac{V_2 - V_1}{V_1}$ x 100

RESULT:

Bulking of fine aggregate =

EXPERIMENT 4

(a) BULK DENSITY

AIM:

To determine the bulk density of given fine aggregates.

APPARATUS:

Balance, cylindrical container, measuring jar.

INTOORDUCTION:

Bulk density of aggregates is the mass of aggregates required to fill the container of a unit volume after aggregates are batched based on volume. Bulk Density = Mass of the aggregate \ Volume of aggregate particles with voids between them. This bulk density is used to convert quantities by mass to quantities by volume. Bulk density depends on several factors: Size distribution of aggregates, Shape of particles and degree of compaction. There are two methods this quantity is measured by: (1) Loose method. (2) Compaction method. For test purpose, the degree of compaction has to be specified: loose and compacted. Generally the standard condition is a compacted aggregate in a dry state. The ratio of the loose bulk density to the compacted bulk density lies usually between 0.87 and 0.96. The bulk density is used for converting proportions by weight into the proportions by volume.

PROCEDURE:

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 straightedge.

6. Determine the weight of the aggregate in the measure and record that weight "W" in kg.
7. To find the loose bulk density, Fill the cylindrical measure to overflowing by means of a shovel or scoop, the aggregate being discharged from a height not exceeding 5 cm above the top of the measure
8. Level the top surface of the aggregate in the metal measure, with a straightedge or tamping bar.
9. Determine the weight of the aggregate in the measure and record the weight "W" in kg.

OBSERVATIONS:

	Sample 1	Sample 2
Capacity of cylinder, V (ml)		
Weight of cylinder, W_1 (ml)		
Weight of cylinder + loose aggregates, W_2 (ml)		
Weight of cylinder + compacted aggregates, W_3 (ml)		
Loose bulk density, $\frac{W_2 - W_1}{V}$		
Compacted bulk density, $\frac{W_3 - W_1}{V}$		

RESULT:

The bulk density (loose) of the give sample of fine aggregates =

The bulk density (compacted) of the give sample of fine aggregates =

(b)SILT CONTENT

AIM:

To find out silt content in sand (fine aggregate)

APPARATUS REQUIRED:

250 ml measuring cylinder, Water, Sand & Tray

THEORY:

Silt content is a fine material which is less than 150 micron. It is unstable in the presence of water. It is unstable in the presence of water. If we use silty sand for bonding, it will reduce the strength and cause rework. You may be experienced this while plastering for a roof where the mason tries to plaster the mortar where it gets continually peel off. Excessive quantity of silt, not only reduces the bonding of cement and fine aggregates but also affects the strength and durability of work. You can check out this article for silt and clay properties. In the field, we have to conduct silt test for every 20 Cum of sand. This may vary.

PROCEDURE:

1. First, we have to fill the measuring cylinder with 1% solution of salt and water up to 50 ml.
2. Add sand to it until the level reaches 100 ml. Then fill the solution up to 150 ml level.
3. Cover the cylinder and shake it well (as shown in video)
4. After 3 hours, the silt content settled down over the sand layer
5. Now note down the silt layer alone volume as V1 ml (settled over the sand)
6. Then note down the sand volume (below the silt) as V2 ml
7. Repeat the procedure two more times to get the average

OBSERVATIONS:

Sl No	Description	Sample No		
		Sample 1	Sample 2	Sample 3
1.	Volume of sample, V_1 (ml)			
2.	Volume of silt, V_2 (ml)			
3.	Percentage of silt $\frac{V_2}{V_1}$ x 100			

RESULT:

The silt content present in the given sample of fine aggregate =

EXPERIMENT 5

(a) SPECIFIC GRAVITY

AIM:

To determine the specific gravity of the coarse aggregate.

APPARATUS:

Balance, pycnometer, metal tray, conical mould.

THEORY:

Specific gravity of an aggregate is defined as the ratio of the mass of a given volume of a sample to the mass of a equal volume of water at the same temperature. The specific gravity of fine aggregate is generally required for calculations of volume yield of concrete. The specific gravity also gives information on quality and properties of aggregates. Apecific gravity also gives information on quality and properties of aggregates.

