1. FINENESS OF CEMENT

(IS: 269-1989 and IS: 4031-1988)

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

APPARATUS: IS-90 micron sieve conforming to IS:460-1965, standard balance, weights, brush.

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

PROCEDURE:

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

PRECAUTIONS: Air set lumps in the cement sample are to be crushed using fingers and not to be pressed with the sieve. Sieving shall be done holding the sieve in both hands and with gentle wrist motion. More or less continuous rotation of the sieve shall be carried out throughout sieving.

OBSERVATIONS AND CALCULATIONS:

Sl. NO.	Weight of sample taken(grams)	Weight of residue(grams)	Fineness(%)=(wt of residue/100)*100

Average fineness of cement =

RESULT: Fineness of given sample of cement =

COMMENTS:

1. NORMAL CONSISTENCY OF CEMENT

(IS: 269 - 1989 and IS: 4031 - 1988 (Part 4))

AIM: To determine the quantity of water required to produce a cement paste of standard consistency.

APPARATUS: Vicat apparatus (conforming to IS: 5513 - 1976) with plunger (10 mm in diameter) balance, weights, gauging trowel.

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

PROCEDURE:

1. Prepare a paste of weighed quantity of cement (400 grams) with a weighed quantity of potable or distilled water, starting with 26% water of 400g of cement.
2. Take care that the time of gauging is not less than 3 minutes, not more than 5 minutes and the gauging shall be completed before setting occurs.
3. The gauging time shall be counted from the time of adding the water to the dry cement until commencing to fill the mould.
4. Fill the vicat mould with this paste, the mould resting upon a non porous plate.
5. After completely filling the mould, trim off the surface of the paste, making it in level with the top of the mould. The mould may slightly be shaken to expel the air.
6. Place the test block with the mould, together with the non-porous resting plate, under the rod bearing the plunger (10mm diameter), lower the plunger gently to touch the surface of the test block and quickly release, allowing it to penetrate into the paste.
7. This operation shall be carried out immediately after filling the mould.
8. Prepare trial pastes with varying percentages of water and test as described above until the amount of water necessary for making the standard consistency as defined above is obtained.
9. Express the amount of water as a percentage by weight of the dry cement.

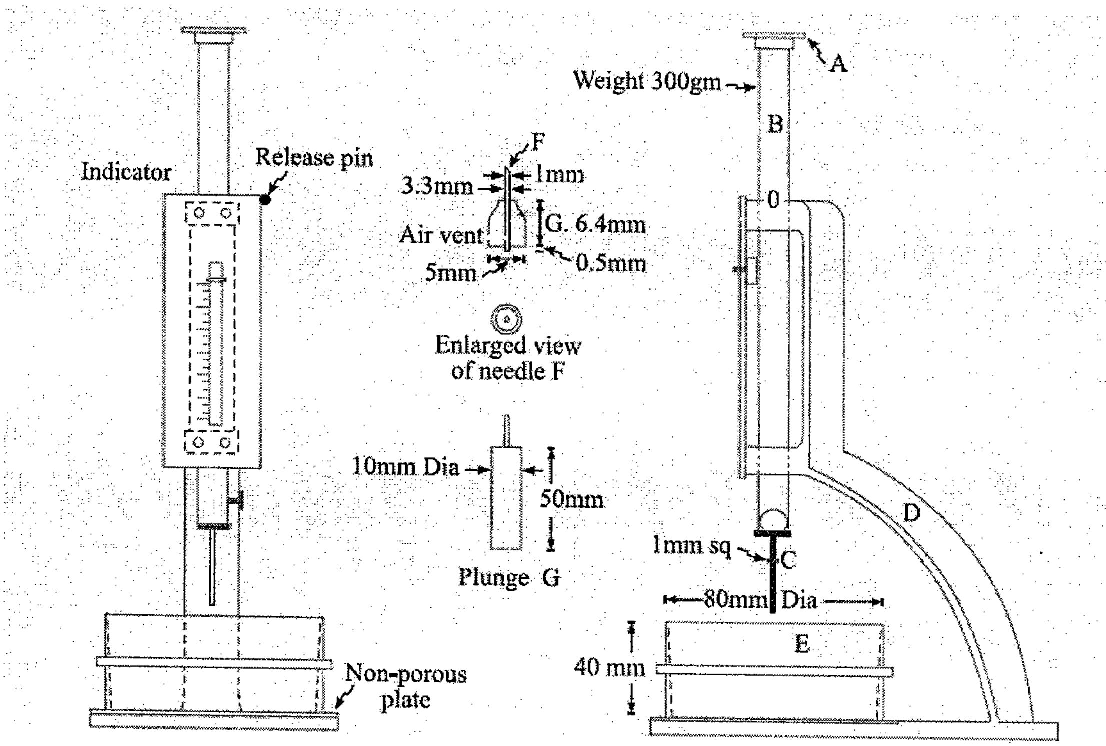
PRECAUTIONS: Clean appliances shall be used for gauging. In filling the mould the operator hands and the blade of the gauging trowel shall alone be used. The temperature of cement, water and that of test room, at the time when the above operations are being performed, shall be 27 + 2 C. For each repetition of the experiment fresh cement is to be taken.

OBSERVATIONS:

S. No	Weight of cement taken in gms (a)	Weight of water taken in gms (b)	Plunger penetration (mm)	Time Taken	Consistency of cement in % by weight b/a * 100

RESULT: Normal consistency for the given sample of cement is

COMMENTS:



2. INITIAL AND FINAL SETTING TIMES OF CEMENT

(IS: 269- 1989 and IS: 4031- 1988 part 5)

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

APPARATUS: Vicat apparatus (conforming to IS: 5513-1976) with attachments, balance, weights, gauging trowel, Stop clock.

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

PROCEDURE:

Preparation of Test Block:

1. Prepare a neat cement paste by gauging 400 grams of cement with 0.85 times the water required to give a paste of standard consistency.
2. Potable or distilled water shall be used in preparing the paste.
3. The paste shall be gauged in the manner and under the conditions prescribed in determination of consistency of standard cement paste.
4. Start a stop-watch at the instant when water is added to the cement.
5. Fill the mould with the cement paste gauged as above the mould resting on a nonporous plate.
6. Fill the mould completely and smooth off the surface of the paste making it level with the top of the mould. The cement block thus prepared in the mould is the test block.

DETERMINATION OF INITIAL SETTING TIME:

1. Place the test blocks confined in the mould and rest it on the non-porous plate, under the rod bearing initial setting needle, lower the needle gently in contact with the surface of the test block and quickly release, allowing it to penetrate into the test block.
2. In the beginning, the needle will completely pierce the test block.
3. Repeat this procedure until the needle, when brought in contact with the test block and released as described above, fails to pierce the block to a point 5 to 7 mm measured from the bottom of the mould shall be the initial setting time.

OBSERVATIONS AND CALCULATIONS:

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

DETERMINATION OF FINAL SETTING TIME:

1. Replace the needle of the Vicat apparatus by the needle with an annular attachment.
2. The cement shall be considered as finally set when, upon applying the needle gently to the surface of the test block, the needle makes an impression there on, while the attachment fails to do so.
3. The period elapsed between the time when water is added to the cement and the time at which the needle makes an impression on the surface of test block while the attachment fails to do so shall be the final setting time.

