BHARTIYA INSTITUTE OF ENGINEERING & TECHNOLOGY
SIKAR

DEPARTMENT OF CIVIL ENGINEERING

LAB MANUAL

4CE4-25: CONCRETE TECHNOLOGY

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LIST OF EXPERIMENTS

1.To determine the fineness of Cement by Blaine's air permeability test."

2.To determine the flexural strength of Concrete."

3.To determine Soundness of cement by Le-chatelier apparatus"

4.To determine the specific gravity of fine aggregate (sand) by Pycnometer.

5.To determine the bulking of fine aggregate and to draw curve between watercontent and bulking."

6.Sieve analysis of coarse aggregates and fine aggregates.

7.To determine the workability of given concrete mix by slump test.

8. To design concrete mix of M-20 grade in accordance with I S 10262.

9.To design concrete mix of M-40 grade with super plasticizer in accordance with I S10262."

10.To determine the Permeability of Concrete."

11.Study of Core cutter, UPV & Rebound Hammer equipment."

EXPERIMENT NO.1

DETERMINATION OF FINENESS OF CEMENT BY SIEVING

Theory: Cement is obtained by grinding various raw materials after calcination. The degree to which cement is ground to smaller and smaller particles is called fineness of cement. The fineness of cement has an important role on the rate of hydration and hence on the rate of gain of strength and also on the rate of evolution of heat. Finer cement offers a greater surface area for hydration and hence the faster development of strength although the ultimate strength is not affected. Fineness also provides more cohesiveness to concrete and avoid separation of water at the top of concrete (called bleeding). However, increase in fineness of cement increases the drying shrinkage and cracking of the concrete.

Fineness of cement is tested either by sieving or by determination of specific surface using air-permeability apparatus. The specific surface is defined as the total surface area of all the particles in cm^2 per one gram of cement. Although determination of specific surface is more accurate to judge fineness of cement, it is rarely used except for specific purpose. In contrast sieving is most commonly used method to determine fineness of cement and is quite good for field works.

Objective: Determination of fineness of cement by dry sieving.

Reference: IS 4031 (Part-1):1988.

Apparatus: IS-90 micron sieve conforming to IS: 460 (Part 1-3)-1985; Weighing balance; Gauging trowel; Brush.

Material: Ordinary Portland cement

Procedure:

1. Weigh accurately 100 g of cement to the nearest 0.01 g and place it on a standard 90 micron IS sieve.
2. Break down any air-set lumps in the cement sample with fingers.
3. Agitate the sieve by giving swirling, planetary and linear movements for a period of 10 minutes or until no more fine material passes through it.
4. Collect the residue left on the sieve, using brush if necessary, and weigh the residue.
5. Express the residue as a percentage of the quantity first placed on the sieve to the nearest 0.1 percent.
6. Repeat the whole procedures two more times each using fresh 100 g sample.

Observations:

Sl. No.	Weight of sample taken (W) (in g.)	Weight of residue (R) (in g.)	%age of residue $\left(= \frac{R}{W} \times 100\right)$	Average % of residue
1.				
2.				
3.				

Result:

Percentage residue of cement sample by dry sieving is ____________ percentage.

Conclusions:

The given sample of cement contains less than/ more than 10% by weight of material coarser than 90 micron sieve. Therefore it satisfies/ not satisfies the criterion as specified by IS code.

Precautions: (Discuss about the precautions to be taken while conducting this experiment)

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Questions: (Answer the following questions.)

1. Discuss the effects of fineness on hydration of cement?
2. Enumerate the advantages and disadvantages of using finer cement.
3. What is the *correction factor* of a sieve? Explain its necessity.

EXPERIMENT NO.2

TESTS FOR DETERMINATION OF FLEXURAL STRENGTH OF CONCRETE

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.

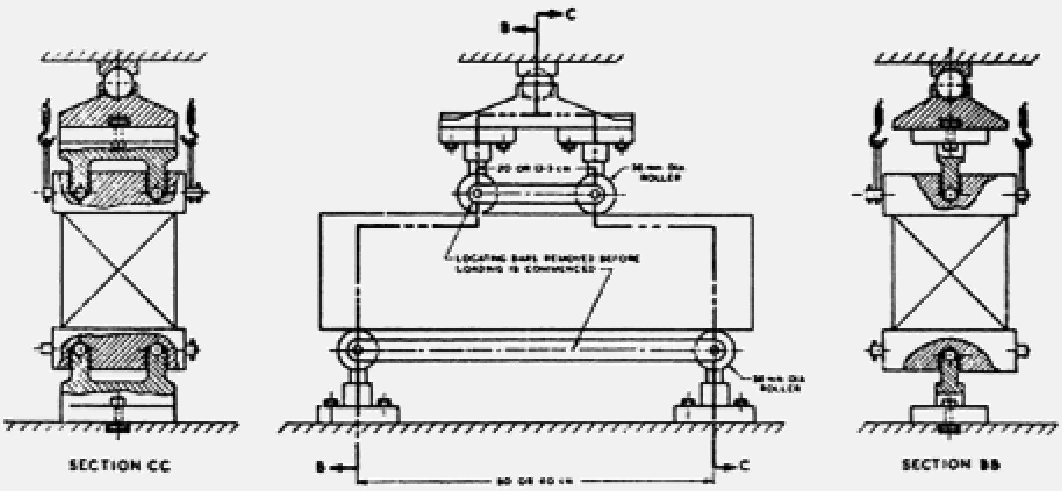

Figure 9: Arrangement for loading of flexure test specimen

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.

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.

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 (f_b)** (MPa)
	7 days			
	28 days			

* '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, f_b, is calculated from:

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

But, if 200> a> 170 mm for a 150 mm specimen f_b, is calculated from:

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

Results:

- The average 7 days modulus of rupture of concrete sample is : ________ MPa
- The average 28 days modulus of rupture of concrete sample is : ________ MPa

Precautions: (Discuss about the precautions to be taken while conducting this experiment)

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Questions:

1. What is the relationship of flexural strength of concrete with its compressive strength?
2. What is the significance of moment of inertia with respect to bending stress?
3. What is cracking load?

EXPERIMENT NO.3

DETERMINATION OF SOUNDNESS OF CEMENT

Theory: The ability of cement to maintain a constant volume is known as soundness of the cement. It is essential that the cement concrete shall not undergo appreciable change in volume after setting. Unsoundness produces cracks, distortion and disintegration there by giving passage to water and atmospheric gases which may have injurious effects on concrete and reinforcement. Soundness of cement is ensured by limiting the quantities of free lime, magnesia and sulphates as these compounds undergo a large change in volume.

Unsoundness in cement does not come to surface for a considerable period of time. Thus this test is designed to accelerate the hydration of free lime by the application of heat thus discovering the defects in a short time. Further, to minimise the shrinkage of cement paste, the test setup is kept immersed in water bath.

This test is carried out with the help of “Le Chatelier’s apparatus” which consists of a small split cylinder of spring brass or other suitable metal of 0.5mm thickness forming a mould 30 mm internal diameter and 30mm high (Figure 2). On either side of the split mould are attached to indicators with pointed ends, the distance from these ends to the center of the cylinder being 165 mm. The mould shall be kept in good condition with the jaws not more than 50mm apart.

