Lab Manual OF CONCRETE TECHNOLOGY

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EXPERIMENT-01

Determine fine silt in aggregate by field method.

EXPERIMENT-02

Determine flakiness index and elongation index of coarse aggregate (IS 2386Part I)

APPARATUS: metal gauge, Weighing Balance, Gauging Trowel, Sieves.

REFERENCE:

- IS: 2386 (Part I) – 1963 Method of test for aggregates for concrete
- IS: 383-1970 specification for coarse and fine aggregate from natural source for concrete

THEORY:

The flakiness index of an aggregate is the percentage by weight of particles in it whose least dimension (thickness) is less than three-fifths of their mean dimension. Particle shape and surface texture influence the properties of freshly mixed concrete more than the properties of hardened concrete. Rough-textured, angular, and elongated particles require more water to produce workable concrete than smooth, rounded compact aggregate. Consequently, the cement content must also be increased to maintain the water-cement ratio. Generally, flat and elongated particles are avoided or are limited to about 15 % by weight of the total aggregate.

PROCEDURE

- A quantity of aggregate shall be taken sufficient to provide the minimum number of 200 pieces of any fraction to be tested.
- The sample shall be sieved with sieves specified in Table.
- Then each fraction shall be gauged in turn for thickness on a metal gauge of the pattern shown in Fig or in bulk on sieves having elongated slots. The width of the slot used in the gauge or sieve shall be of the dimensions specified in column 3 of Table for the appropriate size of material.
- The total amount passing the gauge shall be weighed to an accuracy of at least 0.1percent of the weight of the test sample.

$$\text{Flakiness Index } = 100 \text{ x} \frac{\sum w}{\sum W}$$

CALUCULATIONS:

Where,

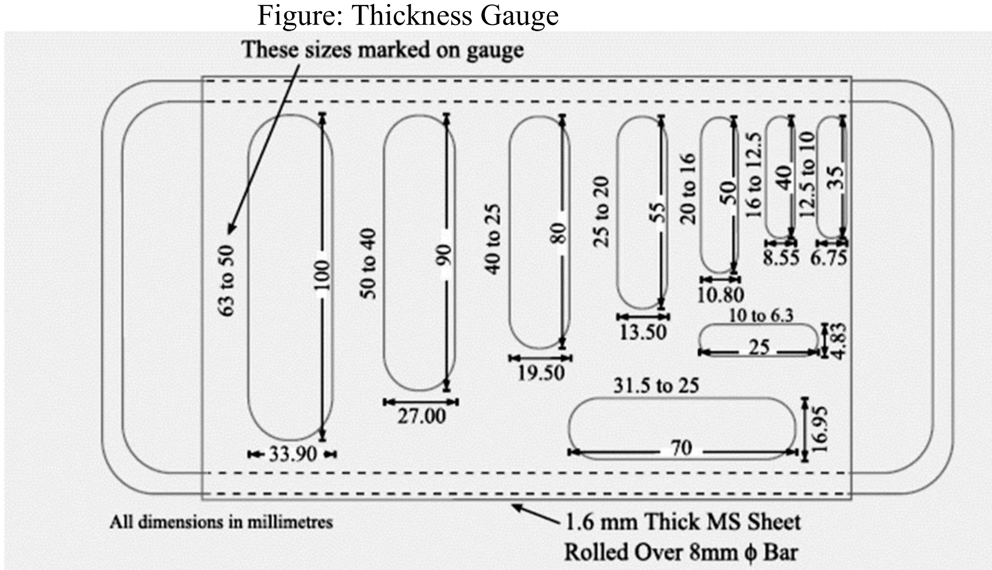
w is the weights of material passing the various thickness gauges

W is the total weights of aggregate passing and retained on the specified sieves.

Dimensions of Thickness:

Size of Aggregate (mm)		Weight Retained on Thickness Gauge	Thickness Gauge (mm)	Weight Of flaky particles W g
Passing through IS sieve	Retained on IS sieve			
63	50		33.90	
50	40		27.00	
40	31.5		21.50	
31.5	25		16.95	
25	20		13.50	
20	16		10.80	
16	12.5		8.55	
12.5	10		6.75	
10	6.3		4.89	

Figure: Thickness Gauge



EXPERIMENT-03

Determine specific gravity and water absorption of aggregate (IS2386part III for aggregates of size 40 mm to 10 mm)

THEORY: For design of concrete mix, information about the specific gravity and water absorption of the coarse aggregates are required. Specific gravity of aggregate provides valuable information on its quality and properties. If the specific gravity is above or below the value normally assigned to a particular type of aggregate; it may indicate that shape and grading of aggregate has altered. It is also important in determination of moisture contact and in many concrete mix design calculations. It is also required for the calculation of volumeyield of concrete.

Reference: IS: 2386 (Part-3)-1963.

Apparatus: Balance of capacity 5kg weight, box wire basket 200mm in diameter, water container for immersing the wire basket, absorbent cloth for surface drying of the sample and thermos static drying oven.

Material: coarse aggregates (5 Kg),

PROCEDURE:

1. A sample of not less than 2 Kg of the aggregate shall be thoroughly washed to remove finer particles and dust, drained and then placed in the wire basket and immersed in distilled water at a temperature between 22°C to 32°C with a cover of at least 5 cm of water above the top of the basket.
2. Immediately after immersion the entrapped air shall be removed from the sample by lifting the basket containing it 25 mm above the base of the tank and allowing it to drop 25 times at the rate of about one drop per second.
3. The basket and aggregate shall remain completely immersed during the operation and for a period of 24 ± l/2 hours afterwards.
4. The basket and the sample shall then be jolted and weighed in water at a temperature of 22°C to 32°C (weight A).
5. The basket and the aggregate shall then be removed from the water and allowed to drain for a few minutes, after which the, aggregate shall be gently emptied from the basket on to one of the dry clothes, and the empty basket shall be returned to the water and weighed in water (weight B).
6. The aggregate placed on the dry cloth shall be gently surface dried with the cloth, transferring it to the second dry cloth when the first will remove no further moisture. The aggregate shall then be weighed (weight C).
7. The aggregate shall then be placed in the oven in the shallow tray, at a temperature of 100 to 110°C and maintained at this temperature for 24 ± l/2 hours. It shall then be removed from the oven, cooled in an airtight container,and weighed (weight D).