PROCEDURE:

- Take the empty weight of the pycnometer, let the weight be W_1.
- Take the sample of coarse aggregate for which the specific gravity has to be found out and transfer that to the empty flask and then it is weighed. Let the weight be W_2.
- The pycnometer with the sample is filled with water up to a mark (made on the flask) and its weight is taken. The flask should be completely dry on the outer surface W_3.
- Fill the flask with water to the top cone, roll the flask in an inclined position to eliminate the air bubble and replace with water by means of wash bottle W_4.
- Calculate the specific gravity of the coarse aggregate by using the formula
- Specific gravity = $\frac{Dry\ weight\ of\ aggregate}{Weight\ of\ equal\ volume\ of\ water}$

OBSERVATIONS

Description of item	**Trial 1**	**Trial 2**	**Trial 3**
Weight of empty pycnometer (W_1) g			
Weight of pycnometer + 1/3 volume of coarse aggregate (W_2) g			
Weight of pycnometer + 1/3 volume of coarse aggregate + 2/3 volume of water (W_3) g			
Weight of pycnometer + Full water (W_4)g			

CALCULATIONS

Specific gravity = $\frac{W_2 - W_1}{(W_4 - W_1) - (W_3 - W_2)}$

RESULTS:

The specific gravity of given coarse aggregates =

(b)SIEVE ANALYSIS

AIM:

To determine the particle size distribution of the given sample of coarse aggregates.

APPARATUS:

THEORY:

In a gradation and size analysis, a sample of dry aggregate of known weight is separated through a series of sieves with progressively smaller openings. Once separated, the weight of particles retained on each sieve is measured and compared to the total sample weight. Particle size distribution is then expressed as a percent retained by weight on each sieve size. Results are usually expressed in tabular or graphical format. Graphical displays almost always use the standard 0.45 power gradation graph.

PROCEDURE:

1. Take 1kg of the coarse aggregate test sample.
2. Arrange the IS sieve in descending 25mm,20mm 12.5mm, 10mm, 4.75mm.
3. Now fill the sample to the highest sieve and sieve well for up to 10 minutes.
4. After completion of sieving, then weigh the aggregates retained in each sieve & note it down.

OBSERVATIONS:

Sl No	Seive size	Wt. of C.A. retained	Wt. of C.A. passing	% Wt. of C.A. retained	% Wt of C.A. passing	Cumulative % Wt of C.A. retained
1						
2						

3						
4						
5						
6						
7						
8						
9						

RESULT:

Fineness modulus of coarse aggregate =

(c) BULK DENSITY

AIM:

To determine the bulk density of given coarse aggregates.

APPARATUS:

Balance, cylindrical container, measuring jar.

INTORDUCTION:

Bulk density of aggregates is the mass of aggregates required to fill the container of a unit volume after aggregates are batched based on volume. Bulk Density = Mass of the aggregate \ Volume of aggregate particles with voids between them. This bulk density is used to convert quantities by mass to quantities by volume. Bulk density depends on several factors: Size distribution of aggregates, Shape of particles and degree of compaction. There are two methods this quantity is measured by: (1) Loose method. (2) Compaction method. For test purpose, the degree of compaction has to be specified: loose and compacted. Generally the standard condition is a compacted aggregate in a dry state. The ratio of the loose bulk density to the compacted bulk density lies usually between 0.87 and 0.96. The bulk density is used for converting proportions by weight into the proportions by volume.

PROCEDURE:

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 straightedge.
6. Determine the weight of the aggregate in the measure and record that weight "W" in kg.

7. To find the loose bulk density, Fill the cylindrical measure to overflowing by means of a shovel or scoop, the aggregate being discharged from a height not exceeding 5 cm above the top of the measure
8. Level the top surface of the aggregate in the metal measure, with a straightedge or tamping bar.
9. Determine the weight of the aggregate in the measure and record the weight “W” in kg.

OBSERVATIONS:

	Sample 1	Sample 2
Capacity of cylinder, V (ml)		
Weight of cylinder, W_1 (ml)		
Weight of cylinder + loose aggregates, W_2 (ml)		
Weight of cylinder + compacted aggregates, W_3 (ml)		
Loose bulk density, $\frac{W_2 - W_1}{V}$		
Compacted bulk density, $\frac{W_3 - W_1}{V}$		

RESULT:

The bulk density (loose) of the give sample of coarse aggregates =

The bulk density (compacted) of the give sample of coarse aggregates =

(d)FLAKINESS INDEX

AIM:

To determine the Flakiness index of coarse aggregates

APPARATUS:

Balance, a set of 10 sieves ranging from 63mm IS sieve to 6.3mm is sieve; thickness gauge and length gauge.