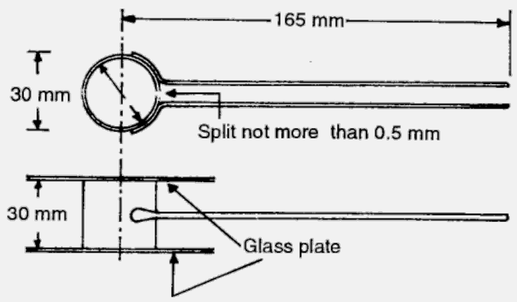

Figure 2: Le- Chatelier apparatus

Objective: Determination of soundness of cement by Le-Chatelier method.

Reference: IS 4031 (Part-3):1988.

Apparatus: Le- Chatelier apparatus conforming to IS: 5514-1969; Measuring cylinder; Gauging trowel; Balance; Water bath.

Material: Ordinary Portland cement; Water; Grease

Procedure:

1. Weigh accurately 100 g of cement to the nearest 0.15 g and add to it 0.78 times the water required to give a paste of standard consistency (i.e. 0.78×P).
2. Place the lightly grease mould on a lightly grease glass sheet and fill it with cement paste, taking care to keep the edges of the mould gently together.

3. Cover the mould with another piece of lightly grease glass sheet, place a small weight on this covering glass sheet and immediately submerge the whole assembly in water at a temperature of $27 \pm 2^0\ C$.
4. Keep this assembly under water for 24 hrs. After this, take the mould out of water and measure the distance between two indicators. Submerge the mould again in the water.
5. Bring the water to boiling with the mould kept submerged, and keep it boiling for 25 to 30 minutes.
6. Remove the mould from the water allow it to cool and measure the distance between the indicator points.
7. The difference between these two measurements represents the expansion of the cement.
8. Repeat the whole procedures two more times each using fresh 100 g sample.

Observations:

Samples:	
Distance between pointers before boiling (D_1) in mm	
Distance between pointers after boiling (D_2) in mm	
Expansion of the cement = E_1 = (D_2- D_1) in mm	
Average expansion of the cement in mm	

Result:

Average expansion of the cement is obtained is ____________ mm.

Conclusions:

Average expansion of the cement as per Le- Chatelier test is less than/ more than 10 mm. Therefore the given sample of cement is found to be sound/ unsound as per IS code.

Precautions: (Discuss about the precautions to be taken while conducting this experiment)

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-
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Questions:

1. What are the causes of unsoundness in cement? List out the methods to reduce unsoundness.
2. Why the cement paste is kept submerged under water during the test?
3. What is the purpose of boiling the setup?
4. What are the limiting values for maximum expansion of cement as per Le-Chatelier test for following cements: rapid hardening cement; portland puzzolana cement; high alumina cement; low heat cement; and super sulphated cement?

SPECIFIC GRAVITY AND WATER ABSORPTION OF FINE AGGREGATES

Theory:

Specific gravity of an aggregate is defined as the ratio of the mass of solid in a given volume of sample to the mass of equal volume of water at $4^{o}\ C$. However, all rocks contain some small amount of void and the apparent specific gravity includes this voids. The specific gravity of aggregates is an indirect measure of material's density and its quality. A low specific gravity may indicate high porosity and therefore poor durability and low strength.

Some of the pores contained by aggregates are permeable while others are impermeable. Accordingly, two types of specific gravities are defined absolute specific gravity and apparent specific gravity. If both the permeable and impermeable voids are excluded to determine the true volume of solids, the specific gravity is called true or absolute specific gravity of the aggregate. But true specific gravity has not much of practical use as volume of impermeable internal pores is too difficult to determine.

In contrast, for the determination of apparent specific gravity the impermeable internal pore is added to the effective volume of the aggregates (does not include the permeable pores). Mathematically:

$$\text{Apparent Specific Gravity} = \frac{\text{mass of aggregate}}{\begin{array}{c}\text{mass of water occupying the volume equal to that of solids of}\\ \text{aggragate excluding permeable pores}\end{array}}$$

The apparent specific gravity is realistic one to use for concrete mix proportioning. The apparent specific gravity of most rocks lie between 2.6 to 2.7. Apparent specific gravity can be determined on the basis of surface dry condition (SSD) or oven dry condition (OD), according to the moisture condition of the aggregate.

In saturated surface dry (SSD) situation, the pores of the aggregate are fully filled with water and the surface is dry. This condition can be obtained by immersing coarse aggregate in water for 24 h followed by drying of the surface with a wet cloth. When the aggregate is under the SSD condition, it will neither absorb water nor give out water during the mixing process. Hence, it is a balanced condition and is used as the standard index for concrete mix design.

In contrast, the oven dry condition is obtained by keeping the aggregate in an oven at a temperature of $110^{o}\ C$ for 24 hrs. Due to heating, all the water from internal permeable pores gets evaporated and hence it reaches a constant weight. When the aggregate is under OD condition, it will absorb water during the concrete mixing process until the internal pores are fully filled with water.

Similarly, water absorption is also provides an idea about strength of aggregate. Aggregates having more water absorption are more porous in nature and generally considered unsuitable. Usually, water absorption of coarse aggregate is about 0.5% by weight whereas water absorption of fine aggregate is about 2.0% by weight. Moreover, water absorption values are used to calculate the change in the weight of the aggregate while proportioning and mixing of concrete. Extra water is added to cater the need of water absorption.

Objective: To determine specific gravity and water absorption of fine aggregate.

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

Apparatus: Pycnometer, 1000-ml measuring cylinder, thermostatically controlled oven, taping rod, filter papers and funnel.

Material: Fine aggregates (500 g)

Procedure:

1. Place 500 g of fine aggregate in a tray and cover it with distilled water at a temperature of 22 to 32°C. Remove air entrapped in or bubbles on the surface of the aggregate by gentle agitation with a rod. Keep the sample immersed under water for 24 Hrs.
2. Carefully drain the water from the sample, by decantation through a filter paper. Air dry the aggregate and solid matter retained on the filter paper, to remove the surface moisture. When the material just attains a "free-running" condition, weight the saturated and surface-dry sample (A).
3. Place the aggregate in the pycnometer and fill the remaining space by distilled water. Eliminate entrapped air by rotating the pycnometer on its side, covering the hole in the apex of the cone with a finger. Weight the pycnometer with this condition (B).
4. Empty the contents of the pycnometer into a tray. Ensure that all the aggregate is transferred. Refill the pycnometer with distilled water to the same level as before and measure the weight at this condition (C).
5. Carefully drain the water from the sample, by decantation through a filter paper. Oven-dry the aggregate in the tray at a temperature of 100 to 110^{o}C for 24 hrs. During this period, stir the specimen occasionally to facilitate proper drying. Cool the aggregates calculate its weight (D).
6. Calculate the specific gravity, apparent specific gravity and the water absorption as follows:

$$\text{Specific gravity} = \{D/[A - (B - C)]\} \quad (1)$$

$$\text{Apparent Specific gravity} = \{D/[D - (B - C)]\} \quad (2)$$

$$\text{Water absorption (in \%)} = 100 \times [(A - D)/D] \quad (3)$$

Where, A = Weight in g of saturated surface-dry sample

B = Weight in g of pycnometer containing sample and filled with distilled water

C = Weight in g of pycnometer filled with distilled water only

D = Weight in g of oven dried sample only.