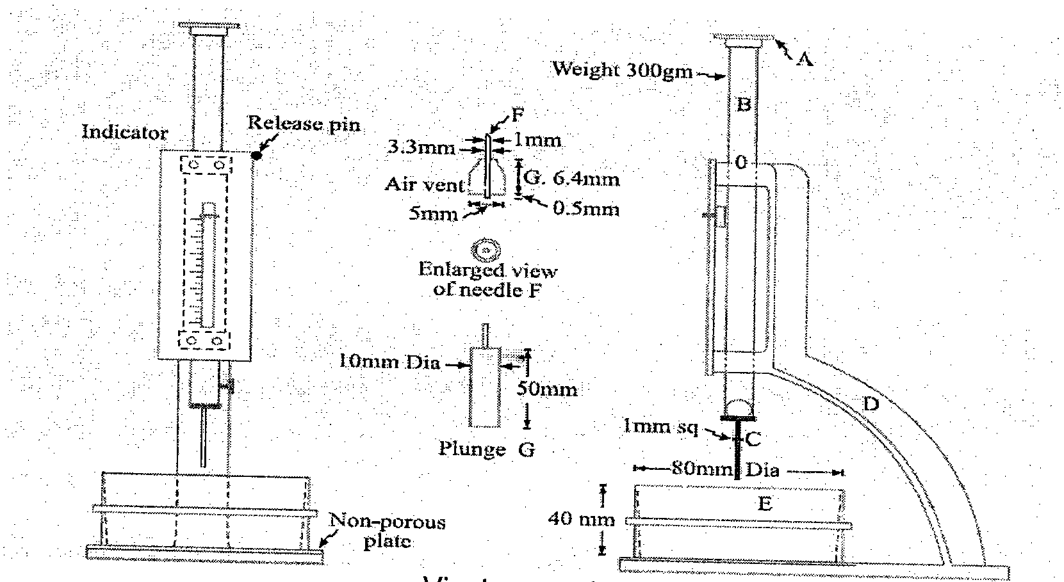
PRECAUTIONS: Clean appliances shall be used for gauging. All the apparatus shall be free from vibration during the test. The temperature of water and that of the test room, at the time of gauging shall be 27 °C $\pm$ 2° C. Care shall be taken to keep the needle straight.

OBSERVATIONS:

Time in minutes :
Height in mm fails to penetrate:

RESULT: Initial setting time for the given sample of cement =
Final setting time for the given sample of cement =

COMMENTS:



Vicat apparatus

3. DETERMINATION OF WORKABILITY OF CONCRETE BY SLUMP CONE TEST

AIM: To determine, by the slump test, the workability (consistency) of concrete mixes of given proportions.

THEORY: Unsupported concrete, when it is FRESH, will flow to the sides and a sinking in height will take place. This vertical settlement is known as SLUMP. 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. A concrete is said to be workable if it can be easily mixed and easily placed, compacted and finished. A workable concrete should not show any segregation or bleeding. Slump increases as water-cement ratio increases.

Slump test is the most commonly used method of measuring consistency of concrete which can be employed either in laboratory or in site of work. It is not a suitable method for very wet or very dry concrete. It does not measure all factors contributing to workability, nor it is always representative of the place-ability of concrete. However, it is used conveniently as a control test and gives an indication of the uniformity of concrete from batch to batch. Repeated batches of the same mix, *brought tothe* same slump, will have the same water content and W/c ratio, provided the weights of aggregate, cement and admixtures are uniform and aggregate grading is within acceptable limits.

APPARATUS: Slump cone, tray for mixing concrete, trowel, tamping *rod, steel* rule, measuring jar, weighing platform machine, spatula. The apparatus for conducting the slump test essentially consists of metallic mould in the form of a frustum of a cone having the dimensions as under:

Bottom diameter = 20cm

Top diameter = 10 cm

Height = 30 cm

The thickness of the metallic sheet for the mould should not be thinner than 1.6mm. For tamping the concrete, a steely tamping rod 16mm diameter; 0.6m long with bullet end is used.

PROCEDURE: Four mixes are to be prepared with W/c ratio (by weight) of 0.5, 0.6, 0.7 and 0.8 respectively and for each mix take 10 Kg. of coarse aggregate, 5 Kg. of sand and 2.5 Kg. of cement. Then the mix proportions are 1:2:4 (Cement:Sand:Coarse Aggregate). If needed, slump values of other mixes i.e. mixes of different proportions can also be found.

1) The internal surface of the mould is thoroughly cleaned and freed from superfluous moisture and any old set concrete before commencing the test. Fix slump cone to the base. The base should be smooth, horizontal, rigid and non-absorbent surface. Apply lubricating oil to the inside walls of slump cone so that concrete is prevented from sticking to the walls of the slump cone.
2) Measure the height of the slump cone. Let it be "h1" cm.
3) Preparation of concrete mix: First mix cement and sand in dry state till a mixture of uniform colour is obtained and to this mixture add coarse aggregate and again mix all the three ingredients. Then add water according to the given W/c ratio and prepare a homogeneous mix.
4) The mould is then filled in four layers; each approximately (1/4) of the height of the mould. Each layer is tamped 25 timesby the tamping rod taking care to distribute the strokes evenly over the cross-section. For the second and subsequent layers, the tamping rod should penetrate into the underlying layer.
5) After the top layer has been rodded, strike off the top with a trowel, so that the mould is exactly filled.

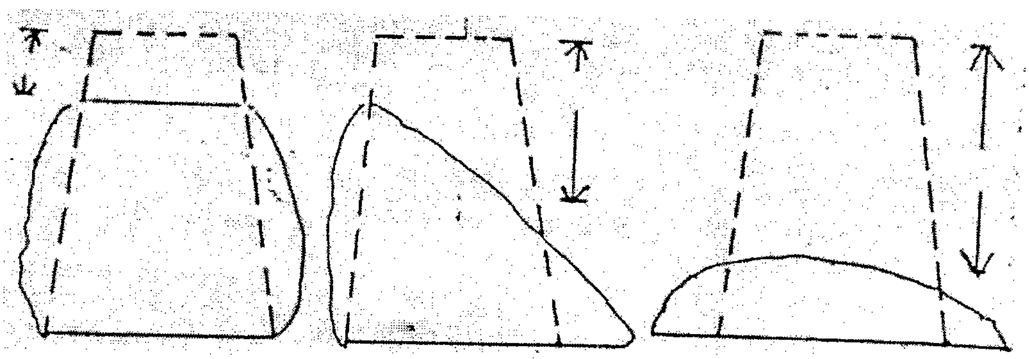
6) The mould is removed from the concrete immediately by raising it slowly and carefully in a vertical direction

7) As soon as the concrete settlement comes to a stop, measure the subsidence of concrete i.e. the difference in level between the height of the mould and that of the highest point of the subsided concrete (OR) measure the height of the concrete and let it be "h2" cm. The difference between (hi) and (h2) gives the slump.
8) Repeat the procedure for different W/c ratios.