8. The specific gravity, apparent specific gravity and water &sorption shall be calculated as.

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

   Apparent Specific gravity $= \{D/[D-(A-B)]\}$

   Water absorption (in %) $= 100 \times [(C-D)/D]$

   Where,

   A = Weight in g of aggregate and basket in water
   B = Weight in g of empty basket in water
   C = Weight in g of the saturated surface - dry aggregate in air
   D = Weight in g of oven dried aggregate in ai

OBSERVATION:

Weight of aggregate and basket in water (A)	
Weight of empty basket in water (B)	
Weight of the saturated surface - dry aggregate in air (C)	
Weight of oven dried aggregate in air (D)	
Specific gravity $= [D/(C-A+B)]$	
Apparent Specific gravity $= [D/(C-D)]$	
Water absorption (in %) $= 100 \times [(C-D)/D]$	

RESULTS:

Following results are obtained for the provided coarse aggregate specimen:

a) Specific gravity : ___________.

b) Apparent specific gravity : ___________.

c) Water absorption : ___________%.

EXPERIMENT-04

Determine the compressive strength of Portland cement (IS269)

THEORY:

The compressive strength of cement mortars is determined to verify whether the cement conforms to IS specifications and whether it will be able to develop the required compressive strength of concrete. The average compressive strength of at least three mortar cubes (area of the face 50 cm^2) composed of one part of cement and three parts of standard stand should satisfy IS code specifications.

REFERENCE:

- IS: 4031 (Part 6) – 1988.

APPARATUS:

- Vibration Machine
- Poking Rod
- Cube Mould size conforming to IS: 10080-1982
- Weighing Balance
- Trowel
- Stopwatch
- Graduated Glass Cylinders

THEORY:

compressive strength of cement mortars is determined to verify whether the cement The conforms to IS specifications and whether it will be able to develop the required compressive strength of concrete. The average compressive strength of at least three mortar cubes (area of the face 50 cm2) composed of one part of cement and three parts of standard stand should satisfy IS code specifications.

PROCEDURE:

- 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.distilled water shall be used in preparing the cubes.
- The material for each cube shall be mixed separately and the quantity of cement, standard sand and water shall be as follows: Cement 200 g and Standard Sand 600 g
- Water (P/4+0.3) percent of combined mass of cement and sand.

- Moulding Specimens: In assembling the mould ready for use, treat the interior facesof the mould with a thin coating of mould oil.
- Place the assembled mould on the table of the vibration machine and hold it firmly inposition by means of a suitable clamp. Attach a hopper of suitable size and shape securely at the top of the mould to facilitate water required to produce a paste of standard consistency.
- 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 color. Thequantity 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 color exceed 4 min, the mixture shall be rejected, and the operation repeated with a fresh quantity of cement, sand, and water.
- The period of vibration shall be two minutes at removed until the completion of the vibration period.
- Immediately after mixing the mortar in accordance with steps 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.
- The specified speed of 12 000 ± 400 vibration per minute.
- 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 surfacewith the blade of a trowel.
- <u>Curing Specimens</u>: - keep the filled mould in moist closet or moist room for 24 ± 1 hour after completion of vibration. At the end of that period, remove them from the mould, immediately submerge in clean fresh water, and keep there until taken out just prior to breaking.
- 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 dry.
- Test three cubes for compressive strength for each period of curing mentioned under the relevant Specifications (i.e. 3 days, 7 days, 28 days)
- The cubes shall be tested on their sides without any packing between the cube andthe steel plates of the testing machine. One of the platens shall be carried on a baseand 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.

OBSERVATIONS:

- Type of cement=..........................
- Brand of cement=.......................
- Date of casting=...........................

Trail No	Age of Cube	Dimensions Of the specimen (mm)			Weight of Cement Cube (g)	Cross-Sectional area(mm^2)	Crushing Load (N)	Average Compressive strength (MPa)
		L mm	B mm	H mm				
1								
2								
3								
4								

$$\text{Compressive Strength} = \frac{\text{Crushing load}}{\text{Cross section area}}$$

Figure: Cube Testing Machine

RESULT:

The average compressive strength of the given cement

1. 3 days......................................N/mm^2
2. 7 days......................................N/mm^2
3. 28 days....................................N/mm^2

EXPERIMENT-05

Determine of bulk density and voids of aggregates ((IS2386part III)

EXPERIMENT-06

Determine particle size distribution of fine, coarse and all in aggregate by sieve analysis (grading of aggregate)

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.

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 fine sand may be 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.

PROCEDURE:

- 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.
- 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.
- 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.
- Light brushing with a fine camel hairbrush may be used on the 150-micron and 75-micron IS Sieves to prevent aggregation of powder and blinding of apertures.
- 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 (g)	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.

$$Finess\ Modulus,\ FM = \frac{Total\ of\ Cumulative\ Percentage\ of\ Passing\ (\%)}{100}$$

CONCLUSION / RESULT:

Fineness modulus of a given sample of fine aggregate is .... that indicate Coarse. sand/ Medium sand/Fine sand.

The given sample of fine aggregate is belonged 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

EXPERIMENT-07

Determine Fineness modulus of fine and coarse aggregate by sieve analysis.

REFERENCE CODES:

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

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, Stopwatch, etc.

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 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.. : 2.9 - 3.2
Sand having a fineness modulus more than 3.2 will be unsuitable for making satisfactory concrete.