Observations:

Weight in g of saturated surface-dry sample (A)	
Weight in g of pycnometer containing sample and filled with distilled water (B)	
Weight in g of pycnometer filled with distilled water only (C)	
Weight of oven dried- sample only (D)	
Specific gravity $= \{D/[A-(B-C)]\}$	
Apparent Specific gravity $= \{D/[D-(B-C)]\}$	
Water absorption (in %) $= 100 \times [(A-D)/D]$	

Results and discussions:

Following results are obtained for the provided fine aggregate specimen:

a) Specific gravity : ___________.
b) Apparent specific gravity : ___________.
c) Water absorption : ___________ %.

Precautions: (Discuss about the precautions to be taken while conducting this experiment)

-
-
-
-

Questions:

1. What is the purpose of conducting water absorption test?
2. What are the limitations in determination of specific gravity using pycnometer?
3. Define unit weight, bulk density?
4. Provide proofs of equations 1, 2 and 3.

EXPERIMENT NO.4

BULKING OF SAND

Theory: Increase in volume of sand due to presence of moisture is known as bulking of sand. Bulking is due to the formation of thin film of water around the sand grains and the interlocking of air in between the sand grains and the film of water. When more water is added sand particles get submerged and volume again becomes equal to dry volume of sand.

Due to the bulking, fine aggregate shows completely unrealistic volume. Therefore, it is absolutely necessary that consideration must be given to the effect of bulking in proportioning the concrete by volume. If cognisance is not given to the effect of bulking, in case of volume batching, the resulting concrete is likely to be under-sanded and harsh. It will also affect the yield of concrete for given cement content.

To compensate the bulking effect extra sand is added in the concrete so that the ratio of coarse to fine aggregates will not change from the specified value. Maximum increase in volume may be 20 % to 40 % when moisture content is 5 % to 10 % by weight. Fine sands show greater percentage of bulking than coarse sands with equal percentage of moisture.

Objective: To ascertain the bulking phenomena of given sample of sand.

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

Apparatus: Beaker, 1000ml measuring jar, brush, scale, mixing tray.

Material: Fine aggregate, water.

Procedure:

1. Put sufficient quantity of dry sand into the beaker until it is about one-thirds full.
2. Level off the top of the sand and measure the height (H_1) by pushing a steel rule vertically down through the sand at the middle to the bottom. Measure weight of the sand.
3. Add 2% of water; mix it thoroughly in the container. Smooth and level the top surface measure the height (H_2) of soil. Find the height percentage increment.
4. Repeat the same procedure with increasing amount of water by 2% until percentage increment of sand height is reduced and attends original level.
5. Plot a graph of percentage increment of sand height against percentage of water.

   (*Note: A typical bulking of sand graph looks like Figure 5*)

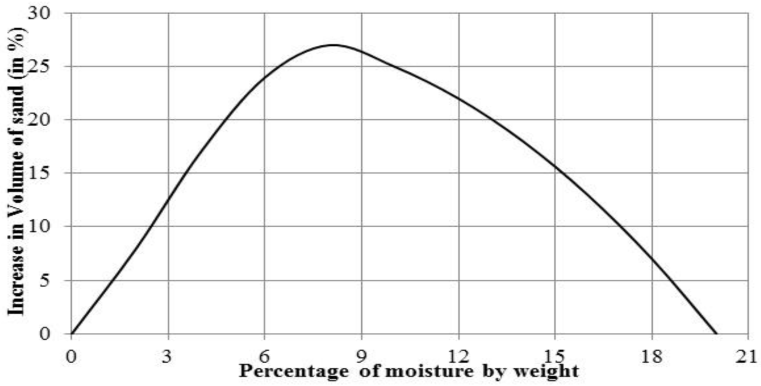

Figure 5: A typical curve showing bulking of sand

Observations:

Initial Height of sand in the Jar (H_1) : _______ mm

Weight of fine aggregate : ________ g

Sl. No.	% of Water	Volume of water (in ml)	Height of sand (H_2)	page bulking $= \frac{H_2 - H_1}{H_1} \times 100$

Results and discussions:

From the tabulated results and the plotted graph is is observed that, the given sand specimen under goes maximum bulking at __________% of moisture contain. Maximum percentage of bulking is ___________.

Precautions: (Discuss about the precautions to be taken while conducting this experiment)

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Questions:

1. What is meant by bulking of sand? Why it happens?
2. What is the significance of bulking of sand experiment?
3. Define bulking factor?
4. What is the effect of moisture on bulking?

EXPERIMENT NO.5

SIEVE ANALYSIS OF COARSE AND FINE AGGREGATES

Theory:

Aggregate is the inert, inexpensive materials dispersed throughout the cement paste so as the produce a large volume of concrete. They constitute more than three quarters of volume of concrete. They provide body to the concrete, reduce shrinkage and make it durable.

The aggregates are classified in two categories; fine aggregate and coarse aggregate. The size of fine aggregates is limited to a maximum of 4.75 mm, beyond which it is known as coarse aggregates. Many a time, fine aggregates are designated as coarse sand, medium sand and fine sand. These classifications do not give any precise meaning. What the supplier terms as fine sand may be really medium or even coarse sand. To avoid this ambiguity fineness modulus could be used as a yard stick to indicate the fineness of sand and in general aggregates.

Fineness modulus for a given aggregate is obtained by sieving known weight of it in a set of standard sieves and by adding the percent weight of material retained on all the sieves and dividing the total percentage by 100. It serves the purpose of comparing one aggregate with another in respect of fineness or coarseness. For classification of fine aggregates, the following limits may be taken as guidance:

Fine sand:	Fineness modulus should lie in between 2.2 to 2.6
Medium sand:	Fineness modulus should lie in between 2.6 to 2.9
Coarse sand:	Fineness modulus should lie in between 2.9 to 3.2

Sand having a fineness modulus more than 3.2 is unsuitable for making satisfactory concrete. The coarse aggregates have fineness modulus usually more than 5.

A heap of aggregate is classified as a single sized aggregate when the bulk of aggregate passes one sieve in normal concrete series and retained on next smaller size. Such aggregates are normally expressed by the maximum size of the aggregates present in considerable amount in it. For example, a heap of 20 mm size aggregate means that the heap contains maximum 20 mm size aggregate in a substantial amount.

A graded aggregate comprises of a proportion of all sizes in a normal concrete series. When these sizes are so proportionated to provide a definite grading, it is known as well graded aggregate. Well graded aggregates are desirable for making concrete, as the space between larger particles is effectively filled by smaller particles to produce a well-packed structure. This minimizes the cement requirement.

All-in aggregates comprise a mixture of coarse aggregate and fine aggregates. Such aggregates may directly be used for low quality concreting. But in case of good quality concreting work; necessary adjustments may be made in the grading by the addition of single-sized aggregates.

IS 383:1970 specifies four grading zones for fine aggregates. These four grading zones become progressively finer from Grading Zone I to Grading Zone IV (see Table). The fine aggregates within each of these grading zones are suitable for making concrete. But, the ratio of ratio of fine to coarse aggregate reduces as the fine aggregate becomes finer from Grading Zones I to IV.