NOTE: Any slump specimen which collapses or shears off laterally gives incorrect results and if this occurs, the test is repeated.

OBSERVATIONS AND CALCULATIONS:

Sl.No.	*W/C Ratio*	*Height of slump cone (h1) cm*	*Height of concrete after removing cone (h2)*	*Slump value= (h1-h2) cm*
1.	0.5			
2.	0.6			
3.	0.7			



TRUE SLUMP SHEAR SLUMP COLLAPSE SLUMP

PATTERN OF SLUMP: It indicates the characteristics of concrete in addition to the slump value. During the slump test, one often comes across three types of slumps.

(a) True slump (b) Shear slump (c) Collapse slump

a) If the concrete slumps evenly (uniformly), it is called true slump. This type of slump is obtained normally in rich mixes and where the proportion of the fine aggregate is higher.

b) If one half of the cone slides down, it is called shear slump. This normally happens in leaner mixes such as 1:6 or 1:8 and where the slump requirements are higher. In this case, 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 indicate that the concrete is non-cohesive and shows the characteristic of segregation.

c) In this type of slump, the concrete just collapse and spread over a large area. This normally occurs in very wet mixes.

PRECAUTIONS:

1) The strokes are to be applied uniformly through the entire area of concrete section.
2) The cone should be removed very slowly by lifting it upwards without disturbing the concrete.
3) The experiment should be completed within 3 minutes.
4) During filling the mould must be firmly pressed against its base.
5) The surplus concrete on the top of the mould should be removed carefully with a trowel. The surplus should not be forced into the mould.
6) Test should be made beyond the range of ground vibrations, because they might increase the subsidence of concrete.

Recommended slump values for concrete for various jobs.

Degree of workability	*Slump in mm*	*Use for which concrete is suitable*
Very low	0-25	i) Roads vibrated by power-operated machines.
		ii) Vibrated concrete in large sections.
Low	25-50	i) Roads vibrated by hand-operated machines.
		ii) Mass concrete foundations without vibration or lightly reinforced sections with vibration
Medium	50-100	i) Manually compacted flat slabs using crushed aggregates.
		ii) Normal reinforced work without vibration and heavily reinforced sections with vibration.
High	100-175	For sections with congested reinforcement which is not normally suitable for vibration.

QUESTIONS:

1) Write down the slump range for concrete used for the followingpurposes:
(a) Beams, slabs and stair cases.

(b) Columns and retaining walls,

(c) Mass concrete in foundation.

2) What do you mean by the workability of freshly mixed concrete?
3) If the concrete can be rammed hard, will the slump value be decreased or increased?

4) What are the dimensions of slump cone and tamping rod?

5) Define segregation and bleeding of concrete.
6) What are the undesirable effects of segregation and bleeding?
7) How can the bleeding of concrete be prevented?
8) Name some admixtures that may increase the slump.
9) For which type of mix, slump test is more suitable (Lean mix/Rich mix) and why?
10) Why slump cone test is still-popular inspite of the fact thatmany other workability tests are in vogue?

4.COMPACTION FACTOR TEST

OBJECT: To determine workability of concrete mixes of given proportions by compaction factor test.

THEORY: 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. Such dry concrete in the sensitive to slump test.

This test works on the principle of determining the degree of compaction achieved by a standard amount of work done by allowing the concrete to fall through a standard height. The degree of compaction, called the compaction factor is measured by the density ratio i.e. the ratio of the density actually achieved in the test to the density of same concrete fully compacted.

APPARATUS: Compaction factor apparatus, trowels, graduated cylinder, weighing machine, tamping rod and trays.

PROCEDURE:

1) Keep the compaction factor apparatus on a level ground and add oil in the inner surface of the hoopers and cylinder.
2) Fasten the hopper doors.
3) Weigh the empty cylinder accurately and note the weight (W1).
4) Fix the cylinder on the base with fly nut and bolt in such a way that the central points of hoopers and cylinder lie on one line. Cover the cylinder with a plate.
5) Three mixes are to be prepared with w/c ratio (by weight) 0.50, 0.60, 0.70 respectively. For each mix take 10 Kg. of coarse aggregate, 5 Kg. of sand and 2.5 Kg. of cement. With each mix proceed as follows:

(a) Mix sand and cement dry, until a mixture of uniform colour is obtained. Now mix the coarse aggregate and cement sand mixture until coarse aggregate is uniformly distributed through out the batch.

(b) Add the required percentage of water to the above mixture and mix it thoroughly until concrete appears to be homogeneous.

6) Fill the freshly mixed concrete in upper hopper gently and carefully with hand scoop without compacting.
7) After two minutes, release the trap door so that the concrete is allowed to fall into the lower hopper bringing the concrete into standard compaction.
8) Immediately after the concrete has come to rest, open the trap door of lower hopper and allow the concrete to fall into thecylinder bringing the concrete into standard compaction.
9) Remove the excess concrete above the top of the cylinder bypair of trowels, one in each hand, with blades horizontal slidethem from the opposite edges of the mould inward to the centrewith a sawing motion.
10) Clean the cylinder from all sides properly. Find the weight (W2) of partially compacted concrete thus filled in the cylinder.
11) Refill the cylinder with the same sample of concrete in approximately 5 cm layers, vibrating each layer heavily so as to expel all the air and to obtain full compaction of concretes.
12) Level up mix and weigh (W2) the cylinder filled with fully compacted concrete.

OBSERVATIONS AND CALCULATIONS

Weight of cylinder W1 =

Sl. No.	W/C ratio	Wt.of cylinder with partially compacted concrete W2	Wt.of cylinder with fully compacted concrete W3	Wt.of partially compacted concrete W2-W1	Wt.of compacted concrete W3-W1	Compaction factor =[$\frac{W2-W1}{W3-W1}$]
01.	0.50					
02.	0.60					
03.	0.70					

PRECAUTIONS

1. The test should be carried out on a level ground.
2. The top hopper must be filled gently and to the same extent on each occasion and the time between the end of mixing and release of concrete from top hopper must be constant, two minutes will be convenient.
3. The outside of mould must be wiped clean before weighing and weights should be recorded to the nearest 10 gm.
4. The hoppers and cylinder must be washed clean and wiped before reuse.
5. The mix should not be pressed or compacted in the upper"hopper".
6. If the concrete in the hopper does not fall through, when the trap door is released, it should be freed by passing a metal rod, similar to that used in slump test, vertically through its centre. A single steady penetration will usually affect release.

DISCUSSIONS: Compaction factor test is adopted to determine the workability of concrete, where the nominal maximum size of aggregate does not exceed 4 0mm and is primarily used in laboratory. It is more sensitive and precise than slump test and is particularly, useful for concrete mixes of low workability as are normally used when the concrete is to be compacted by vibration, such concrete may constantly fail to slump. The compaction factor (C.F.) test is able to indicate small variations of workability over a wide range.