PROCEDURE:

- 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.
- 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.
- 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.
- Light brushing with a fine camel hairbrush may be used on the 150-micron and 75-micron IS Sieves to prevent aggregation of powder and blinding of apertures.
- 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 (g)	Percentage of Weight Retained (%)	Percentage of Weight Passing (%)	Cumulative Percentage of Passing (%)	Remark
4.75 mm					
2.36 mm					
1.18 mm					
600 microns					
300 microns					
150 microns					
Total					

CALCULATION:

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

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.

$$Finess\ Modulus, FM = \frac{Total\ of\ Cumulative\ Percentage\ of\ Passing\ (\%)}{100}$$

CONCLUSION / RESULT:

- Fineness modulus of a given sample of fine aggregate is that indicate Coarse sand/Medium sand/Fine sand.
- Coarse aggregate is belonged to Grading Zones I / II / III / IV

EXPERIEMNT-09

Test for workability (slump test):

(a)To verify the effect of water, fine aggregate/coarse aggregate ratio, and aggregate/Cement ratio on slump.

(b) To test cube strength of concrete with varying water cement ratio.

(a)To verify the effect of water, fine aggregate/coarse aggregate ratio, and aggregate/Cement ratio on slump.

APPARATUS:

- Pan to mix concrete.
- weighing balance
- trowel
- cone
- steel scale
- tamping rod
- mixing tray

REFERENCE CODE:

- IS: 456-2000, code for plain and reinforced concrete
- IS: 1199-1959 methods of sampling and analysis of concrete

THEORY:

This is the test extensively used in site work all over the world. Fresh unsupported concrete will flow to the sides and the vertical sinking of concrete is known as slump. The slump cone is a hollow frustum made of thin steel sheet with internal dimensions, as the top diameter 10 cms. The bottom diameter 20 cms, and height 30cms.

PROCEDURE

- Mix the dry constituents thoroughly to get a uniform color and then add water.
- The internal surface of the mould is to be thoroughly cleaned and placed on a smooth, horizontal, and non-absorbent surface.
- Place the mixed concrete in the cleaned slump cone in 4 layers each approximately 1/4 in height of the mould. Tamp each layer 25 times with tamping rod. Using the tampering rod or a trowel strike of the excess concrete above the concrete cone. Measure the vertical height of cone (h1).
- Slowly and carefully remove in the vertical direction. As soon as the cone is removed the concrete settles in vertical direction. Place the steel scale above top ofsettled concrete in horizontal position and measure the height of cone(h2).
- Complete the experiment in two minutes after sampling.

- The difference of two heights (h1-h2) gives the value of slump

OBSERVATIONS:

1) Type of cement=……………….
2) Brand of cement=……………….
3) Density of concrete=...............

Trail No	Proportion					SLUMP In mm	Remarks
	w/c	W liter	C kg	FA kg	CA kg		
1							
2							
3							
4							

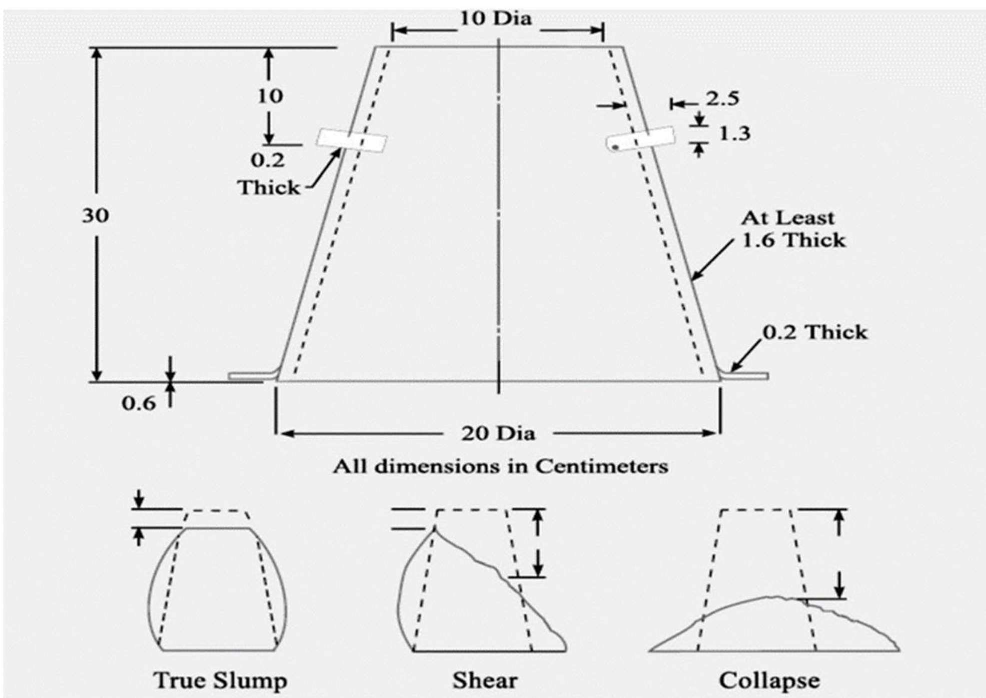


Figure: Different Types of Slumps

RESULTS:

The slump of concrete= ....mm

(Indicate Low/Medium/ High Degree of workability)

EXPERIMENT-10

Compaction factor test for workability (IS: 1199)

APPARATUS:

- Compaction factor apparatus
- Weighing balance
- Tamping rod Trowel
- Scoop about 150 mm long
- Tamper (16 mm in diameter and 600 mm length)
- Ruler
- Tools and containers for mixing or concrete mixer etc.

REFERENCE CODE:

- IS; 1199-1959 methods of sampling and analysis of concrete.
- IS:5515-1983 Specification for compressive factor apparatus

THEORY:

The compaction factor is defined as the ratio of the weight of partially compacted concrete to the weight of fully compacted concrete. The compacting factor test is designed primarily for use in the laboratory, but it can also be used in the field. It is more precise and sensitive than the slump test and is particularly useful for concrete mixes of very low workability as are normally used when concrete is to be compacted by vibration.