Table 1: Grading of fine aggregates

I.S. Sieve Designation	Percentage of passing by weight for grading			
	Zone-I	Zone-II	Zone-III	Zone-IV
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 μ	15-34	35-59	60-79	80-100
300 μ	5-20	8-30	12-40	15-50
150 μ	0-10	0-10	0-10	0-15

The grading of coarse aggregate may vary through wider limits than that of fine aggregates. However, this variation does not much affect the workability, uniformity and finishing qualities of concrete mix. As per IS-383:1970 the grading limit of coarse aggregate, both for single size as well as graded should be as per the table given below.

Table 2: Grading of single-graded coarse aggregates

Sieve Size (mm)	For Single-Sized Aggregate of Nominal Size						For Graded Aggregate of Nominal Size			
	63 mm	40 mm	20 mm	16 mm	12.5 mm	10 mm	40 mm	20 mm	16 mm	12.5 mm
	Percentage of Passing by weight for grading									
80	100	–	–	–	–	–	100	–	–	–
63	85 to 100	100	–	–	–	–	–	–	–	–
40	0 to 30	85 to 100	100	–	–	–	95 to 100	100	–	–
20	0 to 5	0 to 20	85 to 100	100	–	–	30 to 70	95 to 100	100	100
16	–	–	–	85 to 100	100	–	–	–	90 to 100	–
12.5	–	–	–	–	85 to 100	100	–	–	–	90 to 100
10	0 to 5	0 to 5	0 to 20	0 to 30	0 to 45	85 to 100	10 to 35	25 to 55	30 to 70	40 to 85
4.75	–	–	0 to 5	0 to 5	0 to 10	0 to 20	0 to 5	0 to 10	0 to 10	0 to 10
2.36	–	–	–	–	–	0 to 5	–	–	–	–

Objective: To determine fineness modulus and grade of fine and coarse aggregate.

Reference: IS: 383-1970.

Apparatus: Set of sieves*; Balance; Gauging Trowel; Watch.

a) *For fine aggregates: 4.75 mm, 2.36 mm, 1.18 mm, 600 micron, 300 micron & 150 micron, pan.
b) *For coarse aggregates: 80mm, 40mm, 20mm, 10mm, 4.75mm, pan.

Material: a) Fine aggregates (1 Kg)
b) Coarse aggregates (5 Kg)

Procedure:

1. Take the aggregate from the sample by quartering.
2. Sieve the aggregate using the appropriate sieves.
3. Record the weight of aggregate retained on each sieve.
4. Calculate the cumulative weight of aggregate retained on each sieve.
5. Calculate the cumulative percentage of aggregate retained.
6. Add the cumulative weight of aggregate and calculate the fineness modulus using formula:

   a. Fineness modulus for fine aggregates $= \frac{\sum C}{100}$

   b. Fineness modulus for coarse aggregates $= \frac{\sum C}{100} + 5$

   Where, C denotes the cumulative percentage of mass retained in a sieve.

7. Determine the grade of aggregates from the Table 1 and the Table 2.
8. Plot the gradation curves, in a semi-log graph, between percentage of aggregates passed and size of sieve both for a) Fine aggregate and b) For coarse aggregate.
   (*Note: A typical grading curve for fine aggregates looks like Figure 4. A similar grading curve will be observed for coarse aggregates.*)

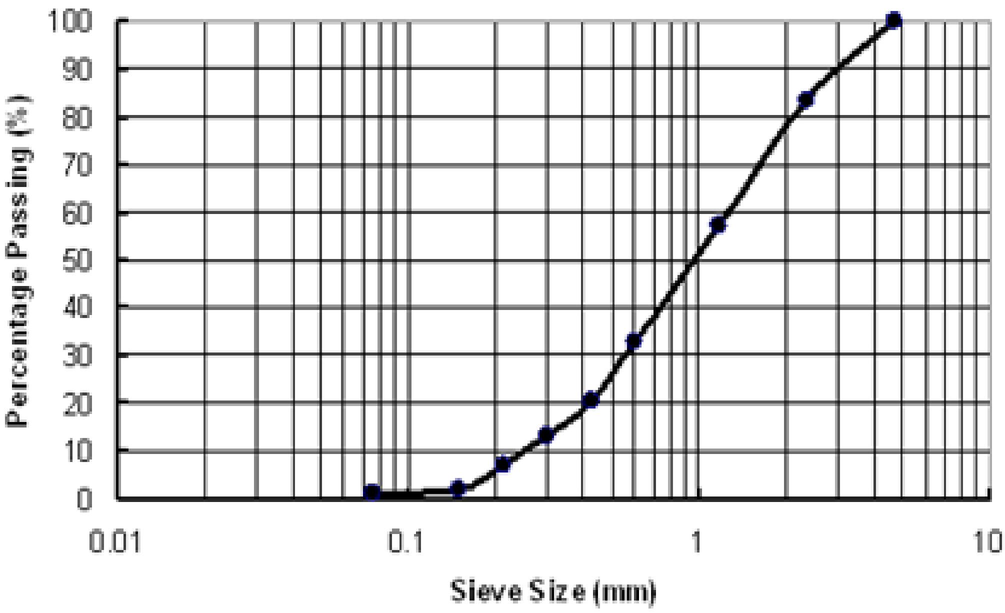

Figure 4: A typical gradation curve for fine aggregates

Observations:

(a) For fine aggregates:

Weight of fine aggregate taken (W_f): __________Kgs					
Sl. No.	Sieve size	Weight retained (in kg)	%age retained $\left(\frac{C_3}{W_f} \times 100\right)$	Cumulative %age retained	Percentage passed ($100 - C_5$)
C_1	C_2	C_3	C4	C_5	C_6
1	4.75 mm				
2	2.36 mm				
3	1.18 mm				
4	600 micron				
5	300 micron				
6	150 micron				
7	Pan			-	-
Sum of cumulative percentage retained (excluding pan) $\sum C_5$=					-
Fineness Modulus $\frac{\sum C_5}{100}$ =					-
Zone to which the fine aggregate belongs:					

(b) For coarse aggregates:

Weight of coarse aggregate taken (W_c): __________Kgs					
Sl. No.	Sieve size	Weight retained (in kg)	%age retained $\left(\frac{C_3}{W_c} \times 100\right)$	Cumulative %age retained	Percentage passed ($100 - C_5$)
C_1	C_2	C_3	C4	C_5	C_6
1	80 mm				
2	40 mm				
3	20 mm				
4	10 mm				
5	4.75 mm				
6	Pan			-	-
Sum of cumulative percentage retained (excluding pan) $\sum C_5$=					-
Fineness Modulus $\frac{\sum C_5}{100} + 5$ =					-
Grade to which the coarse aggregate belongs:					

Results and discussions:

The fineness modulus of given samples are:

a) For fine aggregates : ___________.

b) For coarse aggregates : ___________.

The grading to which the given samples belong are:

a) For fine aggregates : ___________.

b) For coarse aggregates : ___________.

Precautions: (Discuss about the precautions to be taken while conducting this experiment)

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-

Questions:

1. What are a) fine aggregate, b) coarse aggregate, and c) all-in aggregate?
2. What is the significance of measuring fineness modulus of aggregates?
3. What is a well graded aggregate? How grading of aggregates can be controlled?
4. What is the use of gradation curve?
5. Why well graded aggregate is most suitable for concreting purpose?