THEORY:

An aggregate having least dimension less than 3/5th of its mean dimension is termed as flaky aggregate. The mean dimension is the average of the sieve sizes through which the particles pass and the sieve size on which these are retained. On the other hand the particles having the largest dimension (length) greater than 9/5 times the mean size the termed elongated. The presence of excess of flaky and elongated particles in concrete aggregate decreases the workability appreciably for a given water-cement ratio, thus requiring larger amounts of sand, cement and water. The flaky and elongated particles tend to orient in one plane and cause laminations which adversely affect the durability of the concrete. The percentage of flaky and elongated particles should be limited to 10 to 15. The tests are not applicable to sizes smaller than 6.3mm.

PROCEDURE:

To determine the flakiness index of coarse aggregate

1. Take a sufficient quantity W1 of coarse aggregate by quartering so as to provide at least 200 pieces of any fraction.

2. Carry out sieving by hand. Shake each sieve in order; 63mm, 50mm, 40mm, 31.5mm, 55mm, 20mm, 16mm, 12.5mm, 10mm and 6.3mm, over a clean dry tray for a period not less than 2 minutes. The shaking is done with a varied motion; backward and forward, left to right circular, clockwise, anticlockwise and with frequent jarring, so that the material is kept moving over the sieve surface in frequently changing directions.

3. Pass the separated aggregate fractions as retained on the sieves in step 2 through the corresponding slots in the thickness gauge e.g. the material passing through 50-mm sieve and retained on 40mm sieve is passed through 1/2(50+40)x3/5 = 27.0mm slot.

Determine the mass of aggregate passing through each of the slots.

4. Find the total mass W2 of the materials passing through the slots of the thickness gauge.

5. Calculate the flakiness index as defined below. The flakiness index is an empirical factor expressing a total material passing though the slots of the thickness gauge as the percentage of the mass of sample taken for testing.

OBSERVATIONS AND CALCULATIONS

Flakiness index of coarse aggregate

Sl. No.	Size of Aggregate			Mass of aggregate (gm)	Mass of aggregate retaining the slot, (gm)
	Passing through IS: sieve, (mm)	Retained on IS: sieve, (mm)	Thickness gauge size, (mm)		
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					
9.					
				$\Sigma W = W_1 =$	$\Sigma W = W_2 =$

Flakiness index of coarse aggregate = W2/ W1x100= percent.

RESULTS

Flakiness Index =

EXPERIMENT 6

(a) ELONGATION INDEX

AIM

To determine the elongation index of coarse aggregates

APPARATUS

Balance, a set of 10 sieves ranging from 63mm IS sieve to 6.3mm is sieve; thickness gauge and length gauge.

THEORY

An aggregate having least dimension less than 3/5th of its mean dimension is termed as flaky aggregate. The mean dimension is the average of the sieve sizes through which the particles pass and the sieve size on which these are retained. On the other hand the particles having the largest dimension (length) greater than 9/5 times the mean size the termed elongated. The presence of excess of flaky and elongated particles in concrete aggregate decreases the workability appreciably for a given water-cement ratio, thus requiring larger amounts of sand, cement and water. The flaky and elongated particles tend to orient in one plane and cause laminations which adversely affect the durability of the concrete. The percentage of flaky and elongated particles should be limited to 10 to 15. The tests are not applicable to sizes smaller than 6.3mm.

PROCEDURE

To determine the Elongation index of coarse aggregate

1. Take a sufficient quantity W_3 of coarse aggregate by quartering so as to provide at least 200 pieces of any fraction

2. Carry out sieving by hand. Shake each sieve in order; 63rnm, 50mm, 40mm, 31.5mm, 55mm, 0mm, 16mm, 12.5mm, 10mm and 6.3mm (IS:2386, Part I-1963) as explained in the part (a) so that the material is kept moving over the sieve surface in frequently changing directions.

3. Pass the separated aggregate fractions as retained on the sieves in step 2 through the corresponding length gauge.

A particle of length which cannot pass through the corresponding gauge size is taken as retained by the length gauge. Determine the mass of aggregate retained on each of the length gauge sizes.