LIMITATIONS OF THE METHOD

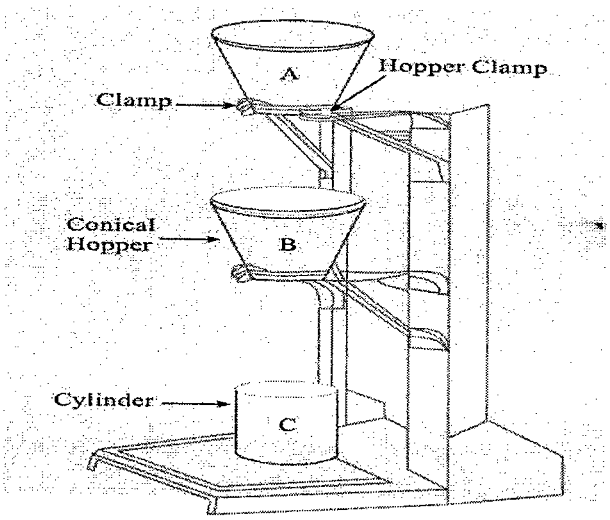
1. When maximum size of aggregate is large as compared with more particle size, the drop into bottom container will produce segregation and give unreliable comparison with other mixes of smaller maximum aggregate size.
2. The method of introducing concrete into mould bears no relationship to any of the more common methods of placing and compacting high quality concrete.
3. Compaction factor test establishes the fact that with increase in the size of coarse aggregate the workability decreases.

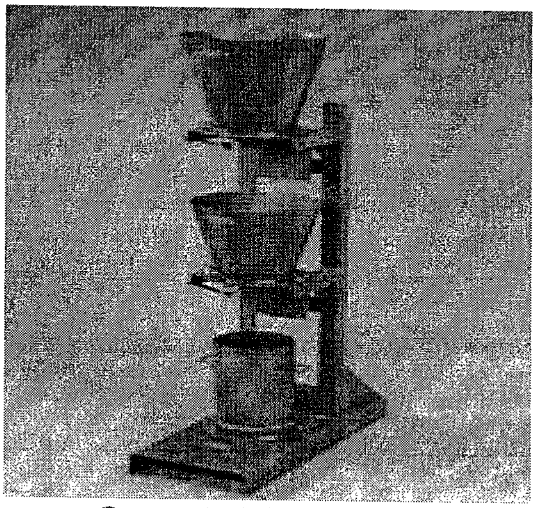
SUGGESTED RANGES OF WORKABILITY OF CONCRETE

MEASURED IN ACCORDANCE WITH IS;13,99-1958

(I.S : 456-1973 THIRD REVISION)

Placing conditions	*Degree of workability*	*Values of workability*
Concreting of small sections with vibration	Very low	20-10 seconds, vee-bee time or. 0-75-0.80 compacting factor
Concreting of lightly reinforced sections with vibration	Low	10.5 seconds, vee-bee time.
Concreting of lightly reinforced section without vibration	Medium	5.2 seconds Vee-Bee time or 0.85-0.92 compacting factor or 25075 mm, slump
Concreting of heavily reinforced sections without vibration	High	Above 0.92 C.F. or 75-125 mm slump





Compacting Factor Apparatus

5. VEE BEE CONSISTENCY TEST

AIM: To determine the workability of the concrete mix of given proportion by Vee-Bee consistometer test.

APPARATUS: Vee Bee Consistometer : a) A vibrator table resting upon elastic supports, b) A metal pot, c) A sheet metal cone, open at both ends, and d) A standard iron rod. Weights and weighing device, Tamper (16 mm in diameter and 600 mm length), Ruler, Tools and containers for mixing, or concrete mixer etc.

PRINCIPLE: It is based on the principle of measuring the energy required to transform a concrete specimen in the shape of a conical frustum into a cylinder.

THEORY:

Vee Bee Consistometer Test: This is a good laboratory test to measure indirectly the workability of concrete.

This test consists of a vibrating table, a metal pot, a sheet metal cone, a standard iron rod. The vibrator table (C) is 380 mm long and 260 mm wide and is supported on rubber shock absorbers at a height of about 305 mm above floor level. The table is mounted on a base (K) which rests on three rubber feet and is equipped with an electrically operated vibrometer mounted under it, operating on either 65 or 220 volts three phase, 50 cycles alternating current. A sheet metal cone (B) open at both ends is placed in the metal pot (A) and the metal pot is fixed on to the vibrator table by means of two wing-nuts (H). The sheet metal cone is 30 cm high and its bottom diameter is 20 cm and top diameter 10 cm. A swivel arm holder (M) is fixed to the base and, into this is telescoped another swivel arm (N) with funnel (D) and guide-sleeve (E). The swivel arm can be readily detached from the vibrator table. The graduated rod (J) is fixed on to the swivel arm and at the end of the graduated arm _8. glass disc records the slump of concrete after rod is 20 mm in (C) is screwed. The division of the scale on the rod bf the concrete cone in centimetres and the volume vibration of the cone in the pot. The standard iron diameter and 500 mm in length.

PROCEDURE:

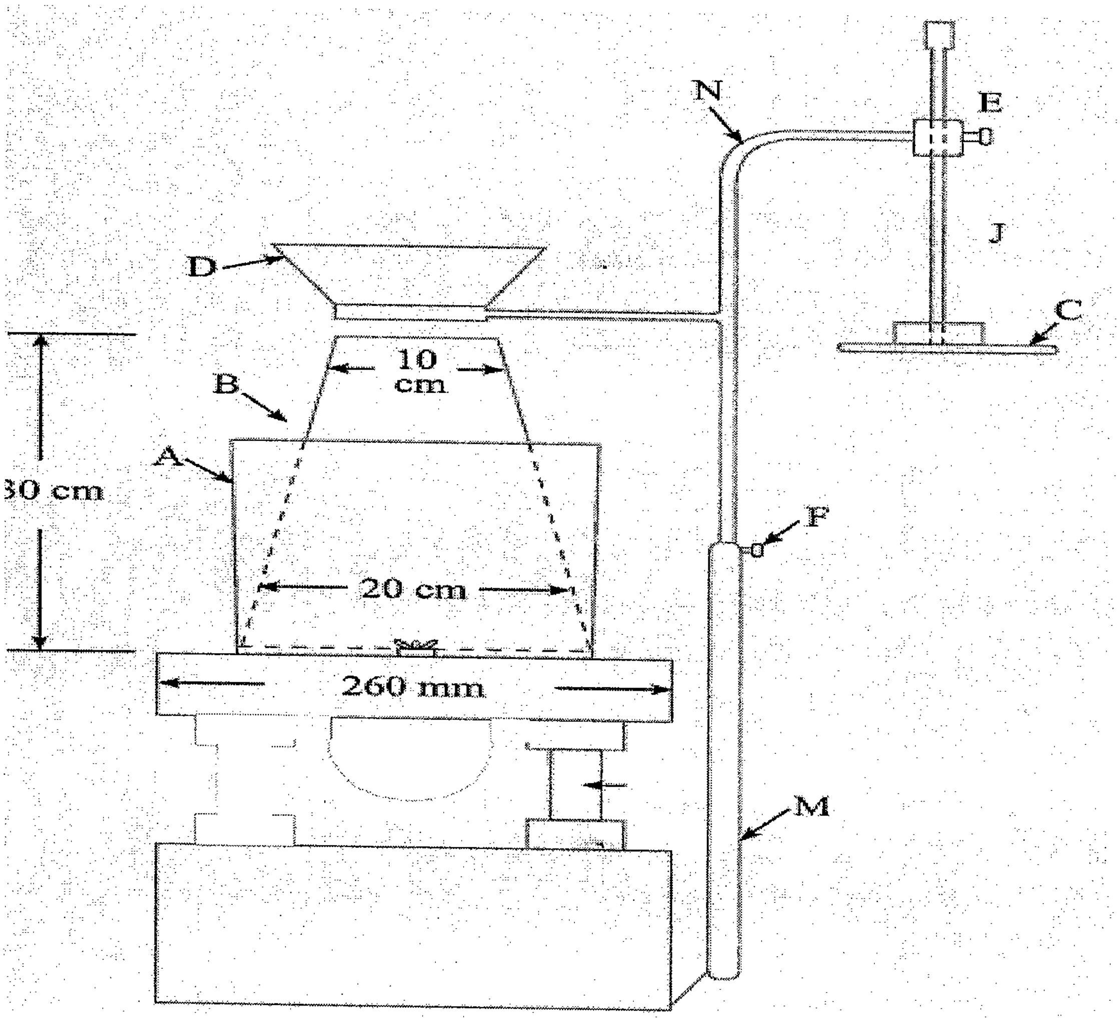
1. Slump test as described earlier is performed, placing the slump cone inside the sheet metal cylindrical pot of the consistometer.
2. The glass disc attached to the swivel arm is turned and placed on the top of the concrete in the pot. The electrical vibrator is then switched on and simultaneously a stop watch started.
3. The vibration is continued till such a time as the conical shape of the concrete disappears and the concrete assumes a cylindrical shape. This can be judged by observing the glass disc from the top for disappearance of transparency.
4. Immediately when the concrete fully assumes a cylindrical shape, the stop watch is switched off. The time required for the shape of concrete to change from slump cone shape to cylindrical shape in seconds is known as Vee Bee Degree.
5. This method is very suitable for very dry çoncrete whose slump value cannot be measured by Slump Test, but the vibration is too vigorous for concrete with a slump greater than about 50 mm.