EXPERIMENT NO.6

MEASUREMENT OF WORKABILITY OF CONCRETE

BY SLUMP CONE TEST

Theory:

A concrete is said to be workable if it can be easily mixed, placed, compacted and finished. A workable concrete should not show any segregation or bleeding. Segregation is said to occur when coarse aggregate tries to separate out from the finer material and a concentration of coarse aggregate at one place occurs. This results in large voids, less durability and strength. Bleeding of concrete is said to occur when excess water comes up at the surface of concrete. This causes small pores through the mass of concrete and is undesirable.

Unsupported fresh concrete flows to the sides and a sinking in height takes place. This vertical settlement is known as slump. The slump is a measure indicating the consistency or workability of cement concrete. It gives an idea of water content needed for concrete to be used for different works. To measure the slump value, the test fresh concrete is filled into a mould of specified shape and dimensions, and the settlement or slump is measured when supporting mould is removed. The slump increases as water-content is increased. For different works different slump values have been recommended. The following table indicates the relationship between degree of workability and slump value.

Degree of workability	Very Low	Low	Medium	High
Slump value (in mm)	0-25	25-50	50-100	100-175

Slump test is adopted in the laboratory or during the progress of the work in the field for determining consistency of concrete where nominal max., size of aggregates does not exceed 40 mm. The pattern of slump indicates the characteristics of concrete in addition to the slump value. If the concrete slumps evenly it is called true slump. If one half of the cone slides down, it is called shear slump. In case of a shear slump, the slump value is measured as the difference in height between the height of the mould and the average value of the subsidence. Shear slump also indicates that the concrete is non-cohesive and shows the characteristic of segregation. Any slump specimen, which collapses or shears off laterally gives incorrect results and at this juncture the test is repeated only true slump should be measured.

Although, slump test is popular due to the simplicity of apparatus used and simple procedure, unfortunately, the simplicity is also often allows a wide variability and many time it could not provide true guide to workability. For example, a harsh mix cannot be said to have same workability as one with a large proportion of sand even though they may have the same slump.

The slump cone experiment is conducted in an apparatus called slump cone (Figure 6). This apparatus essentially consists of a metallic mould in the form of a frustum of a cone having the internal dimensions as under: Bottom diameter: 20 cm, Top diameter: 10 cm, Height: 30 cm and the thickness of the metallic sheet for the mould should not be thinner than 1.6 mm.

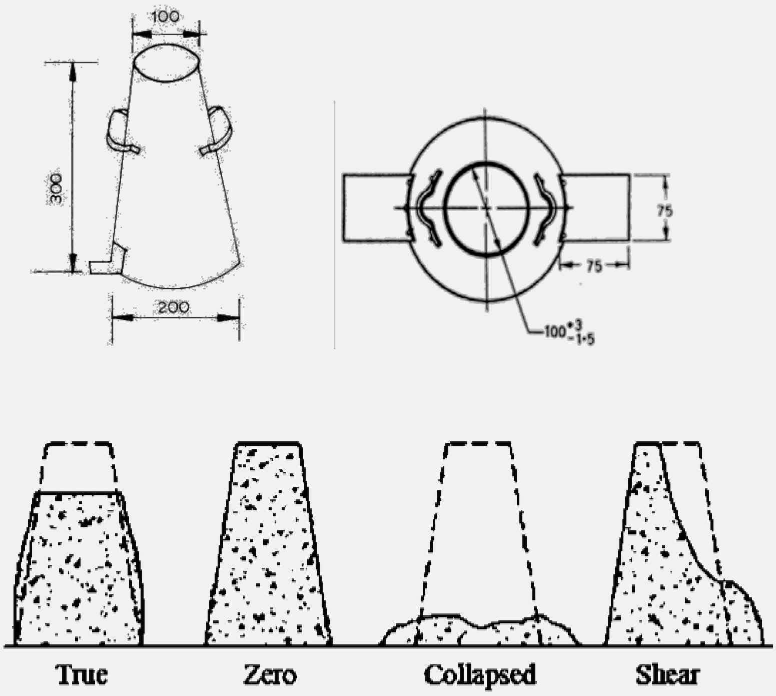

Figure 6: Slump cone and types of slump

Objective: To determine the workability of freshly mixed concrete by the use of slump test.

Reference: IS: 7320-1974, IS: 1199-1959, SP: 23-1982.

Apparatus: Slump cone, tamping rod, metallic sheet, weighing machine and scale.

Material: Cement, sand, aggregate and water

Procedure:

1. Clean the internal surface of the mould thoroughly and place it on a smooth horizontal, rigid and non-absorbent surf ace, such as of a metal plate.
2. Consider a W/C ratio of 0.5 to 0.6 and design mix of proportion about 1:2:4 (it is presumed that a mix is designed already for the test). Weigh the quantity of cement, sand, aggregate and water correctly. Mix thoroughly. Use this freshly prepared concrete for the test.
3. Fill the mould to about one fourth of its height with concrete. While filling, hold the mould firmly in position
4. Tamp the layer with the round end of the tamping rod with 25 strokes disturbing the strokes uniformly over the cross section.
5. Fill the mould further in 3 layers each time by 1/4th height and tamping evenly each layer as above. After completion of rodding of the topmost layer strike of the concrete with a trowel or tamping bar, level with the top of mould.
6. Lift the mould vertically slowly and remove it.
7. The concrete will subside. Measure the height of the specimen of concrete after subsidence.

8. The slump of concrete is the subsidence, i.e. difference in original height and height up to the topmost point of the subsided concrete in millimetres.

Observations:

W/C ratio	
Slump Value	

Result:

The slump of concrete is: _________ mm.

Conclusions:

The slump value indicates that the concrete has Very low/ Low/ Medium/ High degree of workability.

Precautions: (Discuss about the precautions to be taken while conducting this experiment)

-
-
-

Questions:

1. What is meaning of consistency in concrete?
2. What is slump of concrete?
3. What is the significance of shear slump?
4. What is segregation?

Concrete Mix Design

EXPERIMENT NO.7

Concrete mix design is a method to determine proportion of concrete ingredients so that the concrete desired proportion during both fresh and harden state with maximum possible economy.

★ Objective of mix design :

→ To achieve desire workability without segregation and bleeding for fully compaction in fresh state.

→ To achieve desire strength in its harden state.

→ To achieve durability.

→ To achieve optimum economy in construction.

★ Basic Variables in Concrete mix design :

→ Type of ~~d~~ cement and its compressive strength.

→ Characterestics of Concrete such as workability during fresh state.

→ Strength of Concrete desired and degree of quality control at site.

→ Characterstics of Ingredient such as quality and type of cement, size, shape and grading of aggregates.

→ Derieved parameters such as w/c Ratio, water content or cement content, propostional of fine and Coarse aggregate. site conditions regarding degree of quality control, moisture, etc.

★ Various mix design method :

1) I.S. code method.

2) ACI mix design method.

3) USBR method.

4) British mix design method
5) Indian road Congress (IRC-44-method)
6) Arbitary method.
7) minimum void method
8) Maximum Void method
9) w/c Ratio method
10) Fineness modulus method.
11) DOE method.
12) standard deviation method.

1) mix design by IS Code method :
(IS : 10262 - 2009).
This method of mix design consist of determination of the following ;
Water Content
% of fine agg.
W/C Ratio
grading of fine agg.