4. Find the total mass W4 of the material retained on the length gauges.

5. Determine the elongation index as percentage material retained by the length gauges of the total material taken for testing.

OBSERVATIONS:

Sl. No.	Size of Aggregate			Mass of aggregate (gm)	Mass of aggregate retaining the slot, (gm)
	Passing through IS: sieve, (mm)	Retained on IS: sieve, (mm)	Length gauge size, (mm)		
1.	63	50	-----		
2.	50	40	81.0		
3.	40	31.5	58.5		
4.	31.5	25	----		
5.	25	20	40.5		
6.	20	16	32.4		
7.	16	12.5	25.6		
8.	12.5	10	20.2		
9.	10	6.3	14.7		
				$\Sigma W = W_3 =$	$\Sigma W = W_4 =$

Elongation index = W4/ W3x100 =   percent.

RESULTS

Elongation Index =

(b) WATER ABSORPTION AND MOISTURE CONTENT

AIM

To determine the water absorption and moisture content of given coarse aggregates

APPARATUS

Balance, Wire basket (not more than 6.3mm mesh) Container, Oven, shallow tray and two dry absorbent clothes, Weight box, Metal tray (frying pan) and a source of heat.

THEORY

Water absorption gives an idea of strength of rock. Stones having more water absorption are more porous in nature and generally considered unsuitable unless they are found to be acceptable based on strength, impact and hardness test. Absorption influences the behavior of aggregate in concrete in several aspects. For example a highly absorptive aggregate. If used in dry condition, will reduce "effective water cement ratio". Which in turn results in unworkable concrete mix, if a highly absorptive aggregate is used in construction of flexible pavement consumes cause quantity of binder (bitumen) which leads to higher cost.

The determination of moisture content of an aggregate is necessary in order to determine net water cement ratio for a batch of concrete. High moisture content will increase effective water-cement ratio to an appreciable extent and may even make the concrete weak unless a suitable allowance is made.

PROCEDURE

Water absorption test

1. Take the sample of the coarse aggregate and soak in water and keep it for 24 .The temperature should be 27+/- 5 degree.
2. Weigh the sample of saturated. Surface dry (i.e. it should be saturated and free from surface moisture i.e. surface dry condition). Let this weight be W1.
3. Dry the sample in an oven at 100deg -110deg for a period of 24 hrs .And take the weight of the dry sample and let that be W2.
4. Calculate the absorption of the coarse aggregate by the formula.

Water absorption in percent = $\frac{W_1 - W_2}{W_2}$ X 100

Moisture content

1. Weigh approximately 1000gm of aggregate from the material to be tested by the method of quartering in a metal tray.
2. Heat the aggregate in the tray for about 20 minutes.
3. Weigh the tray with dry aggregate.
4. Take the aggregate out and clean the tray thoroughly and weigh it.
5. Express the loss in mass as a percentage of the dried sample to give the moisture content.

OBSERVATION AND CALCULATION:

Water absorption

Material	**Trial 1**	**Trial 2**	**Trial 3**	**Avg**
Mass of saturated agg W1 gm				
Mass of oven dry agg W2 gm				

Moisture content

Material	**Coarse aggregates**	
Mass of tray and sample W1 gm		
Mass of tray and dry sample W2 gm		
Mass of empty tray W3 gm		
Moisture (by difference) (W1- W2)= Wm gms		
Mass of dry aggregates (W2- W3) = Wa gm		
Moisture content% w = (Wm/Wa)X100		

RESULT

The water absorption of given coarse aggregate =

Moisture content in the given coarse aggregates = __%

(c) SOUNDNESS OF AGGREGATE

AIM:

To determine the soundness of the given sample of coarse aggregates

APPARATUS:

Sample container, weighing machine, drying oven, immersion tank.

THEORY:

The soundness test determines an aggregate's resistance to disintegration by weathering and, in particular, freeze-thaw cycles. The soundness test repeatedly submerges an aggregate sample in a sodium sulfate or magnesium sulfate solution. This process causes salt crystals to form in the aggregate's water permeable pores. The formation of these crystals creates internal forces that apply pressure on aggregate pores and tend to break the aggregate. After a specified number of submerging and drying repetitions, the aggregate is sieved to determine the percent loss of material.