Observation:

The time required for the shape of concrete to change from slump cone shape to cylindrical shape in seconds is known as Vee Bee Degree .

Conclusion / R :

The Vee Bee Degre of concrete .... sec indicate **Low/ Medium/ High** Degree of workability



Figure

6. COMPRESSIVE STRENGTH OF CONCRETE

AIM: To determine the compressive strength of concrete by crushing test on cubes and cylinders.

APPARATUS: Compression Testing Machine, Specimen, Scale.

THEORY: In design of R.C.C. sections allowable, stress is taken for the design. This allowable stress is a fraction of the ultimate (crushing) strength of concrete. As per I.S.456, a factor of safety of 3.0 is adopted for obtaining allowable comp. stresses. The permissible stresses are specified with reference to cube strength.

The testing of concrete cube (or cylinder) are required (i) to verify the strength of concrete mix used in actual construction and (ii) to verify the strength of trial mixes as in the case of design of mixes. I.S. code has specified the strength on cubes of 150 x 150 xl50 mm. Alternatively if test results on cylinder strengths (150 x 300 mm) are available the results shall satisfy:

Minimum cylinder compressive strength = 0.8 x compressive strength specified on cubes.

PREPARATION OF SAMPLES

1) Take the required quantities of materials from the table depending upon the mix under preparation.
2) Cement and sand are thoroughly mixed until the mixture is of uniform colour.
3) The coarse aggregate is then added and mixed dry.
4) Add water and mix the whole mass for minimum two minutes so that the resulting concrete is uniform in colour.
5) The moulds, both cubes (150mm x 15 0mm x 150mm) and cylinders (150mm dia and 3 0 0mm height) should be oiled to prevent the concrete from sticking.
6) The concrete should be filled in the mould in three equal layers. Each layer should be compacted 35 times with a 16mm diameter, rod, 600mm long and bullet pointed at lower end. When cylinder is used the strokes for each layer should not be less than 3 0.
7) Strike off the surface with a trowel.
8) Place the moulds containing the test specimen in moist air of atleast 90% humidity and at temperature (27° ± 2°)C for 24 hours.
9) Next day, the specimens are taken out from the moulds and cured under clean, fresh water at temperature (27° ± 2°)C.
10) The curing is done until the required days of testing and the specimens shall be taken out just prior to the test.

TESTING

1) Tests shall be conducted at the end of 7 days and 2 8 days. The tests should **be** carried out immediately upon the removal of specimens from water.
2) Measure the dimensions of the given specimen.
3) Keep the specimen in compression testing Machine so that the load is applied to the transverse sides as cast and not to the top and bottom as cast. The rate of loading should be 14 0 Kg/sq.cm./minute.
4) Note the mode of failure and angle of plane (if any) on which the specimen fails. Record the

ultimate load reached during the test.

OBSERVATIONS AND CALCULATIONS

Size of specimen =

Area of cross section A =

Sl. No.	*Identification No.*	*Date of casting*	*Date of testing*	*Ultimate load P(Newtons)*	*Ultimate compressive strength P/A N/mm²*
1.					
2.					
3.					
4.					

Average =

NOTE: The test strength of sample shall be the average of the strength of three specimens. The individual variation should not be more than ± 15 percent of the average.

DISCUSSIONS & CONCLUSIONS

I.S.456: 1978 classified concrete mixes according to its strength. The concrete is classified into seven grades, and the grades are based on the basis of compressive strength of 15 cm cubes at 28 days mixed and cured under prescribed conditions. The strength requirements of each grade of concrete as specified by ISI are given in the following table.

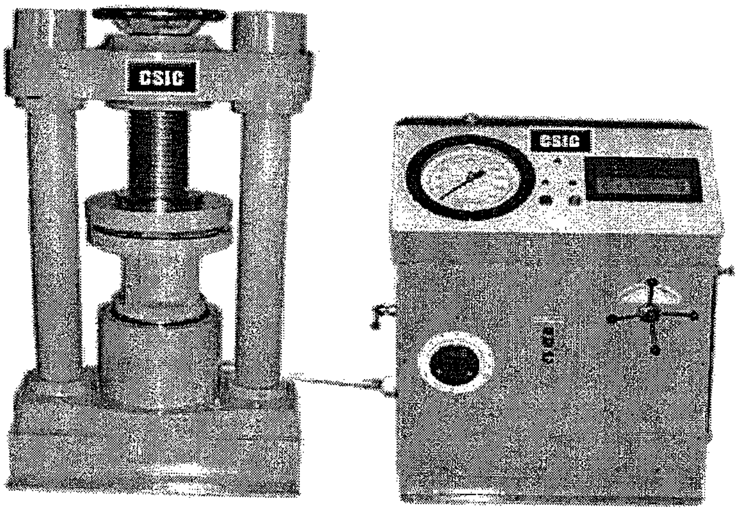
REQUIREMENTS

Grade of concrete	STRENGTH REQUIREMENTS OF CONCRETE Compressive strength of 15 cm cube of 28 days after mixing conducted in accordance with IS:516-1959	
	Preliminary test (min) Kg/sq.cm.(N/sq.mm)	Working test (min) Kg/ Sq.cm. (N/sq.mm)

NOTE: Preliminary Test: A test conducted in a Laboratory on the trial mix of the concrete produced in the laboratory with the object of

(1) Designing of concrete mix before the actual concreting operations start.
(2) Determining the adjustments required in the materials used during the execution of work.
(3) Verifying the strength of concrete mix.