Data require for mix design :
→ characterstics compressive strength at 28 days.
→ degree of workability
→ Estimation of Interfere
→ Selection of W/C ratio & fine aggregate to total agg. Ratio.
→ Calculation of Cement Content.

step 1 :- Target strength for mix proportioning.
(Cl 3.2, page No - 1 of IS : 10262 - 2009)

$$f_{ck}' = f_{ck} + 1.65S$$

S = standard deviation (from table - 1, Page - 2 of IS : 10262)

Step 2 :- Selection of w/c ratio : (from table - 5, Page - 20 of IS : 456-2000)

S.No.	Exposure Condition	Plain concrete			Reinforced Concrete		
		Min. Cement Content (kg/m³)	Max. w/c ratio	Min grade concrete.	Min. Cement Content (kg/m³)	Max. w/c ratio	min. grade of concrete
1.	mild	220	0.60	–	300	0.55	M20
2	Moderate	240	0.60	M15	300	0.50	M25
3.	Severe	250	0.50	M20	320	0.45	M35
4.	Very severe	260	0.45	M20	340	0.45	M35
5.	Extreme	280	0.40	M25	360	0.40	M40

w/c ratio as per graph on the basis of target strength.

S.No.	Grade of Concrete	Target mean strength	w/c Ratio
1.	M20	26.6	0.50
2.	M25	31.6	0.42
3.	M30	38.25	0.40
4.	M35	43.25	0.39
5.	M40	48.25	0.385
6.	M45	53.25	0.38
7.	M50	58.25	0.315

standard w/c ratio for table 3, page-3 of IS 10262 = 0.50

Note : Addopt lower of these two w/c Ratio.

Step 3 :- Selection of Water Content :

(from table 2, page 3 of IS : 10262)

Date ___ / ___ / ___

Saathi

step 4: Calculation of Cement Content :-

From table - 5 of IS : 456 - 2000, Take min. ciment content.
(Acc. to exposure condition of type of structure)

Also, cement content = $\frac{\text{water content}}{\text{w/c ratio}}$

Note: Adopt higher of these two cement content.

Step 5: Proportion of vol. of Course agg. and fine agg. Content. :

Based on size of C.A. and sand grading zone, refer table No. 3
Page - 3 of IS : 10262 - 2009

Adjustment in the value of C.A.

Formula = $\frac{\pm \text{ change value in w/c ratio} \times 0.01}{0.05}$ (increase or dec.)

Step-6: mix Calculation :

Vol^m of Concrete = 1m^3

Vol. of ~~Concrete~~ Cement = $\frac{\text{mass of cement}}{\text{Specific gravity of cement}} \times \frac{1}{1000}$

Vol. of water = $\frac{\text{Mass of water}}{\text{specific gravity of water}} \times \frac{1}{1000}$

step 4: Note for Calculation of Cement Content.

As per ~~code~~ clause 8.1.1 of IS 1343-1980, The max cement content = 450 kg/m^3

Ques) Design a concrete mix of an 25 grade by IS method by using data. ;

Specific gravity of Cement, fine aggregate, coarse agg. as 3.12, 2.90, 2.60 respectively. Water absorbtion values for fine and

and Coarse agg is 0.80 and 0.50% respectively. Free moisture nill in both types of agg.
Slump to be 100mm. Degree of quality control good exposure condition moderate. determine least quantity of ingrediants in kg/m³ of concrete.

Sol:- Assume size of C.A. = 20mm
Assume sand grading zone = Zone III
Assume type of structure = R.C.C.

Step I: Target strength for mix proportionality :
(Cl. 3.2 Page 1 ; IS : 10262)

$f_{ck}' = f_{ck} + 1.65\ S$

$f_{ck}' = 25 + 1.65\ (4)$ {S=4 for M25 from tables

$f_{ck}' = 31.6\ N/mm^2$

Step 2: Selection of w/c ratio :
(from table-5, IS : 456-2000)

→ For moderate exposure, R.C.C. structure, max. w/c ratio = 0.50
→ Also from graph / Based on experience, w/c ratio = 0.42
{∵ By Previous table}

→ Adopt lower of these two ;
w/c ratio = 0.42.

Step 3: Selection of water content :
(Cl, 4.2 Page-2, IS : 10262)

From table-2, for size of agg. 20mm, water content = 186 kg/
This water content is for slump range 25mm to 50mm
for 50-75 → add 3%.
75-100 → add 6%.

Date ___/___/___

⇒ For 100 mm slump : water Content $= 186 + \frac{6}{100} \times 186$

$= 197.16 \ kg/m^3$

Step 4: Calculation of cement content :
(From table - 5 of IS : 456 - 2000)

→ For moderate exposure, R.C.C. structure :
min. cement content = 300 kg/m³

→ Cement Content $= \frac{\text{water Content}}{\text{w/c Ratio}}$ (By formula)

$= \frac{197.16}{0.42} = 469.428 \ kg/m^3$

→ Addopt max. of these two ;
cement content = 469.428 kg/m³.

But as per clause 8.1.1 of IS 1343 - 1980, The cement content is 450 kg/m³ therefore cement cement content is equal to 450 kg/m³.

Step 5: Proportioning of volume of C.A. and F.A. content :
from table - 3 Page - 3 of IS : 10262

→ For 20mm size of agg. of sand grade zone III : for w/c ratio = 0.50
Vol. of C.A. = 0.64 (per unit vol. of total Agg.)

→ Adjustment in the value of Vol. of C.A for increase / decrease in w/c ratio :

Date ___ / ___ / ______

∵ diff. in w/c ratio = 0.50 − 0.42 ⇒ 0.08

As 0.42 w/c ratio is lower than 0.50 w/c ratio by 0.08 then th

proportion of Coarse aggregate is increased by ;

$$\Rightarrow \frac{0.08 \times 0.01}{0.05} \Rightarrow 0.016$$

Therefore Corrected volume of C.A. = 0.64 + 0.016

= 0.656

→ Volume of fine agg. = 1 − 0.656

= 0.344

6: Mix proportion :

Vol. of Conc. = $1 m^3$

→ Vol. of Cement = $\frac{\text{mass of cement}}{\text{specific gravity of cement}} \times \frac{1}{1000}$

$$= \frac{450}{3.12} \times \frac{1}{1000} \Rightarrow 0.144$$

→ Vol. of water = $\frac{197}{1} \times \frac{1}{1000} = 0.197$

→ Vol. of all in agg. = a − (b+c)

= 1 − (0.414 + 0.197)

(d) = 0.659

→ Vol. of coarse Agg. = d × Vol. of CA. × s.g × 1000

= 0.659 × 0.656 × 2.60 × 1000

= 1124 kg/m^3

Date __ / __ / __

→ Vol. of Fine Agg. = $d \times$ Vol. of F.A. $\times$ S.g. $\times 1000$

$= 0.659 \times 0.344 \times 2.90 \times 1000$

$= 657$ kg/m³

⇒ Mix Proportion per m³ of Conc :

Cement = 450 kg

Water = 197 kg

C.A. = 1124 kg

F.A. = 657 kg.

Step 7: Adjustment in mix proportioning :

Extra water should be added for absorption in :

F.A. = 0.80 %

$= \frac{657 \times 0.80}{100} = 5.26$ kg

C.A = 0.50 %

$= \frac{1124 \times 0.50}{100} = 5.620$ kg

→ Net quantity of water to be added in the mix = 197 + 5.26 + 5.62

⇒ 207.88 ≈ 208 kg.