PROCEDURE:

- Grease the inner surface of the hoppers and the cylinder and fasten the hopper doors.
- Weigh the empty cylinder accurately (W1 Kg) a Fix the cylinder on the base with nuts and bolts.
- Mix coarse and fine aggregates and cement dry until the mixture is uniform in colorand then with water until concrete appears to be homogeneous.
- Fill the freshly mixed concrete in upper hopper gently with trowel without compacting.
- Release the trap door of the upper hopper and allow the concrete of fall into the lower hopper bringing the concrete into standard compaction.
- Immediately after the concrete comes to rest, open the trap door of the lower hopper, and allow the concrete to fall into the cylinder, bringing the concrete into standard compaction.
- Remove the excess concrete above the top of the cylinder by a trowel.
- Find the weight of cylinder i.e. cylinder filled with partially compacted concrete (W 2kg)
- Refill the cylinder with same sample of concrete in approx. 4 layers, tamping eachlayer with tamping for 25 times to obtain full compaction of concrete.
- Level the mix and weigh the cylinder filled with fully compacted concrete (W3 Kg).
- Repeat the procedure for different for different a trowel

OBSERVATIONS AND CALCULATIONS:

Weight of cylinder W1 =.. Kg

Trail no	Quantity of material					Mass of cylinderwith partially compaction W_2 (Kg)	Mass of cylinder wishfully compaction W_3 (Kg)	Compaction Factor $\frac{W_2 - W_1}{W_3 - W_1}$
	w/c	W liter	C kg	FA kg	CA kg			
1								
2								
3								

$$\textbf{Compaction factor} = \frac{W_2 - W_1}{W_3 - W_1}$$

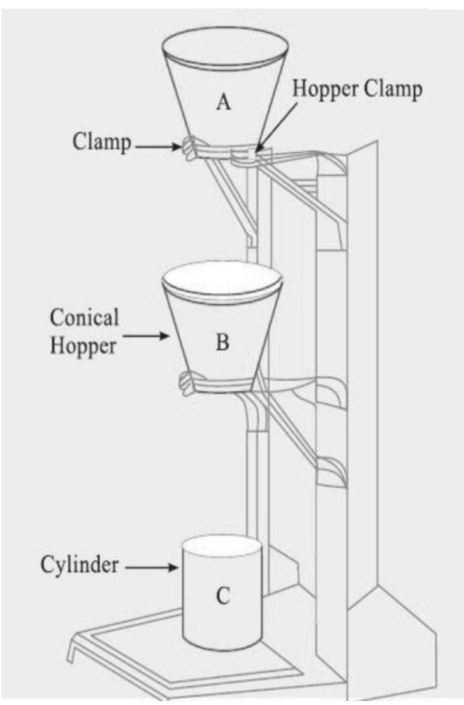


Figure: Compaction factor apparatus

RESULTS:

Compaction factor IS =…………………………………..

EXPERIMENT-11

Conduct Split Cylinder Test

REFERENCE CODES:

- IS: 516 – 1959
- IS: 1199-1959
- SP: 23-1982
- IS: 10086-1982

THEORY:

Age at Test - Tests shall be made at recognized ages of the test specimens, the most usual being 7 and 28 days. Where it may be necessary to obtain the early strengths, tests may be made at the ages of 24 hours ± ½ hour and 72 hours ± 2 hours. The ages shall be calculated from the time of the addition of water to the dry ingredients.

Number of Specimens - At least three specimens, preferably from different batches, shall be made for testing at each selected age.

APPARATUS:

Testing Machine - The testing machine may be of any reliable type, of sufficient capacity for the tests and capable of applying the load at the rate specified in 5.5. The permissible error shall be not greater than ± 2 percent of the maximum load.

Cylinders -The cylindrical mould shall be of 150 mm diameter and 300 mm height conforming to IS: 10086-1982.

Weights and weighing device, Tools and containers for mixing, Tamper (square in cross section) etc.

PROCEDURE:

1. **Sampling of Materials -** Samples of aggregates for each batch of concrete shall be ofthe 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 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 aftermoulding the desired number of test specimens.
5. **Mould -** The cylindrical mould shall be of 150 mm diameter and 300 mm height conforming to IS: 10086-1982.
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 contact the rollers.
9. Two bearings strips of nominal (1/8 in i.e 3.175mm) thick plywood, free of imperfections, approximately (25mm) wide, and of length equal to or slightly longer than that of the specimen should be provided for each specimen.
10. The bearing strips are placed between the specimen and both upper and lower bearingblocks of the testing machine or between the specimen and the supplemental bars or plates.
11. Draw diametric lines and each end of the specimen using a suitable device that will ensure that they are in the same axial plane. Center one of the plywood strips alongthe center of the lower bearing block.
12. Place the specimen on the plywood strip and align so that the lines marked on the ends of the specimen are vertical and centered over the plywood strip.
13. Place a second plywood strip lengthwise on the cylinder, centered on the lines markedon the ends of the cylinder. Apply the load continuously and without shock, at a constant rate within, the range of 689 to 1380 kPa/min splitting tensile stress until failure of the specimen.
14. Record the maximum applied load indicated by the testing machine at failure. Notethe type of failure and appearance of fracture.