WORK TEST: A test conducted either in the field or in a laboratory on the specimen made on the works, out of the concrete being used on the works. The above table mentions seven grades of concrete and specifies both the preliminary test strength and work-cube strength. These strength requirements are applicable to both controlled (design mix) concrete and ordinary (nominal) concrete. But for ordinary concrete preliminary tests are not obligatory according to the IS code. IS.456 also specified that where the strength of the concrete for any two grades specified in the above table, such concrete shall be classified for all purposes as concrete belonging to the lower of the two grades between which its strengths lies.



Figure

7. DETERMINATION OF COMPRESSIVE STRENGTH OF CEMENT

AIM: Determination of the compressive strength of cement.

THEORY: The compressive strength of hardened cement is the most important of all the properties of cement. Cement has the maximum strength in compression and is weaker in tension. Strength tests are not made on neat cement paste because of difficulties of excessive shrinkage and subsequent cracking of neat cement. Strength of cement is indirectly found on cement sand mortar in specific proportions. Standard Ennore sand is used for finding strength of cement.

APPARATUS: Compression testing machine, cube mould of side 7.06cm (sectional area of 50 sq.cm.), Vibrator, Crucible for mixing cement and sand, measuring cylinder, trowels, non-porous plate and balance with weights-box.

PROCEDURE:

1. Take 555 gms of standard sand, 185 gms of cement (in, ratio of cement to sand is 1:3) in a non-porous enamel tray and mix them with a trowel for one minute. Then add water of quantity (P/4 + 3.5) percent of combined weight of cement and sand and mix the ingredients until the mixture is of uniform color. The mixing time should not be less than 3 minutes nor more than 4 minutes.
2. Place the assembled mould on the table of the vibrating machine and firmly hold it in position by means of a suitableclamp. Securely attach the hopper at the top of the mould tofacilitate filling and this hopper shall not be removed untilcompletion of vibration period.
3. Immediately after mixing the mortar as explained above, fillthe entire quantity of mortar in the hopper of the cube mould andcompact by vibrating. The period of vibration shall be 2 minutesat the specified speed of 12000 ± 4 cycles per minute.
4. Remove the mould from the machine and keep it at a temperature of 27 degrees C in an atmosphere of atleast 90% relative humidity for 24 hours after completion of vibration.
5. At the end of this period, remove the cubes from the moulds and immediately submerge in clean and fresh water and keep there until taken out just before testing.

TESTING: Test three cubes at the periods mentioned below, the periods being reckoned from the completion of vibrations. The compressive strength shall be the average of the strengths of the 3 cubes for each period, respectively.

O.P.C. – 3 and 7 days

Rapid hardening Portland cement ----1 and 3 days

Low heat Portland cement --- 3, 7 and 28 days

The cubes shall be tested, the load being applied at the rate of 35 N/sq.mm/minute.

OBSERVATIONS AND CALCULATIONS:

Sl. No.	*3-days strength*		*7-days strength*	
	Load in KN	*Strength in N/sq.mm*	*Load in KN*	*Strength in N/Sq.mm*

PRECAUTIONS

1. The mortar shall not be compressed into the moulds with hand.
2. Neglect the results which fall outside 15% of the average results on either side.
3. Cubes should be tested on their sides and not on their faces
.
4. The inside of the cube mould should be oiled to prevent the mortar from adhering to the sides of the mould.
5. The size of sand particles should be such that not more than 10% by weight shall pass IS:60 micron sieve.
6. The time of wet mixing shall not be less than 3 minutes. If the time of mixing exceeds 4 minutes to bring a uniform color, the mixture shall be rejected and fresh mortar should be prepared.
7. The cubes shall not be allowed to dry until they are broken.

DISCUSSION

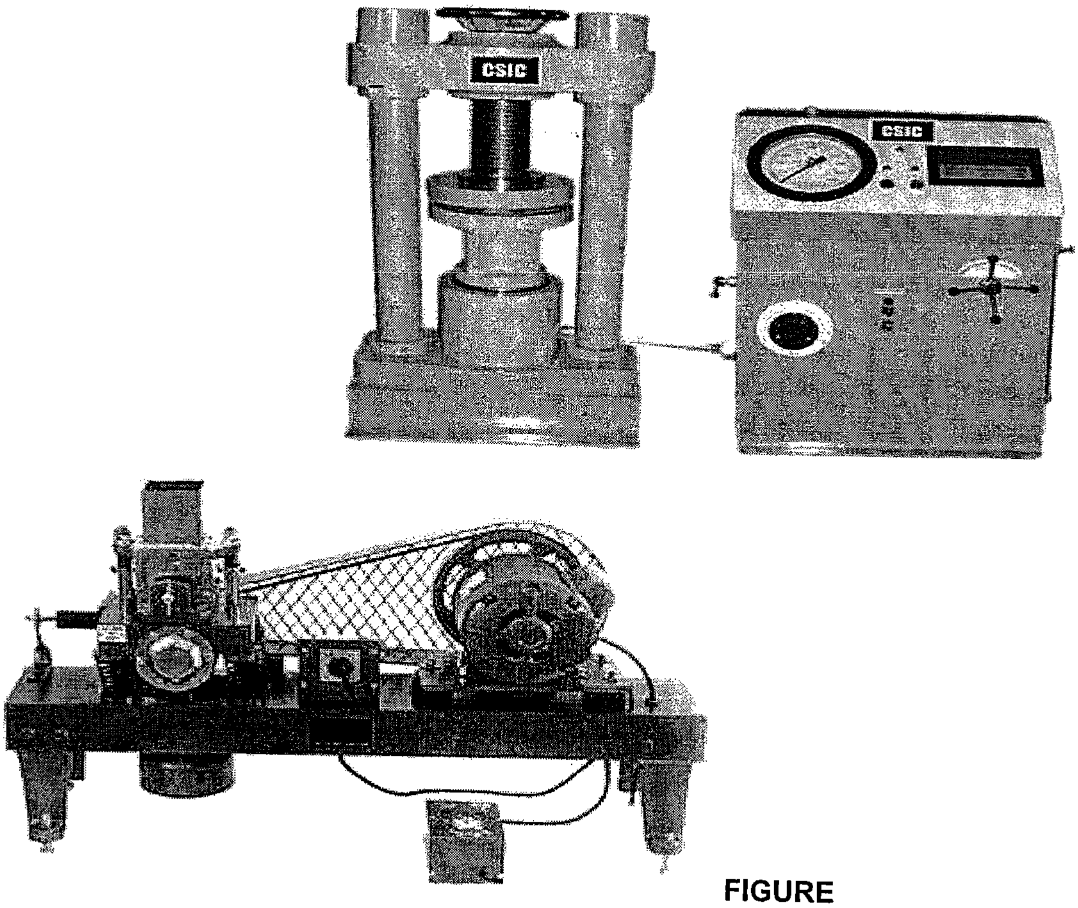
IS-269-1976 specifies the following strengths in compression for the standard mortar cubes. Strength in N/sq.mm.are as follows:

Age	*O.p.C*		*(Change units) Rapid Hardening. Portland cement*	*Low heat cement*
1	—		16.0 (11.5)	—
3	16.(	(11.5)	2.75 (21.0)	10.0 (7.0)
7	22.(	(17.5)	--	16.0 (11.5)
20	—			35.0 (26.5)

The values given in brackets are the strength requirements of mortar cubes when locally available sand is used in place of standard ennore sand.