→ Net quantity of fine agg. ⇒ 657 − 5.26 = 651.74 ≈ 652 kg

→ Net quantity of C.A. ⇒ 1124 − 5.62 = 1118.38 ≈ 1119 kg

Therefore Net mix proportion per m³ of Conc. :-

Cement = 450 kg

Water = 208 kg

F.A. = 652 kg

C.A. = 1119 kg.

Page No. __

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this adjustment, the mix proportion shall be recalculated keeping the free water-cement ratio at the pre-selected value, which will comprise Trial Mix No. 2. In addition two more Trial Mixes No. 3 and 4 shall be made with the water content same as Trial Mix No. 2 and varying the free water-cement ratio by ±10 percent of the preselected value.

Mix No. 2 to 4 normally provides sufficient information, including the relationship between compressive strength and water-cement ratio, from which the mix proportions for field trials may be arrived at. The concrete for field trials shall be produced by methods of actual concrete productio

6 ILLUSTRATIVE EXAMPLES

An illustrative example of concrete mix proportioni is given in Annex A. Another illustrative example mix proportioning of concrete using fly ash is giv in Annex B. These examples are merely illustrative explain the procedure; and the actual m proportioning shall be based on trial batches with t given materials.

EXPERIMENT NO.9

ANNEX A
(*Clause* 6)

ILLUSTRATIVE EXAMPLE ON CONCRETE MIX PROPORTIONING

A-0 An example illustrating the mix proportioning for a concrete of M 40 grade is given in **A-1** to **A-11**.

A-1 STIPULATIONS FOR PROPORTIONING

a)	Grade designation	: M 40
b)	Type of cement	: OPC 43 grade conforming to IS 8112
c)	Maximum nominal size of aggregate	: 20 mm
d)	Minimum cement content	: 320 kg/m^3
e)	Maximum water-cement ratio	: 0.45
f)	Workability	: 100 mm (slump)
g)	Exposure condition	: Severe (for reinforced concrete)
h)	Method of concrete placing	: Pumping
j)	Degree of supervision	: Good
k)	Type of aggregate	: Crushed angular aggregate
m)	Maximum cement content	: 450 kg/m^3
n)	Chemical admixture type	: Superplasticizer

A-2 TEST DATA FOR MATERIALS

a)	Cement used	: OPC 43 grade conforming to IS 8112
b)	Specific gravity of cement	: 3.15
c)	Chemical admixture	: Superplasticizer conforming to IS 9103
d)	Specific gravity of:	
	1) Coarse aggregate	: 2.74
	2) Fine aggregate	: 2.74
e)	Water absorption:	
	1) Coarse aggregate	: 0.5 percent
	2) Fine aggregate	: 1.0 percent

f) Free (surface) moisture:

1) Coarse aggregate : Nil (absorbed moisture also nil)

2) Fine aggregate : Nil

g) Sieve analysis:

1) Coarse aggregate :

IS Sieve Sizes mm	*Analysis of Coarse Aggregate Fraction*		*Percentage of Different Fractions*			*Remarks*
	I	II	I 60 percent	II 40 percent	Combined 100 percent	
20	100	100	60	40	100	Conforming to Table 2 of IS 383
10	0	71.20	0	28.5	28.5	
4.75		9.40		3.7	3.7	
2.36		0				

2) Fine aggregate : Conforming to grading Zone I of Table 4 of IS 383

A-3 TARGET STRENGTH FOR MIX PROPORTIONING

$$f'_{ck} = f_{ck} + 1.65\, s$$

where

f'_{ck} = target average compressive strength at 28 days,

f_{ck} = characteristic compressive strength at 28 days, and

s = standard deviation.

From Table 1, standard deviation, $s = 5$ N/mm^2.

Therefore, target strength = $40 + 1.65 \times 5 = 48.25$ N/mm^2.

A-4 SELECTION OF WATER-CEMENT RATIO

From Table 5 of IS 456, maximum water-cement ratio = 0.45.

Based on experience, adopt water-cement ratio as 0.40.

$0.40 < 0.45$, hence O.K.

A-5 SELECTION OF WATER CONTENT

From Table 2, maximum water content for 20 mm aggregate = 186 litre (for 25 to 50 mm slump range)

Estimated water content for 100 mm slump = $186 + \frac{6}{100} \times 186$

= 197 litre

As superplasticizer is used, the water content can be reduced up 20 percent and above.

Based on trials with superplasticizer water content reduction of 29 percent has been achieved. Hence, the arrived water content = $197 \times 0.71 = 140$ litre

A-6 CALCULATION OF CEMENT CONTENT

Water-cement ratio = 0.40

Cement content = $\frac{140}{0.40}$ = 350 kg/m^3

From Table 5 of IS 456, minimum cement content for 'severe' exposure condition = 320 kg/m^3

350 kg/m^3 > 320 kg/m^3, hence, O.K.

A-7 PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGATE CONTENT

From Table 3, volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone I) for water-cement ratio of 0.50 = 0.60.

In the present case water-cement ratio is 0.40. Therefore, volume of coarse aggregate is required to be increased to decrease the fine aggregate content. As the water-cement ratio is lower by 0.10, the proportion of volume of coarse aggregate is increased by 0.02 (at the rate of –/+ 0.01 for every ± 0.05 change in water-cement ratio). Therefore, corrected proportion of volume of coarse aggregate for the water-cement ratio of 0.40 = 0.62.

NOTE — In case the coarse aggregate is not angular one, then also volume of coarse aggregate may be required to be increased suitably, based on experience.

For pumpable concrete these values should be reduced by 10 percent.

Therefore, volume of coarse aggregate = 0.62 × 0.9 = 0.56.

Volume of fine aggregate content = 1 – 0.56 = 0.44.

A-8 MIX CALCULATIONS

The mix calculations per unit volume of concrete shall be as follows:

a) Volume of concrete = **1 m³**

b) Volume of cement

$$= \frac{\text{Mass of cement}}{\text{Specific gravity of cement}} \times \frac{1}{1\,000}$$

$$= \frac{350}{3.15} \times \frac{1}{1\,000}$$

$$= \mathbf{0.111\ m^3}$$

c) Volume of water

$$= \frac{\text{Mass of water}}{\text{Specific gravity of water}} \times \frac{1}{1\,000}$$

$$= \frac{140}{1} \times \frac{1}{1\,000}$$

$$= \mathbf{0.140\ m^3}$$

d) Volume of chemical admixture (superplasticizer) (@ 2.0 percent by mass of cementitious material)

$$= \frac{\text{Mass of chemical admixture}}{\text{Specific gravity of admixture}} \times \frac{1}{1\,000}$$

$$= \frac{7}{1.145} \times \frac{1}{1\,000}$$

$$= \mathbf{0.006\ m^3}$$

e) Volume of all in aggregate

= [a – (b + c + d)]

= 1–(0.111 + 0.140 + 0.006)

= **0.743 m³**

f) Mass of coarse aggregate

= *e* × Volume of coarse aggregate × Specific gravity of coarse aggregate × 1 000

= 0.743 × 0.56 × 2.74 × 1 000

= **1 140 kg**

g) Mass of fine aggregate

= *e* × volume of fine aggregate × Specific gravity of fine aggregate × 1 000

= 0.743 × 0.44 × 2.74 × 1 000

= **896 kg**

A-9 MIX PROPORTIONS FOR TRIAL NUMBER 1

Cement	=	350 kg/m³
Water	=	140 kg/m³
Fine aggregate	=	896 kg/m³
Coarse aggregate	=	1 140 kg/m³
Chemical admixture	=	7 kg/m³
Water-cement ratio	=	0.4

NOTE — Aggregates should be used in saturated surface dry condition. If otherwise, when computing the requirement of mixing water, allowance shall be made for the free (surface) moisture contributed by the fine and coarse aggregates. On the other hand, if the aggregates are dry, the amount of mixing water should be increased by an amount equal to the moisture likely to be absorbed by the aggregates. Necessary adjustments are also required to be made in mass of aggregates. The surface water and percent water absorption of aggregates shall be determined according to IS 2386.