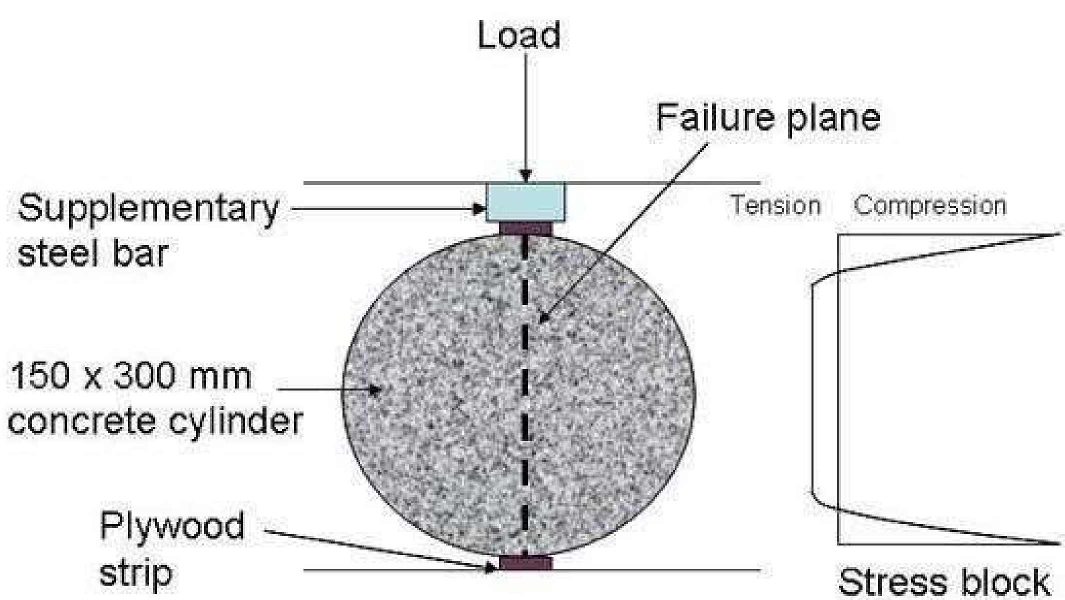


Figure: Loading Arrangement for Determining Split Tensile Strength

Figure: Cylinder in compression machine

OBSERVATIONS:

Calculations of Mix Proportion

Mix proportion of concrete	For 1 cubic meter of concrete	For one batch of mixing
Coarse aggregate (kg)		
Fine aggregate (kg)		
Cement (kg)		
Water (kg)		
S/A		
w/c		
Admixture		

Sr. No.	Age of Specimen	Identification Mark	Dia of Specimen (mm)	Depth (mm)	Maximum Load (N)	Tensile Strength (MPa)	Average Tensile Strength (MPa)
1	7 Days						
2							
3							
4	28 Days						
5			`				
6							

CALCULATION:

Calculate the splitting tensile strength of the specimen as follows:

$$T = \frac{2P}{\pi L d}$$

Where:

T: splitting tensile strength, kPa

P: maximum applied load indicated by testing machine, kN

L: Length, m

d: diameter

CONCLUSION:

ii) The average 7 Days Tensile Strength of concrete sample is found to be …..…..

iii) The average 28 Days Tensile Strength of concrete sample is found to be …..…..

EXPERIMENT-12

Determine the compressive strength of concrete cubes.

REFERENCE CODES:

- IS: 516 - 1959
- IS: 1199-1959
- SP: 23-1982
- IS: 10086-1982

THEORY:

Age at Test - Tests shall be made at recognized ages of the test specimens, the most usual being 7 and 28 days. Where it may be necessary to obtain the early strengths, tests may be made at the ages of 24 hours ± ½ hour and 72 hours ± 2 hours. The ages shall be calculated from the time of the addition of water to the dry ingredients.

Number of Specimens - At least three specimens, preferably from different batches, shall be made for testing at each selected age.

APPARATUS:

Testing Machine: The testing machine may be of any reliable type, of sufficient capacityfor the tests and capable of applying the load at the rate specified in 5.5. The permissible error shall be not greater than ± 2 percent of the maximum load.

Cube Moulds: The mould shall be of 150 mm size conforming to IS: 10086-1982.

Cylinders: The cylindrical mould shall be of 150 mm diameter and 300 mm height conforming to IS: 10086-1982.

Weights and weighing device, Tools and containers for mixing, Tamper (square in cross section) etc.

PROCEDURE:

- **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 suitablemixer in such a manner as to ensure the greatest possible blending and uniformity in the material.
- **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
- **Mould** - Test specimens cubical in shape shall be 15 × 15 × 15 cm. If the largest nominal size of the aggregate does not exceed 2 cm, 10 cm cubes may be used as an alternative. Cylindrical test specimens shall have a length equal to twice the diameter.
- **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 neithersegregation nor excessive laitance.
- **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.
- Placing the Specimen in the Testing Machine - The bearing surfaces of the testing machine shall be wiped clean, and any loose sand or other material removed from the surfaces of the specimen which are

to be in contact with the compression platens.

- In the case of cubes, the specimen shall be placed in the machine in such a manner that the load shall be applied to opposite sides of the cubes as cast, that is, not to the top and bottom.
- The axis of the specimen shall be carefully aligned with the center of thrust of the spherically seated platen. No packing shall be used between the faces of the test specimen and the steel platen of the testing machine.
- The load shall be applied without shock and increased continuously at a rate of approximately 140 kg/sq cm/min until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained.
- The maximum load applied to the specimen shall then be recorded and the appearance of the concrete and any unusual features in the type of failure shall be noted.

OBSERVATION:

Sr. No.	Description	Value
1	Compressive strength at 28 days	
2	Slump	
3	Type of cement	
4	Specific gravity of cement	
5	Type of sand	
6	Specific gravity of sand	
7	Fineness modulus	
8	Type of coarse aggregate	

Data for the calculating of the mix proportion of Mix Calculations Proportion

Mix proportion of concrete	For one cubic meter of concrete	For one batch of mixing
Coarse aggregate (kg)		
Fine aggregate (kg)		
Cement (kg)		
Water (kg)		
S/A		
w/c		
Admixture		

Sr. No.	Age of Cube	Weight of Cement Cube (g)	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						

CONCLUSION:

i) The average 7 Days Compressive Strength of concrete sample is found to be ……..

ii) The average 28 Days Compressive Strength of concrete sample is found to be ……..

EXPERIMENT-13

Conduct Nondestructive test on concrete.

(a) Rebound hammer test

(b) Ultrasonic pulse velocity test

Rebound hammer test.