PROCEDURE:

1. A sample of coarse aggregate is taken to conduct the test and the particles finer than 4.75 mm size are removed ; the size of sample for different sizes are noted.
2. The samples are washed thoroughly and oven -dried which are separated into different sizes.
3. The sample is immersed in the prepared solution of sodium sulphate or magnesium sulphate for 16 to 18 hours.
4. The sample is removed from the solution and drained and oven- dried to a constant weight.
5. The sample is allowed to cool at room temperature.
6. Immersion and drying procedures are repeated for many cycles and after the completion of the final cycle, the cooled sample is washed with barium chloride to free from above solutions.
7. Each sample is dried to constant weight and weighed.

OBSERVATIONS:

Seive size		Grading of original sample percent	Wt of test fraction before test, W_o (gm)	Wt of test fraction after test, W_1 (gm)	Percentage passing finer sieve after test (actual percentage loss)	Weighted average
Passing	Retained					
63	40					
40	20					
20	10					
10	4.75					

CALCULATIONS:

Percentage loss = $\frac{w_0 - w_1}{W_o}$ x 100

RESULT:

Soundness of aggregates =

Experiment 7

Concrete Mix design by IS code method as per 10262- 2019 & 456-2000, DOE method

OBJECTIVES OF MIX DESIGN:

The objectives of concrete mix design are to produce concrete that is economical, durable, and has the desired workability and strength:

WORKABILITY:

The time and effort required to handle, install, compact, and finish concrete. Workability is tested using slump, mini-slump flow, and slump flow tests.

DURABILITY:

Concrete must be able to withstand the conditions it's exposed to, and cracking should be minimized. Durability is affected by the mix design, placement and curing methods, and concrete element design.

STRENGTH:

Concrete should have the desired minimum strength in the hardened stage. Compressive strength is an important factor in concrete mix design, but it requires trained operators and expensive testing machines.

ECONOMY:

Concrete should be produced as economically as possible

FACTORS AFFECTING MIX DESIGN OF CONCRETE:

As per IS 456:2000 and IS 1343:1980 codes, the design of concrete mix depends on the following factors:-

1. Grade of concrete
2. Type of cement
3. Maximum nominal size of aggregate

4. Grading of combined aggregate
5. Maximum water cement ratio
6. Workability
7. Stability
8. Quality control

MIX DESIGN STEPS:

Data:

1. Grade designation:
2. Type of cement:
3. Maximum nominal size of aggregates:
4. Minimum cement content:
5. Water cement ration:
6. Workability:
7. Exposure condition
8. Maximum cement content:
9. Chemical admixture: Nil
10. Fine aggregate:
11. Specific gravity of cement:
12. Specific gravity of coarse aggregate:
13. Specific gravity of fine aggregate:

MIX DESIGN:

Step1:

Target strength = f_{ck} + 1.65(S)

Step2:

Water content = Refer IS10262:2019

Step3:

Cement content:

Step4:

Volume of coarse aggregates:

Step5:

a) Volume of concrete = 1 m^3
b) Volume of cement =

c) Mass of water =
d) Volume of admixture = 0 m^3
e) Volume of all in aggregates = a – (b+c+d)
f) Mass of coarse aggregates =
g) Mass of fine aggregates =
h) Mass of cement

RESULT:

Mix Proportion = Mass of cement: Mass of fine aggregate: Mass of coarse aggregates

Experiment 8

Demonstration of Testing of concrete cube of specified strength

THEORY:

One of the important properties of concrete is its strength in compression. The strength in compression has a definite relationship with all other properties of concrete i.e. these properties improved with the improvement in compressive strength. Thus, with this single test one judge that whether Concreting has been done properly or not. In India cubical moulds of size 15 cm × 15cm × 15 cm are commonly used. The concrete is prepared with definite proportion is poured in the mould and tempered properly so as not to have any voids. After 24 hours these moulds are removed and test specimens are put in water for curing. The top surface of this specimen should be made even and smooth. This is done by putting cement paste and spreading smoothly on whole area of specimen. These specimens are tested by compression testing machine after 3, 7 or 28 days curing. Load should be applied gradually at the rate of 14 N/mm 2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of concrete. At least three specimens are tested at each selected age. The failure of the specimen is called as 'hour glass' type failure. This happens due to lateral restraint provided by the plates to the cubes. Practically, the compression testing system develops a complex system of stresses due to end restraints provided by steel platens of compression testing machine (CTM). Under compression loading, due to "poisons effect", the cube specimen also undergo lateral expansion. However, the steel platens don't undergo lateral expansion to the same extent that of concrete. Thus, there exist a differential tendency of lateral expansion between steel platens and concrete cube faces. As a result of this, tangential forces are induced between the end surfaces of the concrete specimen and the adjacent steel platens of CTM. Therefore, in addition to the applied compressive stress; lateral shearing stresses are also effective in these specimens. Effect of this shear decreases to words the centre of the cube. Thus, the cube has near vertical crack at cubes centre and sometimes, the cube may completely disintegrate leaving a relatively undamaged central core.

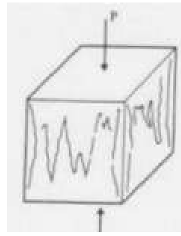


Figure 8: Failure pattern of concrete cubes

PROCEDURE:

1. Calculate the material required for preparing the concrete of given proportions
2. Mix them thoroughly in mechanical mixer until uniform colour of concrete is obtained
3. Pour concrete in the lightly greased cube moulds.
4. Fill concrete in two layers each of approximately 75 mm and ramming each layer with 35 blows evenly distributed over the surface of layer.
5. Struck off concrete flush with the top of the moulds.
6. Level the concrete at the top of the mould by means of trowel and give proper identification mark of the specimen.
7. Immediately after being made, they should be covered with wet mats.
8. Specimens are removed from the moulds after 24hrs and cured in water. Keep it for curing up to 28 days.

TESTING OF CONCRETE CUBES:

9. Take the cube out of water at the end of three days with dry cloth. Measure the dimensions of the surface in which the load is to be applied. Let be ‘L’ and ‘B’ respectively.
10. Place the cube in compressive testing machine and apply the load uniformly at the rate of 35N/mm2.
11. Note the load at which the cube fails. Let it be ‘P’. Also note the type of failure and appearance cracks
12. Calculate the compressive strength of the cube by using formula P/A. Where A is the area of loaded surface (i.e. L×B).
13. Repeat the same procedure (steps 9 to 12) for other two cubes.
14. Repeat the whole procedure (Step 9 to 13) to find the compressive strength of the cube at the end of 7 days and 28 days.

OBSERVATION:

For 28 days strength:

Sl. No	Length (in mm)	Breadth (in mm)	Load (in N)	compressive strength in N/mm^2	Remark

Average =

Experiment 9

Demonstration of Testing of concrete beam for pure bending

THEORY:

Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam to resist failure in bending. It is measured by loading 150 x 150 mm concrete beams with a span length of 700 mm. This test is performed by three point loading experiment. The Third point loading test applies the forces at the 1/3 and 2/3 points equally from the top side by distributing a single centred force through a steel beam to two points rather than one. The beam is supported at two points from below near the ends. The bending moment is lower in a third point test than in a centre point test. Highway designer use a theory based on flexural strength for design of pavements. However, there is very limited use of flexural testing for structural concrete. Figure 9 shows a typical test arrangement for flexural strength test

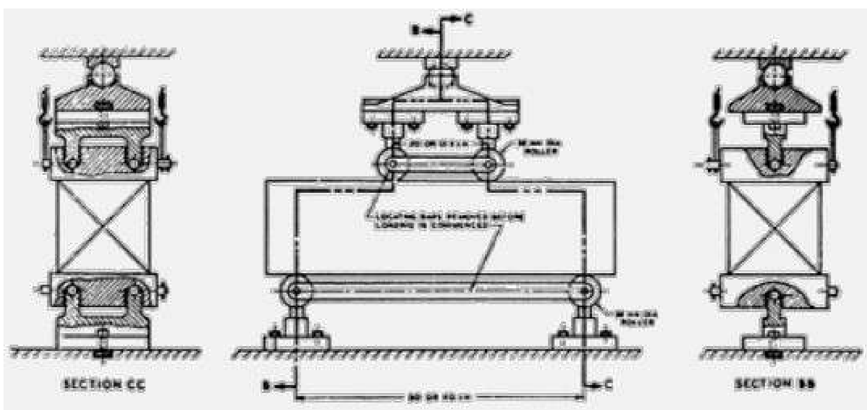


Figure 9: Arrangement for loading of flexure test specimen

Flexural strength tests are extremely sensitive to specimen preparation, handling, and curing procedure. Beams are very heavy and can be damaged when handled and transported from the jobsite to the lab. Allowing a beam to dry will yield lower strengths. The beams must be cured in a standard manner, and should be tested while wet. Meeting all these requirements on a job site is extremely difficult and hence often results in unreliable and generally low MR values. A short period of drying can produce a sharp drop in flexural strength.