A-10 The slump shall be measured and the water content and dosage of admixture shall be adjusted for achieving the required slump based on trial, if required. The mix proportions shall be reworked for the actual water content and checked for durability requirements.

A-11 Two more trials having variation of ± 10 percent of water-cement ratio in **A-10** shall be carried out and a graph between three water-cement ratios and their corresponding strengths shall be plotted to work out the mix proportions for the given target strength for field trials. However, durability requirement shall be met.

ANNEX B

(*Clause* 6)

ILLUSTRATIVE EXAMPLE OF MIX PROPORTIONING OF CONCRETE (USING FLY ASH AS PART REPLACEMENT OF OPC)

B-0 An example illustrating the mix proportioning for a concrete of M 40 grade using fly ash is given B-1 to B-11.

B-1 STIPULATIONS FOR PROPORTIONING

a) Grade designation	:	M 40
b) Type of cement	:	OPC 43 grade conforming to IS 8112
c) Type of mineral admixture	:	Fly ash conforming to IS 3812 (Part 1)
d) Maximum nominal size of aggregate	:	20 mm
e) Minimum cement content	:	320 kg/m³
f) Maximum water-cement ratio	:	0.45
g) Workability	:	100 mm (slump)
h) Exposure condition	:	Severe (for reinforced concrete)
j) Method of concrete placing	:	Pumping
k) Degree of supervision	:	Good
m) Type of aggregate	:	Crushed angular aggregate
n) Maximum cement (OPC) content	:	450 kg/m³
p) Chemical admixture type	:	Superplasticizer

EXPERIMENT NO.10

PERMEABILITY OF CONCRETE

THEORY AND SCOPE:

1. Permeability is the property that governs the rate of flow of a fluid into a porous solid.
2. Permeability occurs in hardened concrete
   (a) Trapped air pocket from in complete compaction.
   (b) Empty space due to the loss of mixing water in evaporation.

AIM:

To determine the permeability of the concrete specimen either cast in laboratory or obtained by cutting out cores from existing structure.

APPARATUS:
Permeability cell, water reservoir, pressure lines (leak proof).

PROCEDURE:

1. The specimen shall be surface dried and the dimension measured to the nearest 0.5mm.
2. Specimen should be kept in the centroid of the cell
3. Keep test mould in testing apparator.
4. Supply the water from water tank which attacked to the equipment.
5. Release the water from water tank of collect the water from outlet of the equipment.
6. Initially calculate the quantity of water in tank and quantity of water collected from the outlet.

CALCULATIONS:

COEFFICIENT OF PERMEABILITY
1. Determine the cross sectional area (A) in square metres of the test sample using the following formula:

$$A= \pi/4 \, D2$$

where D = Diameter of test sample, to the nearest 0.001m.

2. Determine the applied pressure head (h) in metres of water.

3. The D'Arcy Coefficient of Permeability is calculated using the following formula:

$$k = Q / tAh$$

where k = D'Arcy Coefficient of Permeability (m/s)
Q = Volume of water in m^3
L = Length of the test sample in metres, to the nearest 0.001m
t = Elapsed time in seconds
h = Applied pressure head in metres of water
A = Area of the test sample in m^2

REPORTING

1. The D'Arcy Coefficient of Permeability, to the nearest significant figure for the inflow and outflow and the mean.
2. The source of the sample.
3. Any obvious features evident in the test sample such as surface defects, cracks etc.
4. The age of the sample if known.
5. A graphical presentation of the test data (Q versus t).
6. Mass of the test sample before and after test to the nearest 0.1g.

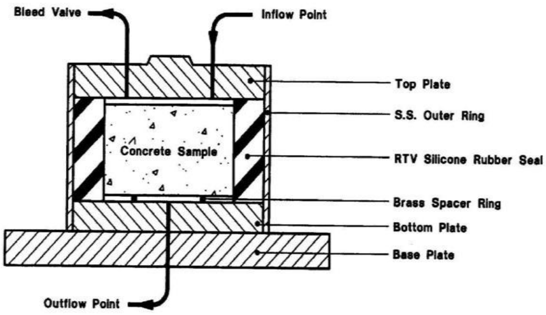

FIGURE 1
DETAILS OF PERMEABILITY CELL

RESULTS:

The D'Arcy Coefficient of Permeability is calculated using the following formula k=___________.

EXPERIMENT NO.11

NON-DESTRUCTIVE TESTING OF CONCRETE
REBOUND HAMMER TEST

Exp. No.: 17

AIM: To determine the compressive strength of concrete by using the rebound hammer.

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 the scale 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.

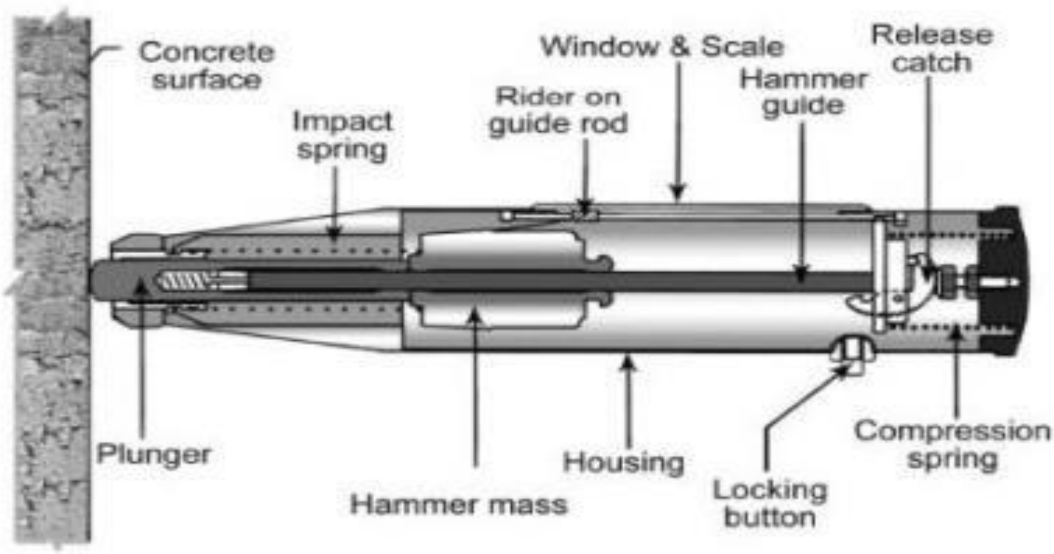

Fig.: Rebound Hammer

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