APPARATUS:

- Rebound Hammer instrument.
- Abrasive Stone

PROCEDURE:

Hold the instrument firmly so that the plunger is perpendicular to the test surface. Gradually push the instrument toward the test surface until the hammer impacts. After impact, maintain pressure on the instrument and if necessary, depress the button on the side of the instrument to lock the plunger in its retracted position. Read the rebound number on thescale to the nearest whole number and record the rebound number. Take ten readings from each test area. No two impact tests shall be closer together than 25 mm (1 in). Examine the impression made on the surface after impact, and if the impact crushes or breaks through a near-surface air void, disregard the reading and take another reading.

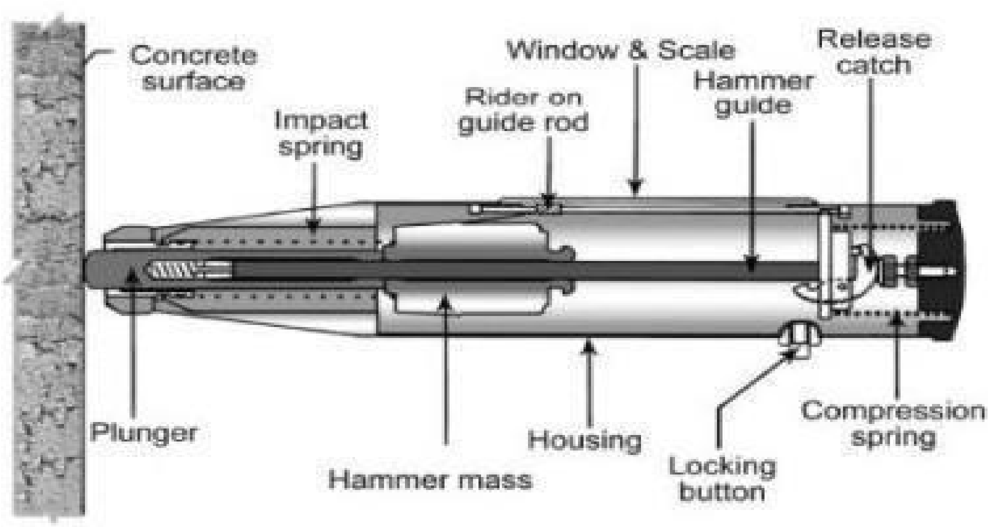


Figure: Rebound Hamm

READING YOUR RESULTS:

Make at least ten readings from a concrete surface and discard the highest and lowest rebound numbers. Average the remaining eight numbers. If desired, take a few test readings before you complete your series of ten regular tests. Use the average rebound number to estimate the strength of the concrete. Compare your average rebound number to the chart shown on your Concrete Rebound Hammer.

Average Rebound Number	Quality of Concrete
>40	Very good hard layer
30 to 40	Good layer
20 to 30	Fair
<20	**Poor concrete**

Ultrasonic pulse velocity test

THEORY:

A pulse of longitudinal vibrations is produced by an electro-acoustical transducer, which is held in contact with one surface of the concrete under test. When the pulse generated is transmitted into concrete from the transducer using a liquid coupling material such as grease or cellulose paste, it undergoes multiple reflections at the boundaries of the different material phases within the concrete. A complex system of stress waves develops which includes both longitudinal and shear waves and propagates through the concrete. The first wave to reach the receiving transducer are the longitudinal waves which are converted into an electrical signal by a second transducer. Electronic timing circuits enable the transit time T of the pulse to be measured.

Longitudinal pulse velocity (in km/s or m/s) is given by: -

$V = L/T$

Where V = Longitudinal pulse velocity

L = Path length

T = Time taken by the pulse to travel the length

REFERENCES:

- IS 13311 (Part 2): 1992: Method of Non-destructive testing of concrete, Part 1: Ultrasonic Pulse Velocity (Reaffirmed 2004)

APPARATUS REQUIRED:

- Electrical pulse generator.
- Transducer - 1 pair.
- Amplifier.
- Electronic timing device

Figure 16: Ultrasonic Pulse Velocity Apparatus

PROCEDURE:

1. In this test method, the ultrasonic pulse is produced by transducer which is held in contact with one surface of concrete member under test. After traversing a known path length (L) in the concrete the pulse of vibration is converted into an electrical signal by the second transducer held in contact with the other surface of the concrete member and an electronic timing circuit enables the transit time (T) of the pulse to be measured. The pulse velocity (V) is given by V=L/T.

2. The natural frequency of the transducers should preferably be within the range of 20 to150 kHz. Generally high frequency transducers are preferable for short path lengths and low frequency transducers for long path lengths. Transducers with a frequency 50 to 60 kHz are

useful for most all around application.

3. There are used petroleum jelly, grease, liquid soap, and kaolin glycerol paste. If there isvery rough concrete surface, it is required to make the concrete surface smooth and then placethe transducer.

4. A minimum path length of 150 mm is recommended for the direct transmission method involving one unmolded and a minimum of 400 mm for the surface probing method along the unmolded surface.

5. Pulse velocity will not be influenced by the shape of the specimen, provided its least lateral dimension (i.e., its dimension measured at right angles to the pulse path) is not less thanthe wavelength of vibrations.

6. For the pulse of 50 Hz frequency, this corresponding to a least lateral dimension of 80mm.

Method of propagating and receiving pulses:

There are three ways of measuring the pulse velocity through the concrete as shown in Figure 17.

1. Direct method: The direct method (cross-probing) is preferred wherever access to opposite sides of the component is possible.

2. Semi-direct method: The semi-direct method is preferred where two sides access is possible but these sides are not opposite sides.

3. Indirect method: The surface (indirect) method is the least satisfactory and should only be used when access to only one surface is possible. This method only indicates the quality of concrete and is influenced by the presence of reinforcement parallel to the surface.