OBJECTIVE: To determine flexural strength of cubic concrete specimens.

REFERENCE: IS: 516 - 1959, IS: 1199-1959, SP: 23-1982, IS: 10086-1982. 39

APPARATUS: Flexural testing beam moulds, tamping rod, metallic sheet, universal testing machine. Material: Cement, sand, aggregate and water, grease

PROCEDURE:

1. Sampling of Materials: Samples of aggregates for each batch of concrete shall be of the desired grading and shall be in an air-dried condition. The cement samples, on arrival at the laboratory, shall be thoroughly mixed dry either by hand or in a suitable mixer in such a manner as to ensure the greatest possible blending and uniformity in the material.

2. Proportioning: The proportions of the materials, including water, in concrete mixes used for determining the suitability of the materials available, shall be similar in all respects to those to be employed in the work.

3. Weighing: The quantities of cement, each size of aggregate, and water for each batch shall be determined by weight, to an accuracy of 0.1 percent of the total weight of the batch.

4. Mixing of Concrete: The concrete shall be mixed by hand, or preferably, in a laboratory batch mixer, in such a manner as to avoid loss of water or other materials. Each batch of concrete shall be of such a size as to leave about 10 percent excess after moulding the desired number of test specimens.

5. Mould: The standard size shall be 15 × 15 × 70 cm. Alternatively, if the largest nominal size of the aggregate does not exceed 19 mm, specimens 10 × 10 × 50 cm may be used.

6. Compacting: The test specimens shall be made as soon as practicable after mixing, and in such a way as to produce full compaction of the concrete with neither segregation nor excessive laitance.

7. Curing: The test specimens shall be stored in a place, free from vibration, in moist air of at least 90 percent relative humidity and at a temperature of 27° ± 2°C for 24 hours ± ½ hour from the time of addition of water to the dry ingredients.

8. Placing the Specimen in the Testing Machine: The bearing surfaces of the supporting and loading rollers shall be wiped clean, and any loose sand or other material removed from the surfaces of the specimen where they are to make contact with the rollers

9. The specimen shall then be placed in the machine in such a manner that the load shall be applied to the uppermost surface as cast in the mould, along two lines spaced 20.0 or 13.3 cm apart.

10. The axis of the specimen shall be carefully aligned with the axis of the loading device. No packing shall be used between the bearing surfaces of the specimen and the rollers. 40

11. The load shall be applied without shock and increasing continuously at a rate such that the extreme fibre stress increases at approximately 7 kg/sq cm/min, that is, at a rate of loading of 400 kg/min for the 15.0 cm specimens and at a rate of 180 kg/min for the 10.0 cm specimens.

12. The load shall be increased until the specimen fails, and the maximum load applied to the specimen during the test shall be recorded. The appearance of the fractured faces of concrete and any unusual features in the type of failure shall be noted.

OBSERVATION:

• Length of Specimen (l) : _______ mm

• Width of the specimen (b) : _______ mm

• Depth of the specimen (d) : _______ mm

Sl. No.	Age of specimen	Maximum load (P) in N	Position of Fracture (a) in mm*	Modulus of rupture (fb)
1				
2				
3				

* 'a' equals the distance between the line of fracture and the nearer support, measured on the centre line of the tensile side of the specimen.

** When a> 200 mm for a 150 mm specimen, the flexural strength of the specimen expressed as the modulus of rupture, fb, is calculated from:

$$f\,b = P \times l / (\times d^{2})$$

But, if 200> a> 170 mm for a 150 mm specimen fb, is calculated from: $f\,b = P \times l / (b \times d^{2})$

RESULTS:

• The average 28 days modulus of rupture of concrete sample is : _______ MPa