NOTE STANDARD SAND: As per the revised specifications, 100 percent passes through 2 mm sieve and 100 percent retained on a 90-micron sieve. Particle size distribution is as under.

Size	Percentage
Greater than 1mm	33.33
Smaller than 1 mm and greater than 500 microns	33.33
Below 500 microns	33.33



FIGURE

SPECIFIC GRAVITY OF CEMENT

(IS: 269 -1989 AND IS: 4031-1988)

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

APPARATUS: Physical balance, specific gravity bottle of 50ml capacity, clean kerosene.

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

PROCEDURE:

1. Clean and dry the specific gravity bottle and weigh it with the stopper (W1).
2. Fill the specific gravity bottle with cement sample at least half of the bottle and weigh with stopper (W2).
3. Fill the specific gravity bottle containing the cement, with kerosene (free of water) placing the stopper and weigh it (W3).
4. While doing the above do not allow any air bubbles to remain in the specific gravity bottle.
5. After weighing the bottle, the bottle shall be cleaned and dried again.
6. Then fill it with fresh kerosene and weigh it with stopper (W4).
7. Remove the kerosene from the bottle and fill it with full of water and weigh it with stopper (W5).
8. All the above weighing should be done at the room temperature of 27c $\pm$ 1^0c.

OBSERVATIONS:

Description of item		**Trial 1**	**Trial2**	**Trail3**
Weight of empty bottle	W1 g			
Weight of bottle + Cement	W2 g			
Weight of bottle + Cement + Kerosene	W3 g			
Weight of bottle + Full Kerosene	W4 g			
Weight of bottle + Full Water	W5 g			

Specific gravity of Kerosene Sk = W4 - W1 / W5 - W1

Specific gravity of Cement Sc = W2 - W1 / ((W4 - W1)-(W3-W2))*Sk

Sc = (W2 - W1)* (W4 - W1) / ((W4 - W1)-(W3-W2))*(W5 - W1)

PRECAUTION:

1. Only kerosene which is free of water shall be used.
2. At time of weighing the temperature of the apparatus will not be allowed to exceed the specified temperature.
3. All air bubbles shall be eliminated in filling the apparatus and inserting the stopper.
4. Weighing shall be done quickly after filling the apparatus and shall be accurate to 0.1 mg.
5. Precautions shall be taken to prevent expansion and overflow of the contents resulting from the heat of the hand when wiping the surface of the apparatus.

RESULT: Average specific gravity of given sample of cement =

COMMENTS:

BULKING OF SAND

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

APPARATUS: 1000ml measuring jar, brush.

INTRODUCTION: 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. To compensate the bulking effect extra sand is added in the concrete so that the ratio of coarse to fine aggregate 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.

PROCEDURE:
1) Take 1000ml measuring jar.
2) Fill it with loose dry sand upto 500ml without tamping at any stage of filling.
3) Then pour that sand on a pan and mix it thoroughly with water whose volume is equal to 2% of that of dry loose sand.
4) Fill the wet loose sand in the container and find the volume of the sand which is in excess of the dry volume of the sand.
5) Repeat the procedure for moisture content of 4%, 6%, 8%, etc. and note down the readings.
6) Continue the procedure till the sand gets completely saturated i.e till it reaches the original volume of 500ml.

OBSERVATIONS:

S.No	Volume of dry loose sand V1	% moisture content added	Volume of wet loose sand V2	% Bulking V2 – V1 / V1
1.	500 ml	2%		
2.		4%		
3.		6%		
4.		8%		
5.				
6.				

GRAPH: Draw a graph between percentage moisture content on X-axis and percentage bulking on Y-axis. The points on the graph should be added as a smooth curve. Then from the graph, determine maximum percentage of bulking and the corresponding moisture content.

PRECAUTIONS:
1) While mixing water with sand grains, mixing should be thorough and uniform.
2) The sample should not be compressed while being filled in jar.
3) The sample must be slowly and gradually poured into measuring jar from its top.
4) Increase in volume of sand due to bulking should be measured accurately.

RESULT: The maximum bulking of the given sand is -----------at -----------% of moisture content.

COMMENTS:

FINENESS MODULUS OF FINE AND COARSE AGGREGATE

AIM: To determine the fineness modulus of given fine and coarse aggregates.

APPARATUS:_IS test sieves, square hole perforated plate 75mm, 40mm, 20mm, 10mm, and fine wire cloth of 4800, 2400, 1200, 600, 300, and 150 Microns. Weighing balance (Sensitivity 0.1 percent) sieve shaker, tray plates.

INTRODUCTION: Fine aggregate is sand used in mortars. Coarse aggregate is broken stone used in concrete. The size of the fine aggregate is limited to maximum 4.75 mm (4800 microns) beyond which it is known as coarse aggregate. Fineness modulus is only a numerical index of fineness, giving some idea about, the mean size of the particles in the entire body of concrete. Determination of fineness modulus is considered as a method of standardization of grading of aggregates i.e. the main object of finding fineness modulus is to grade the given aggregate for the most economical mix and workability with minimum quantity of cement. It is obtained by sieving known weight of given aggregate 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.

PROCEDURE:

Coarse aggregate:

1. Take 5Kgs of coarse aggregate (nominal size 20mm) from the sample by quartering.
2. Carry out sieving by hand, shake each sieve in order 75mm ,40mm, 20mm, 10mm, and No's 480, 240, 120, 60, 30, & 15 .over a clean dry tray for a period of not less than 2 minutes.
3. The shaking is done with a varied motion backward and forward, left to right, circular, clockwise and anticlockwise and with frequent jarring.
4. So that material is kept moving over the sieve surface in frequently changing directions.
5. Find the weight retained on each sieve taken in order

Fine aggregate:

1. Take 1 Kg of sand from sample by quartering in clean dry plate.
2. Arrange the sieves in order of No. 480, 240, 120, 60, 30 and 15 keeping sieve 480 at top and 15 at bottom.
3. Fix them in the sieve shaking machine with the pan at the bottom and cover at the top.
4. Keep the sand in the top sieve no 480, carry out the sieving in the set of sieves and arranged before for not less than 10 minutes.
5. Find the weight retained in each sieve.

OBSERVATIONS:

Coarse aggregate: Wt. of coarse aggregate taken: Kgs.