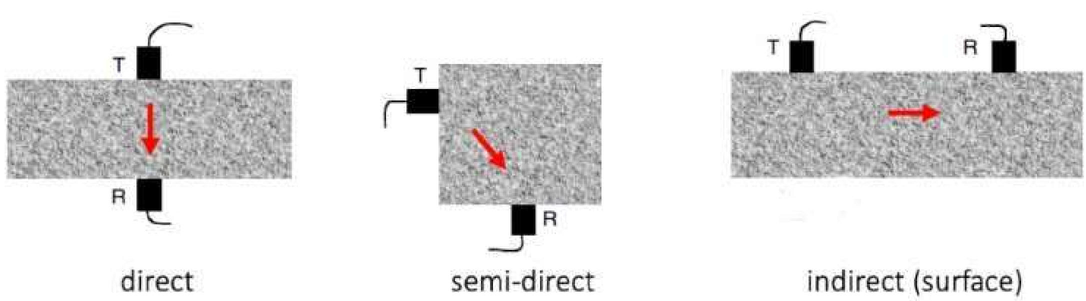


Figure 17: Pulse Measurement Types

Influence of test condition:

1. Moisture content: The moisture content has two effects on the pulse velocity, one chemical the other physical. These effects are important in the production of co-relation for prediction of concrete strength.

2. Surface condition: Smoothness of the contact surface under the test affects the measurement of ultrasonic pulse velocity.

3. Path length, shape, and size of the concrete member: The shape and size of the concrete member do not influence the pulse velocity until the least lateral dimension is less than a certain minimum value. The path length can affect the pulse velocity readings.

4. Temperature: At 30ºC to 60ºC, there can be reduction in pulse velocity up to 5% but 5ºC – 30ºC the pulse velocity is not affected. Below the freezing temperature, increase in pulse velocity is 7.5%.

Table 1: Velocity and Concrete quality (IS: 13311 (Part 1) - 1992)

Sl. No.	Pulse Velocity by Cross Probing (km/sec)	Concrete Quality Grading
1	Above 4.5	Excellent
2	3.5 to 4.5	Good
3	3.0 to 3.5	Medium
4	Below 3.0	Doubtful

OBSERVATIONS AND CALCULATIONS:

Sl. No.	Beam specimen No.	Method of testing	Length (L) mm	Time (T) µs	Velocity mm/ µs	Average Velocity (V) mm/ µs	Quality of Concrete
1.	1	Direct	750	243			
2.		Indirect	375	121			
3.		Semi-Direct	382	124			

4.	2	Direct	750	244			
5.		Indirect	375	123			
6.		Semi-Direct	382	125			
7.	3	Direct	750	242			
8.		Indirect	375	122			
9.		Semi-Direct	382	126			

EXPERIMENT-14
Determine flexural strength of concrete beam.

REFERENCE CODES:

- IS: 516 – 1959
- IS: 1199-1959
- SP: 23-1982
- IS: 10086-1982

THEORY:

Age at Test - Tests shall be made at recognized ages of the test specimens, the most usual being 7 and 28 days. Where it may be necessary to obtain the early strengths, tests may be made at the ages of 24 hours ± ½ hour and 72 hours ± 2 hours. The ages shall be calculated from the time of the addition of water to the dry ingredients.
Number of Specimens - At least three specimens, preferably from different batches, shall be made for testing at each selected age.

APPARATUS:

Testing Machine - The testing machine may be of any reliable type, of sufficient capacity for the tests and capable of applying the load at the rate specified in 5.5. The permissible error shall be not greater than ± 2 percent of the maximum load.
Beam Mould - The beam mould shall conform to IS: 10086-1982. 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.
Weights and weighing device, Tools and containers for mixing, Tamper (square in cross section) etc.

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 weightof the

batch.

4. **Mixing 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. **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 neithersegregation nor excessive laitance.
6. **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.
7. **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.
8. 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.
9. 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.
10. 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.
11. 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.

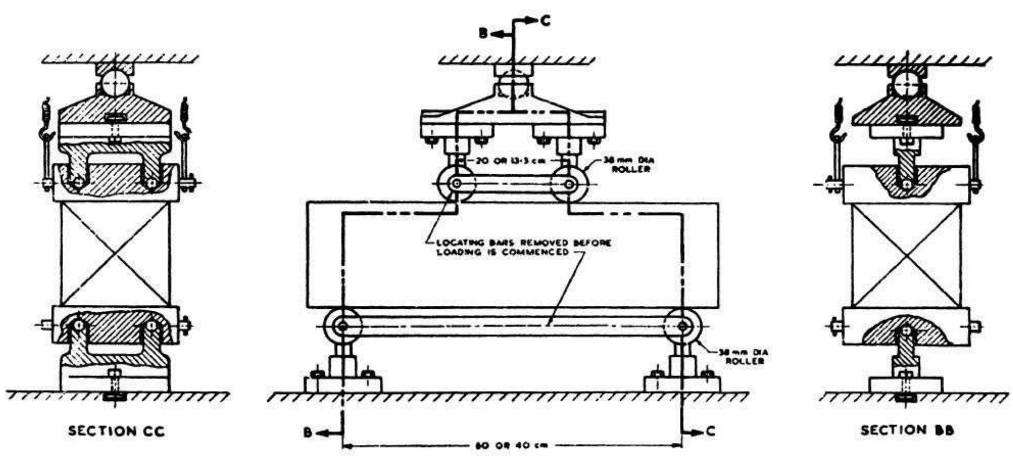


Figure: Flexural strength test of molded concrete flexure test specimens

Observation:

Calculations of Mix Proportion

Mix proportion of concrete	For 1 cubic meter of concrete	For one batch of mixing
Coarse aggregate (kg)		
Fine aggregate (kg)		
Cement (kg)		
Water (kg)		
S/A		
w/c		
Admixture		