S.No	Sieve size	Weight retained	% Weight retained	% weight passing	Cumulative % Weights retained
1.	75 mm				
2.	40 mm				
3.	20 mm				

4.	10 mm				
5.	4800 microns				
6.	2400 microns				
7.	1200 microns				
8.	600 microns				
9.	300 microns				
10.	150 microns				

Fine aggregate: Wt. of fine aggregate taken: Kgs

S.No	Sieve size	Weight retained	% Weight retained	% weight passing	Cumulative % Weights retained
1	4800 microns				
2	2400 microns				
3	1200 microns				
4	600 microns				
5	300 microns				
6	150 microns				

Fineness Modulus: Sum of Cumulative percentage Wt. retained /100

PRECAUTIONS:
1. The sample should be taken by quartering.
2. The sieving must be done carefully to prevent the spilling of aggregate.

RESULT: The fineness modulus of given fine aggregate:
The fineness modulus of given coarse aggregate:

COMMENTS: Limits of fineness modulus of aggregates.

Maximum size of aggregate	Minimum retained	Maximum retained
Fine aggregate	2	3.5
Coarse aggregate		
20 mm	6	6.9
40 mm	6.9	7.5
75 m	7.5	8.0
150 mm	8.0	8.5

SPECIFIC GRAVITY VOID RATIO POROSITY AND BULK DENSITY OF COARSE AND FINE AGGREGATES

IS 2386 PART III-1963

AIM: To determine the specific gravity, void ratio, porosity and bulk density of given coarse and fine aggregates.

APPARATUS: 10 Kg capacity balance with weights, cylindrical containers of 1 liter and 5 liter capacities, measuring jar of 1000ml capacity.

INTRODUCTION: The specific gravity of an aggregate is generally required for calculations in connection with cement concrete design work for determination of moisture content and for the calculations of volume yield of concrete. The specific gravity also gives information on the quality and properties of aggregate. The specific gravity of an aggregate is considered to be a measure of strength of quality of the material. Stones having low specific gravity are generally weaker than those with higher specific gravity values.
The bulk density of an aggregate is used for judging its quality by comparison with normal density for that type of aggregate. It is required for converting proportions by weight into proportions by volume and is used in calculating the percentage of voices in the aggregate.

1. **Specific gravity** is the weight of aggregate relative to the weight of equal volume of water.
2. **Void ratio** is the ratio of volume of voids to the volume of solids in an aggregate.
3. **Percentage of voids or porosity** is the ratio of volume of voids to the total volume of a sample of an aggregate.
4. **Bulk density** or unit weight is the weight of material per unit volume.

PROCEDURE: Coarse aggregate

1. Find the weight of the empty container W1.
2. Take coarse aggregate in the container up to approximately half of the container and find out the weight W2.
3. Fill the container with water upto the level of the coarse aggregates so that all void space inside the aggregate is filled with water. Find its weight W3.
4. Fill the container with water after emptying it from mix of coarse aggregate and water.
5. Water should be upto the mark, upto which coarse aggregate is filled. Find its weight W4
6. Repeat the same process for another trail by taking the aggregate upto the full of the container and by filling the water up to same point.

OBSERVATIONS:

S.No			Trail 1	Trail 2
1)	Weight of empty container	W1		
2)	Weight of container with material	W2		
3)	Weight of container + material + water	W3		
4)	Weight of container + water	W4		

i) Void ratio = Vol. of Voids / Vol of Solids

W3 - W1 / ((W4 - W1)-(W3-W2))

ii) Porosity = Vol. of Voids / Total Vol. of aggregate *100
W3 - W2 / (W4 - W1) * 100

iii) Specific gravity = W2 - W1 / ((W4 - W1) - (W3 - W2))

iv) Bulk density = W2 - W1 / (W4 - W1).

Fine aggregate: Void Ratio and porosity

1. Take 150 ml of dry sand (v1 ml) in clean measuring jar of 1000 ml capacity.
2. Add a measured quantity of 100 ml clean water to the above sample (v2 ml) i.e. v2=100 ml
3. Shake the jar thoroughly till all air bubbles are expelled.
4. Now note the readings against the top surface of water in the jar (V3 ml)

Void ratio = v1 + v2 - v3 / v3 - v2
Porosity = v1 + v2 - v3 / v1

Specific gravity of fine aggregates:

1. Weigh the empty measuring jar of 1000 ml capacity = W1
2. Take the weight of empty measuring jar with 150 ml of sand
   Empty jar + sand =W2
3. Take the weight of empty measuring jar with 150 ml of sand and 100 ml of water
   Empty jar + sand + water = W3
4. Remove the mix of sand and water from bottle and fill it with water up to volume V3 then weigh it.
   Empty jar + water = W4

Specific gravity = Weight of solids / Volume of Solids
W2 - W1 / ((W4 - W1) - (W3 - W2))

PRECAUTIONS: While filling the container with water in determining void ratio and porosity of coarse aggregate care should be taken that water should not be in excess of the level of course aggregate.

RESULT:

1) Specific gravity of course aggregate.
2) Void ratio of course aggregate.
3) Porosity of coarse aggregate.
4) Bulk density of course aggregate.
5) Specific gravity of fine aggregate.
6) Void ratio of the given fine aggregate.
7) Porosity of the given time aggregate.

COMMENTS:

NON-DESTRUCTIVE TESTING OF CONCRETE
REBOUND HAMMER TEST

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.

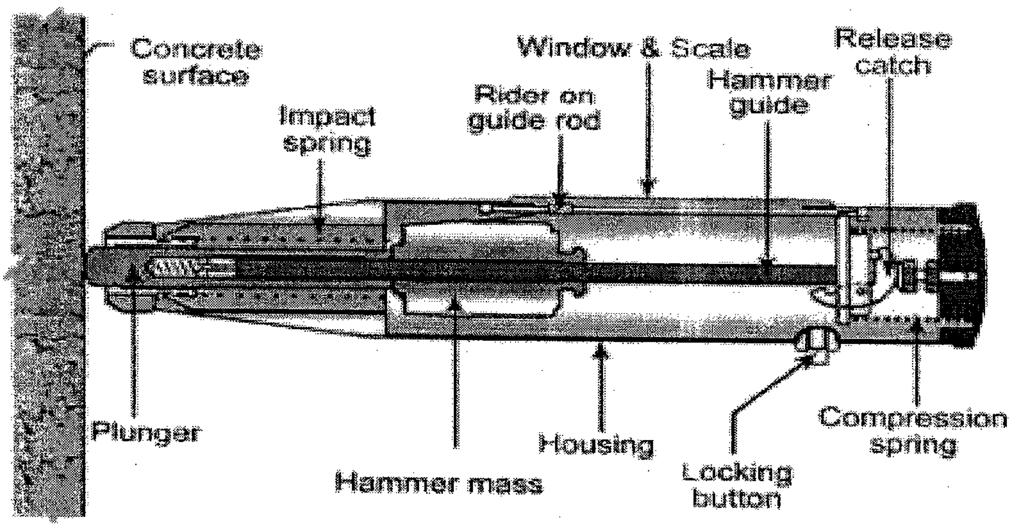


Fig.: Rebound Hammer

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