Sr. No.	Age of Specimen	Identification Mark	Size of Specimen (mm)	Span Length (mm)	Max. Load (N)	Position of Fracture 'a' (mm)	Modulus of Rupture (MPa)
1							
2	7 Days						
3							
4							
5	28 Days		`				
6							

CALCULATION:

The flexural strength of the specimen shall be expressed as the modulus of rupture fb, which, if '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, in cm, shall be calculated to the nearest 0.5 kg/sq cm as follows:

$$f_b = \frac{P \times l}{a \times d^2}$$

when 'a' is greater than 20.0 cm for 15.0 cm specimen, or greater than 13.3 cm for a 10.0 cm specimen, or

$$f_b = \frac{3P \times a}{b \times d^2}$$

when 'a' is less than 20.0 cm but greater than 17.0 cm for 15.0 cm specimen, or less than 13.3 cm but greater than 11.0 cm for a 10.0 cm specimen

where,

b = measured width in cm of the specimen,

d = measured depth in cm of the specimen at the point of failure,

l = length in cm of the span on which the specimen was supported, and
p = maximum load in kg applied to the specimen.

CONCLUSION:

ii) The average 7 Days Modulus of Rupture of concrete sample is found to be ….…..

iii) The average 28 Days Modulus of Rupture of concrete sample is found to be ….…..

EXPERIMENT-15

Perform Concrete Mix Design by weight batching as per I. S. Method.

THEORY:

For design of concrete mix, information about the specific gravity and water absorption of the coarse aggregates are required. Specific gravity of aggregate provides valuable information on its quality and properties. If the specific gravity is above or below than the prescribed value of the aggregate; it may indicate that shape and grading of aggregate has been improper. It is also important in determination of moisture content and in many concrete mix design calculations. It is also required for the calculation of volume yield of concrete.

REFERENCE:

IS 2386: Methods of test for aggregates for concrete, Part 3: Specific gravity, density, voids, absorption, and bulking - 1963

APPARATUS:

- Balance of Capacity 5 kg
- Box Wire Basket 200 mm in Diameter
- Water Container for Immersing the Wire Basket (as shown in Figure 2)
- Absorbent Cloth for Surface Drying of the sample
- Thermostatic Drying Oven.

MATERIAL:

Coarse aggregate: 5 kg

PROCEDURE:

1. A sample of not less than 2 kg of the aggregate shall be thoroughly washed to remove finer particles and dust, drained and then placed in the wire basket and immersed in distilled water at a temperature between 22°C to 32°C with a cover of at least 5 cm of water above the top of the basket.

2. Immediately after immersion the entrapped air shall be removed from the sample by lifting the basket containing it 25 mm above the base of the tank and allowing it to drop 25 times at the rate of about one drop per second.

   The basket and aggregate shall remain completely.

3. The basket and aggregate shall remain completely immersed during the operation andfor a period of 24 ± l/2 hours afterwards.

4. The basket and the sample shall then be jolted and weighed in water at a temperatureof 22°C to 32°C (weight A).

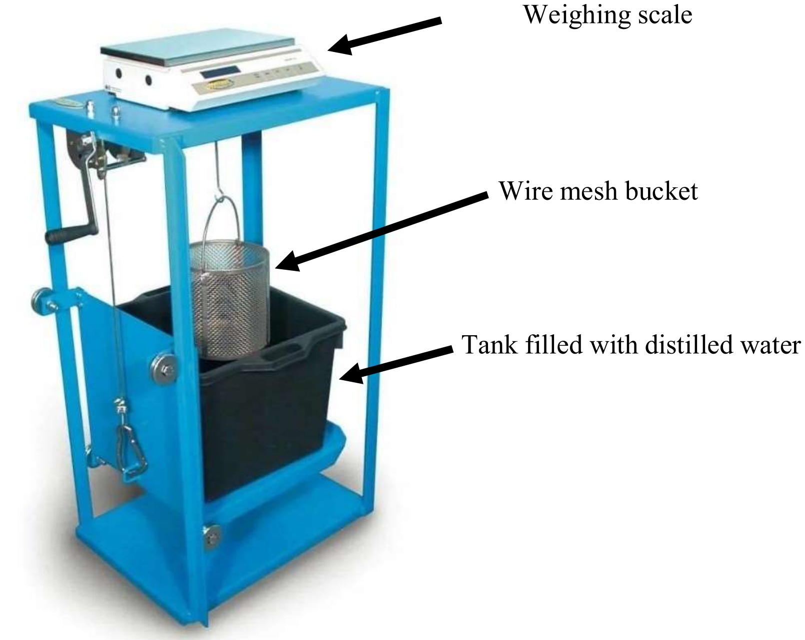


Figure 2: Apparatus for measuring the specific gravity of coarse aggregate

5. The basket and the aggregate shall then be removed from the water and allowed to drain for a few minutes, after which the aggregate shall be gently emptied from the basket on to one of the dry clothes, and the empty basket shall be returned to the waterand weighed in water (weight B).

6. The aggregate placed on the dry cloth shall be gently surface dried with the cloth, transferring it to the second dry cloth when the first will remove no further moisture. The aggregate shall then be weighed (weight C).

7. The aggregate shall then be placed in the oven in the shallow tray, at a temperature of 100 to 110°C and maintained at this temperature for 24 ± l/2 hours. It shall then be removed from the oven, cooled in the airtight container, and weighed (weight D).

8. The specific gravity, apparent specific gravity and water &sorption shall be calculated

Observations:

Weight of saturated sample in water (A_1) (g)	4535
Weight of empty basket in water (A_2) (g)	1345
Weight of saturated and surface dry sample in air (B) (g)	4938
Weight of oven dried aggregate in air (C) (g)	4912
Weight of saturated aggregate in water (A) (g) = $A_1 - A_2$	
Specific gravity= ______	
Apparent specific gravity =	
Water absorption (percent of dry weight) = ______	

Results and discussions:

Following results are obtained for the provided coarse aggregate specimen:

(a)Specific gravity:______.

(b)Apparent specific gravity:____.